



New Mexico Tech

Socorro | New Mexico

2021-2022

Course Catalog

Academic Calendar

2021 Fall Semester

| | |
|--|----------------|
| Deadline for December Intent to Graduate | August 01 |
| Validation Day | August 16 |
| Classes Begin | August 16 |
| Late Registration Fees Begin (\$30/day) | August 19 |
| Last day to add a class | August 24 |
| Academic Holiday | September 06 |
| Non-Validated Student Disenrollment | September 01 |
| Last day to drop a class/Census | September 03 |
| Academic Holiday | October 15 |
| Mid-semester | October 13 |
| Mid-term Grades Due | October 18 |
| Grade Option Deadline (pass/fail or Audit) | November 10 |
| Deadline for May Intent to Graduate | November 10 |
| Last Day to Withdraw from a class | November 10 |
| Pre-Registration for Spring 2021 | November 15-19 |
| Thanksgiving Vacation | November 22-28 |
| Last Day of Classes | December 03 |
| Finals Begin | December 04 |
| End of Finals | December 10 |

2022 Winterim

| | |
|-----------------------------------|------------|
| Classes Begin | January 03 |
| Last day to Add/Drop a class | January 03 |
| Last day to Withdraw from a class | January 10 |
| Last Day of Classes/Finals | January 14 |
| Grades Due on | January 17 |

2022 Spring Semester

| | |
|---|-------------|
| Holiday, MLK | January 17 |
| Classes Begin | January 18 |
| Validation Day | January 18 |
| Late Registration Fees Begin (\$30/day) | January 20 |
| Last day to Add a Class | January 25 |
| Non-validated Student Disenrollment | February 02 |
| Last day to Drop a class/Census Day | February 04 |
| Mid-semester | March 16 |
| Spring Vacation | March 14-18 |
| Grades Due | March 21 |
| Last day to Withdraw from a class | April 06 |

| | |
|--|---------------|
| Grade Option Deadline (pass/fail or Audit) | April 06 |
| Academic Holiday | April 15 |
| Pre-Registration for Summer 2021 | April 18-22 |
| Pre-Registration for Fall 2021 | April 25-29 |
| Last Day of Classes | May 04 |
| Finals Begin | May 05 |
| End of Finals | May 10 |
| Final Grades for Graduating Seniors | May 11 (noon) |
| Commencement | May 14 |
| Grades Due (non-graduates) | May 16 |
| Deadline for August Intent to Graduate | May 16 |

2022 Interim

| | |
|-----------------------------------|---------|
| Classes Begin | May 16 |
| Last day to Add/Drop a class | May 18 |
| Academic Holiday | May 30 |
| Last day to Withdraw from a class | May 31 |
| Last Day of Classes/Finals | June 03 |

2022 Field Camp

| | |
|--------------------|----------------|
| Geology Field Camp | May 16 -Jul 28 |
|--------------------|----------------|

2022 Summer Session

| | |
|--|---------|
| Validation Day | June 06 |
| Classes Begin | June 06 |
| Late Registration Fees Begin (\$30/day) | June 09 |
| Last day to add a class (noon) | June 10 |
| Non-validated Student Disenrollment | June 10 |
| Last Day to Drop (3pm) | June 14 |
| Mid-Semester | June 29 |
| Holiday | June 29 |
| Academic Holiday | July 04 |
| Mid-Semester Grades Due | July 05 |
| Grade Option Deadline (pass/fail or Audit) | July 13 |
| Last day to Withdraw from a class | July 13 |
| Last Day of Classes/Finals | July 29 |

2022 Fall Semester

| | |
|--|-----------|
| Deadline for December Intent to Graduate | July 20 |
| Validation Day | August 15 |

Academic Calendar

| | |
|--|------------------|
| Classes Begin | August 15 |
| Late Registration Fees Begin (\$30/day) | August 18 |
| Last day to add a class | August 23 |
| Non-Validated Student Disenrollment | August 30 |
| Last day to drop a class/Census | September 02 |
| Academic Holiday | September 05 |
| Mid-semester | October 12 |
| Mid-Term Grades Due | October 17 |
| Academic Holiday | October 21 |
| Grade Option Deadline (pass/fail or Audit) | November 09 |
| Last Day to Withdraw from a class | November 09 |
| Pre-Registration for Spring 2023 | November 14 - 18 |
| Thanksgiving Vacation | November 21- 25 |
| Last Day of Classes | December 02 |
| Finals Begin | December 03 |
| End of Finals | December 09 |
| Term Grades Due | December 12 |

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Equal Opportunity Policy

The New Mexico Institute of Mining and Technology is committed to the policy that all persons shall have access to its programs, facilities, and employment without regard to race, age, religion, color, national origin, ancestry, sex, sexual orientation, physical or mental handicap or serious medical condition, spousal affiliation, or gender identity, as required by the New Mexico Human Rights Act, Title VI and Title VII of the 1964 Civil Rights Act as amended, Civil Rights Act of 1866, Executive Order 11246, Section 503 and 504 of the Rehabilitation Act of 1973, The Americans with Disabilities Act, The Age in Employment Discrimination Act of 1990, Vietnam Era Veterans Readjustment Assistance Act of 1974, Title IX of the Education Amendments Act of 1975, Immigration Reform and Control Act, or by other applicable laws and regulations. Inquiries regarding compliance may be directed to: Randy Saavedra, Director, Affirmative Action , Room 20D Brown Hall, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801; telephone 505.835.5005.e-mail: Randy.Saavedra@nmt.edu.

The University assumes no responsibility or liability for any delay or failure to provide some or all academic or other campus activities or for any modification to instruction or institutional offering due to any force majeure, For these purposes, the term “ force majeure” shall mean fire, earthquake, flood, act of God, strikes, work stoppages or other labor disturbances, riots or civil commotions, crimes, litigation, war or other act of any foreign nation, plague, epidemic, power of government or governmental agency or authority, or any other cause like or unlike any cause mentioned above, which is beyond the control or authority of NMT and either makes performance of the policies and protocols set forth herein illegal, impractical, and / or in the reasonable judgement of NMT, threatens the safety and wellness of its students, employees and / or community members.

Other Formats

The New Mexico Tech 2021-2022 catalog is available on-line at: www.nmt.edu

The catalog is also available in other formats upon request. Contact:

The Office of the Registrar
New Mexico Tech
801 Leroy Place
Socorro, NM 87801
575.835.5133 or 1.800.428.TECH.

Proviso

The provisions of this catalog are not to be regarded as an irrevocable contract between the student and New Mexico Institute of Mining and Technology. New Mexico Tech reserves the right to change any provisions or requirements at any time within the student's term of residence.

Assurance of Learning

New Mexico Tech is committed to achieving the learning goals that correspond to the School's mission and values. The purpose of the assurance of student learning is to support and improve student learning by developing methods to: articulate the goals of each academic program, gain feedback on each unit's progress toward achieving those goals, and use the feedback to modify the academic programs to ensure that the goals are effectively achieved. Individual student learning results achieved through coursework are for the exclusive use of NMT to improve our programs and will not be used for evaluation of any student's final grade.

Institute-Wide Student Learning Outcomes:

New Mexico Tech bases its curricula and its co-curricular activities on the following student learning outcomes; we continuously assess the level of achievement our students demonstrate in these outcomes. NMT students will:

1. learn to reason well and to evaluate and apply information;
2. develop analytical and quantitative skills for competence in science and math;
3. communicate to different audiences in multiple forms;
4. exercise their role as members of diverse societies and cultures;
5. learn responsible values and ethics for their professional lives;
6. gain expertise in their chosen field of study.

Accreditation

New Mexico Tech is accredited by the Higher Learning Commission (HLC) as a doctoral degree-granting university. Its credits are accepted by leading colleges and universities throughout the United States. It is approved by the Attorney General of the United States for the attendance of non-immigrant students, by the United States Department for Exchange Visitor Program P-I-1282, and by the Veteran's Approval Division of the Office of Military Affairs for attendance by students entitled to veteran's benefits.

HLC Contact Information:

Higher Learning Commission
230 South LaSalle Street
Suite 7-500
Chicago, IL 60604
800-621-7440
<https://www.hlcommission.org/>

NMT Contact Information:

New Mexico Tech
801 Leroy Place
Socorro NM 87801
575-835-5434
www.nmt.edu



Alteration and/or unauthorized use prohibited.

The Bachelor of Science (BS) programs in Chemical Engineering, Civil Engineering, Electrical Engineering, Environmental Engineering, Materials Engineering, Mechanical Engineering, Mineral Engineering, and Petroleum and Natural Gas Engineering are accredited by the Engineering Accreditation Commission of ABET, www.abet.org.

The Bachelor of Science program in Computer Science is accredited by the Computing Accreditation Commission of ABET, www.abet.org.

Course Abbreviations

| | |
|-------|---|
| AE | Aerospace Engineering |
| ACCT | Accounting |
| ANTH | Anthropology |
| ARTH | Art History |
| AFAS | Air Force ROTC |
| BA | Business Administration |
| BCS | Business Computer Systems |
| BIOL | Biology |
| BIOT | Biotechnology |
| BMS | Biomedical Sciences |
| CE | Civil Engineering |
| CED | Community Education |
| CERT | CED Certificate Program |
| CH E | Chemical Engineering |
| CHEM | Chemistry |
| CLASS | Communication, Liberal Arts and Social sciences |
| COMM | Communication |
| CYBS | Transdisciplinary cybersecurity |
| CSE | Computer Science Engineering |
| ECON | Economics |
| EDUC | Education |
| EE | Electrical Engineering |
| EMGT | Engineering Management |
| ENGL | English |
| ENVE | Environmental Engineering |
| ENVS | Environmental Science |
| GEOL | Earth Science |
| ES | Engineering Science |
| ARTS | Fine Arts |
| FIN | Finance |
| FREN | French |
| GEOB | Geobiology |
| GEOC | Geochemistry |
| GEOL | Geology |
| GEOP | Geophysics |
| GRMN | German |
| HIST | History |
| HUMA | Humanities |
| HYD | Hydrology |
| IT | Information Technology |
| LIFE | Lifestyle |
| MTLS | Materials Engineering |
| MENG | Mechanical Engineering |
| MATH | Mathematics |
| ME | Mineral Engineering |
| MGMT | Management |
| MKT | Marketing |
| MUSC | Music |
| OPT | Optics |
| PETR | Petroleum Engineering |
| PHIL | Philosophy |
| PHYS | Physics |
| PHED | Physical Recreation |
| POLS | Political Science |
| PSYC | Psychology |
| SPAN | Spanish |
| SOSC | Social Science |

| | |
|------|-------------------------------------|
| ST | Science Teaching |
| STC | Society for Technical Communication |
| TCOM | Technical Communication |
| GNDR | Women's and Gender Studies |

Other Abbreviations, Acronyms, and Terms Used at Tech

| | |
|---------|--|
| ACT | Academic Center for Technology |
| AOC | Array Operations Center |
| CED | Community Education Department |
| DE | Distance Education |
| E&ES | Department of Earth and Environmental Science |
| EEG | Environmental Evaluation Group |
| ECO | Etscorn Campus Observatory |
| EMRTC | Energetic Materials Research and Testing Center |
| FacMgmt | Facilities Management |
| FE exam | Fundamentals of Engineering exam |
| GPA | Grade Point Average |
| ICASA | Institute for Complex Additive Systems Analysis |
| IERA | Institute for Engineering Research & Applications |
| ILEA | International Law Enforcement Academy |
| IRIS | Incorporated Research Institutions for Seismology |
| ITC | Information Technology Center |
| LIBROS | Tech Library's On-Line Catalog |
| MEVO | Mount Erebus Volcano Observatory |
| MRO | Magdalena Ridge Observatory |
| MROI | Magdalena Ridge Observatory Interferometer |
| MSEC | Mineral Science and Engineering Complex |
| NCKRI | National Cave and Karst Research Institute |
| NMBGMR | New Mexico Bureau of Geology & Mineral Resources (often referred to as "the Bureau") |
| NMCCNS | New Mexico Common Course Numbering System |
| NRAO | National Radio Astronomy Observatory |
| OCLC | Library Database |
| OST | Optical Surfacing Technology |
| PAS | Performing Arts Series |
| PASSCAL | IRIS's Program for Array Seismic Studies of the Continental Lithosphere |
| PRRC | Petroleum Recovery Research Center |
| R&ED | Research and Economic Development Office |
| RA | Resident Assistant /Research Assistant |
| RCN | Residential Computing Network |
| ROTC | Reserve Officer Training Corps |
| SGA | Student Government Association |
| SAC | Student Activities Center |
| SAIC | Science Application International Corporation |
| SUR | Student and University Relations Office |
| TA | Teaching Assistant |
| TAC | Tech Authorization Code (long-distance phone access) |
| VLA | Very Large Array radio telescope |
| VLBA | Very Long Baseline Array radio telescope |
| VSQ | Visiting Scientists' Quarters |
| WIPP | Waste Isolation Pilot Project |

Degrees Offered at Tech

Associate Degrees

Associate of General Studies
Associate of Science in Business

Undergraduate Certificate

Management

Bachelor of Science

Basic Sciences
Biology
Biomedical Sciences
Chemical Engineering
Chemistry
Civil Engineering
Computer Science
Earth Science
Electrical Engineering
Environmental Engineering
Environmental Science
Information Technology
Management
Management of Technology
Materials Engineering
Mathematics
Mechanical Engineering
Mineral Engineering
Petroleum & Natural Gas Engineering
Physics
Psychology
Technical Communication

Bachelor of Arts

Chemistry
Earth Sciences
Management
Psychology

Bachelor of General Studies

Undergraduate Minors

Aerospace Engineering
Biology
Biomedical Engineering
Chemistry
Chemical Engineering
Civil Engineering
Computer Engineering
Computer Science
Earth Science
Education
Electrical Engineering

Environmental Engineering
Explosives Engineering
Geobiology
Geophysics
Hispanic Studies
History
Hydrology
Literature
Management
Materials Engineering
Mathematics
Mechanical Engineering
Mineral Engineering
Mineral Resources
Music
Optical Science and Engineering
Petroleum Engineering
Petroleum Geology
Philosophy
Physics
Polymer Science
Psychology
Science, Technology, & Society
Secondary Education
Technical Communication

Master Degrees

Graduate Certificate

Cybersecurity
Electrical Engineering
Elementary Alternative Licensure
Explosive Engineering
Hydrology
Scientific & Professional
Communication
Secondary Alternative Licensure
Technology Leadership

Professional Master

Hydrology
Transdisciplinary Cybersecurity

Accelerated Masters

Biology
Chemistry
Physics
Computer Science
Electrical Engineering
Materials Engineering

Master of Engineering

Chemical Engineering
Management
Materials Engineering
Mechanical Engineering

Master of Science

Biology
Chemistry
Computer Science
Electrical Engineering
Civil & Environmental Engineering
Chemical Engineering
Geochemistry
Geology
Geophysics
Hydrology
Materials Engineering
Mathematics
Mechanical Engineering
Mineral Engineering
Petroleum Engineering
Physics
Science Teaching
Transdisciplinary Cybersecurity

Doctor of Philosophy

Biotechnology
Chemistry
Computer Science
Chemical Engineering
Earth and Environmental Science

- Geobiology
- Geochemistry
- Geology
- Geophysics
- Hydrology

 Electrical Engineering

- Cyber Electronic Systems

 Materials Engineering
Mathematics

- Applied & Industrial Mathematics

 Mechanical Engineering

- Intelligent Energetic Systems

 Mineral Engineering
Petroleum Engineering
Physics

- Astrophysics
- Atmospheric Physics
- Instrumentation

Degrees Offered at Tech

- Mathematical Physics
- Transdisciplinary Cybersecurity

Graduate Minors

Analysis
Applied & Industrial Mathematics
Numerical Analysis
Operations Research & Statistics
Physics

The University

An Overview of New Mexico Tech

New Mexico Institute of Mining and Technology, commonly known as New Mexico Tech, is devoted to excellence in education and research. The atmosphere is casual, and each student can expect to be recognized as a distinct individual.

New Mexico Tech students may choose from programs in the earth sciences, physical and biological sciences, engineering disciplines, technical communication, mathematics, management, computer science, and information technology. In addition, breadth and enrichment are provided by supporting programs in the arts, humanities, and social sciences. The New Mexico Tech student gains a liberal education, as well as a thorough science, mathematics, and engineering education.

At New Mexico Tech there is no artificial distinction between pure and applied research and no sharp dividing line between teaching and research. The New Mexico Tech student is challenged to learn, to think in the abstract, and to bring abstractions to bear on practical situations. Employment of students in the many research facilities and in departmental research is central to New Mexico Tech's programs.

Undergraduate students can choose from among two dozen Bachelor of Science programs or pursue a degree in general studies. Graduate programs extend through the doctoral level and contribute to the research atmosphere that also benefits undergraduate instruction. Many graduating seniors continue their studies in graduate or professional schools.

With an enrollment of more than 1,500 undergraduate students and more than 500 graduate students, New Mexico Tech offers the advantages of small classes—the average class size is 14 students for lectures and only 12 students in lab sessions. (Introductory classes are usually larger.)

Although New Mexico Tech does not offer athletic scholarships or participate in major spectator sports, students participate in a rich variety of intramural, club, and individual sports activities. Student organizations cater to professional, hobby, religious, and social interests.

The Campus

New Mexico Tech's beautifully landscaped campus is an oasis of green in the desert, with tall trees, grassy lawns, and flowerbeds. The central section of 320 acres contains academic buildings, laboratories, residence halls, family housing, and recreational areas. An additional 40 square-mile area adjoining the main campus is used for research and testing activities. Socorro Peak, with an elevation of 2,208 m (7,243 ft) above sea level, is immediately west of the campus quadrangle and contains a mine now used for seismic studies. Recreational areas on campus include the Joseph A. Fidel Student Services Center, Student Activities Center (SAC), Swim Center, tennis courts, Macey Theater/Conference Center, the Etscorn Campus Observatory, the Gymnasium, and an 18-hole Golf Course.

A Brief History of New Mexico Tech

What began over a century ago as a mining school has evolved into an important research and educational institution. New Mexico Tech was founded as the New Mexico School of Mines in 1889, when it was established by an act of the Territorial Legislature. Over the years, Tech's emphasis has expanded, first into the area of petroleum engineering, and then, in the 1940s, into physics research. Today, New Mexico Tech is known for its expertise in highly specialized areas such as earth and atmospheric sciences, astrophysics, testing of energetic materials, and such engineering fields as chemical, civil, electrical, materials, mechanical, environmental, petroleum, and mineral engineering.

In addition to the educational arm of the Institute, New Mexico Tech has numerous research and service entities, including the New Mexico Bureau of Geology and Mineral Resources, the Research and Economic Development Division, the Petroleum Recovery Research Center, the Energetic Materials Research and Testing Center, Optical Surfacing Technologies, Langmuir Laboratory for Atmospheric Research, the Institute for Complex Additive Systems Analysis, and Incorporated Research Institutions for Seismology.

In recognition of the growing role of the Institute, the State Legislature changed the name in 1951 from "New Mexico School of Mines" to "New Mexico Institute of Mining and Technology," which is still the official name. The name "New Mexico Tech" came into common use in the 1960s.

The graduate program was begun in 1946 and involves staff and facilities of the entire Institute.

Our Mission

New Mexico Tech serves the state and beyond through education, research, and service, focused in science, technology, engineering, and mathematics. Involved faculty educate a diverse student body in rigorous and collaborative programs, preparing scientists and engineers for the future. Our innovative and interdisciplinary research expands the reach of humanity's knowledge and capabilities. Researchers, faculty, and students work together to solve real world problems. Our economic development and technology transfer benefit the economy of the state and create opportunities for success. We serve the public through applied research, professional development, and teacher education, benefitting the people of New Mexico.

Our Vision

New Mexico Tech aspires to be a preeminent *community of scholars* dedicated to research, education, and innovation – advancing science, technology, engineering, and mathematics – to meet the challenges of tomorrow. We will drive innovation and education through transdisciplinary collaborations.

Institutional Values

• Research

NMT values groundbreaking research that generates knowledge and innovative design concepts to solve challenging science and engineering problems. Success in research requires a relentless commitment and focus by faculty, students, and research staff. Our small size encourages interdisciplinary collaborations to solve problems that are not tractable within a single field. We are dedicated to balancing the demands for education and research productivity and developing the resources and support necessary for globally competitive research that will solve complex problems, discover innovative abilities, and transform our future.

• Integrity

Integrity is honored as a fundamental value at New Mexico Tech. Dishonesty, cheating, and plagiarism have no place in a respected institution of research and higher education. Real integrity goes further than avoiding these negatives; integrity means having the courage to defend the truth, to act fairly, ethically, and honestly in all our endeavors, and to be responsible members of the community.

• Creativity

Creativity is integral in all endeavors from learning to business to research. It calls for curiosity, adaptability, resourcefulness, and requires imagination, vision, risk-taking, and diligence. Solving difficult problems often requires non-traditional approaches. Whether a task is being performed by NMT staff, students, faculty, administrators, or regents, our institution encourages and expects creativity.

• Lifelong Learning

We value learning how to learn. We develop lifelong learning skills through a rigorous curriculum, a challenging educational experience with a foundation of critical thinking and problem-solving, invigorating research, and significant professional development; this foundation prepares students, faculty, and staff for continuing individual and career growth. We intend our faculty to-student ratio and collegial environment to facilitate mentorship and one-on-one guidance on how to approach difficult concepts and challenging problems. This value strengthens all of our abilities to be independent and highly productive learners and contributors.

• Excellence

New Mexico Tech is known for the high quality of its education and research; we aspire to excellence in all aspects of our mission.

• Economic Prosperity & Technological Development

New Mexico Tech values the economic prosperity and technological development of New Mexico and the world. Our professional development programs advance the skill level of the state and national workforce. Our outreach programs attempt to inspire underrepresented communities to pursue STEM careers and participate fully in our economic future. We prepare people of all backgrounds to join the well-educated workforce of tomorrow through academic rigor and practical research experience. As a result of our strengths, we provide strategic support, technical assistance, and technology transfer that bolster public and private sector competitiveness.

• Integrated Planning & Decision Making

We value openness, fairness, collaboration, and stakeholder input in all aspects of the NMT operation. It is critical that data be a driving factor in important decisions involving university functions. Data is to be shared to the extent possible to detect errors, to assure data quality, and to facilitate stakeholder participation in integrated decision making across organizations. We commit to collecting, sharing, and archiving consistent data and participating in transparent decision making.

• Collegiality & Collaboration

We value the positive energy, performance, and support that come from a collegial and collaborative environment, where team members actively contribute to the advancement of our students, our colleagues, and our institution.

Research and Service Organizations at Tech

New Mexico Tech has a number of organizations whose missions involve research and/or public service. Many of these organizations employ students at the graduate and undergraduate levels, providing students with employment as well as educational work experiences that enhance their value to future employers.

New Mexico Tech Office of Research

www.nmt.edu/research/

Faculty and student involvement in research is a distinguishing characteristic of New Mexico Tech. The Research Division encourages research throughout Tech in many ways. The Division places a special emphasis on encouraging interdisciplinary and collaborative work and not only provides financial support, but also promotes research through professional and technical expertise, services, and facilities.

The main state-supported research component is the Geophysical Research Center (GRC). The GRC supports research in atmospheric physics and chemistry, air quality, seismology, and groundwater hydrology. The Langmuir Laboratory for Atmospheric Research (part of the GRC), located in the nearby Magdalena Mountains, is an internationally recognized facility for research in lightning, cloud physics, and water chemistry. The Incorporated Research Institutions for Seismology (IRIS) is operated in coordination with the GRC and the Tech Geophysics program. The GRC also supports numerous cloud physics radar facilities, and a Schweitzer aircraft for in-situ measurements of thunderstorms. Through the GRC, a number of faculty, graduate students, and undergraduate students are supported in their research.

Additional research activities and facilities directly sponsored and supported by R&ED include an astronomical observatory in the Magdalena Mountains and astronomical research on campus in cooperation with the National Radio Astronomy Observatory.

The Research Office is Tech's central link for information about potential funding sources and program guidelines for sponsoring agencies. Other Research services include a machine shop equipped for specialized research projects, a Makers Space, a corporation equipment and maintenance yard, and Tech's hazardous waste and safety office. These groups and the administrative office staff, are available to assist researchers, as well as the entire Tech community. Research contributes to New Mexico's growth in the area of technology by cooperating with industry and governmental agencies to move new ideas and discoveries from the academic laboratory into the marketplace.

Research Compliance and Safety

The Research Compliance and Safety division is dedicated to identifying and mitigating the risks involved in research, and providing resources to students, faculty and staff to meet the demands of an increasingly complicated regulatory climate surrounding research and the funding thereof. We promote positive safety culture in NMT research endeavors, and our office is the primary point of contact for Laboratory Safety, Biological Safety, Hazardous Materials Safety, Human Subjects Research (Institutional Review Board), Animal Subjects Research (IACUC), Export Control and Industrial Security. Student contributions to and involvement in these areas provide value to our work and valuable experiences for students.

Energetic Materials Research and Testing Center (EMRTC)

www.emrtc.nmt.edu

In existence for more than 70 years, the Energetic Materials Research and Testing Center (EMRTC) is the largest of the research divisions at New Mexico Tech.

EMRTC conducts research on the performance and safety of energetic materials and explosives for the U.S. Government, friendly foreign governments, and academic and commercial entities at its 40-square mile field test laboratory. This complex includes more than 30 separate test sites, gun ranges, and state-of-the-art research laboratories. EMRTC also develops tools to analyze material interactions by using computer codes designed to simulate detonation, fragmentation, and impact.

To support the educational and research processes of New Mexico Tech, EMRTC provides joint appointments for faculty and staff and opportunities for graduate and undergraduate student employment.

EMRTC hires up to 30 undergraduate and graduate students each semester and through the summer months. The opportunities provided include construction, design, analysis, test setup, instrumentation, and data collection and analysis, report preparation, and other valuable work experiences for the real world. Many of EMRTC's student workers have been able to get jobs (some at EMRTC) based on the experience they gained while working at EMRTC.

EMRTC also develops and conducts a program of training courses for federal, state, tribal, and allied government agencies; academic institutions; and commercial entities in the following areas:

- **National Domestic Preparedness** — EMRTC is a member of the National Domestic Preparedness Consortium (NDPC), a partnership of public and private organizations whose goal is to provide a focused, threat responsive, long term national capability to execute and sustain a comprehensive and coordinated domestic emergency responder education, training, testing and exercise program.

EMRTC conducts this training for state, county, and city officials who are responsible for responding to terrorist incidents. Trainees actively engage in scenario-based activities designed to provide practice in the skills they will use on the job. First responders and other participants from every state in the nation have been trained at EMRTC.

- **Anti-Terrorist Research and Training** — EMRTC’s anti-terrorist activities include research and test programs conducted to develop means for reducing injury and for mitigating damage caused by terrorist bombings and other incidents.
- **Explosives Safety** — EMRTC conducts research and training programs in explosives and energetic materials safety. Research includes investigations of materials handling, storage, and transportation. Training includes acquainting personnel who operate government and commercial firing sites and laboratories involved in the research, development, testing, and evaluation of energetic materials with safety requirements and techniques.

As a result of its diversified business areas, wide-ranging research and test activities, and ever expanding training programs, EMRTC synergistically complements New Mexico Tech’s educational and research responsibilities, enhances employment opportunities, and significantly contributes to the economic development of New Mexico.

IRIS PASSCAL Instrument Center

www.passcal.nmt.edu

The Incorporated Research Institutions for Seismology (IRIS; www.iris.edu) Consortium’s Portable Array Seismic Studies of the Continental Lithosphere (PASSCAL) Instrument Center is located in New Mexico Tech’s Research Park. The Center is primarily supported by the National Science Foundation (NSF) and U.S. Department of Energy, and is operated by Tech professional staff in coordination with the Department of Earth & Environmental Science Geophysics Program and the Geophysical Research Center. In association with researchers and students from around the world, Instrument Center staff engage in hardware/software development and training associated with earthquake, volcano, glaciological, and other seismological research, handle logistical support and fieldwork for Earth science experiments, and maintain the world’s largest academic pool of research seismological instrumentation. PASSCAL instruments are routinely employed in teaching and research projects with investigators from Tech’s Geophysics Program, as well as many other U.S. and international research institutions. A key component of the Instrument Center’s operation is to provide unique opportunities for New Mexico Tech and other students to learn about and contribute to the international seismological research community through employment, internships, and other opportunities.

Langmuir Laboratory for Atmospheric Research

www.langmuir.nmt.edu

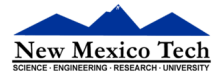
Langmuir Laboratory, built by New Mexico Tech in 1963, is located at an elevation of 3,240 m (10,630 ft) in the Magdalena Mountains, 27 km southwest of the main campus. The laboratory was named in honor of Dr. Irving Langmuir, Nobel Prize winner, who participated in numerous experiments at Tech related to cloud physics after the discovery of cloud seeding in 1946. The Magdalena Mountains offer favorable conditions for the study of thunderstorms because many occur there during the summer, and the storms tend to remain isolated, stationary, and relatively small. High altitude discharges, such as Sprites, Blue Jets, and Gigantic Jets can also be observed over distant thunderstorms due to the dark skies and clear viewing conditions. Other areas of study include cloud physics, natural radioactivity, and seismology.

Langmuir Laboratory operates one of only four lightning triggering facilities in the world. Triggered lightning is used to study basic lightning physics, as well as for engineering and testing purposes. The facility also has a restricted airspace (R-5113) that is dedicated for the laboratory’s use in the summer months. The airspace allows us to fly balloons, aircraft, rockets and UAVs up to 45,000 feet altitude while maintaining safe separation from other air traffic. In addition to standard laboratory workspace, there are two underground Faraday cages used for lightning studies, and a high-bay balloon hangar. Overnight living accommodations are available for researchers, faculty, students, and visitors who work at the laboratory.

The Langmuir Research Site consists of 33,000 acres of Cibola National Forest land which surrounds Langmuir Laboratory. In 1980, through the efforts of the Langmuir Laboratory and New Mexico’s Congressional Delegation, Public Law 96-550 was passed by Congress, preserving the land in its undeveloped state and encouraging scientific research as a prime land use in this area. The laboratory is operated under a special use permit issued by the U.S. Forest Service.

Institute for Complex Additive Systems Analysis (ICASA)

(www.icasa.nmt.edu)



ICASA Capabilities

ICASA

About and Mission

The Institute for Complex Additive Systems Analysis (ICASA) is a non-profit research division of New Mexico Institute of Mining and Technology (NMT), a state university. ICASA's mission is to contribute innovative and relevant solutions to national security and critical infrastructure protection problems. This is performed through examination of the control plane of the system — the mechanisms that enable it to dynamically change and respond to its environment. NMT has been consistently recognized by the National Security Agency and Department of Homeland Security as a Center of Academic Excellence in Information Assurance Education since 2001 and a Center of Academic Excellence in Information Assurance Research since 2009. As an academic research institute, ICASA is committed to fostering student excellence. Having employed over 150 student interns, ICASA provides opportunities for the development and refinement of analytical skills against real-world problems.

Problem Space

ICASA focuses on systems that are:

1. utility infrastructure
2. computer networks
3. social systems
4. financial markets
5. Telecommunication systems

Types of Questions Answered

- What are the system's vulnerabilities?
- How can the system be controlled?
- Is the system being disrupted?
- How will the system behave in the future if current conditions are extrapolated?
- Can undesirable conditions be avoided?
- Can desirable conditions be invoked?
- Given limited visibility, how does the rest of the system look or behave?

Rapid Technology Re-application

Many of ICASA's established analytic mechanisms and tools are readily re-applied to novel situations and problems, enabling rapid development.

Sample Projects

Computer Networks

Internet Monitoring: Cyber I&W

The Internet Monitor is a suite of tools for detecting, classifying, and localizing large-scale disruptions in the Internet. This mechanism is based on analysis of Border Gateway Protocol (BGP) traffic to examine the Internet's dynamic routing topology. The tool provides near-real-time indications and warning (I&W) for the Internet's health at a global scale.

These technologies have also been reapplied to regional and radio networks with significant success.

Process Analysis for Cyber Operations

ICASA's PACO method leverages Hierarchical Task Decomposition (HTD) and automated Analysis of Competing Hypotheses (ACH) in a cohesive framework to identify and prioritize situations of concern on a network.

Electric Power Analysis

ICASA's electric power analysis capability involves identifying vulnerabilities, extrapolating topology, and understanding the behavior of target power grids.



Social Media Prediction

ICASA has developed social media analysis mechanisms for predicting the spread and impact of messages across Twitter and web communities.

DAVE

The Data Analysis and Visualization Environment (DAVE) is ICASA's data analysis sandbox software that facilitates rapid development of analytic mechanisms for analysts and data scientists.

Magdalena Ridge Observatory (MRO)

www.mro.nmt.edu

The Magdalena Ridge Observatory (MRO) is a world-class, state-of-the-art astronomical research facility consisting of two projects, the fast-tracking 2.4-meter Telescope and the multi-telescope Interferometer (MROI). Located at an elevation of almost 10,640 feet in the Magdalena Mountains of the Cibola National Forest, and just a one-hour drive from campus, the MRO is the fourth highest observatory in the world. The operational goals of the Observatories include conducting classical astronomical research, contributing to addressing national security concerns (space surveillance), and supporting and enhancing education and public outreach.

The 2.4-meter Telescope is primarily utilized to observe, track, and characterize solar system astronomical targets, artificial Earth satellites, space vehicles, and terrestrial military targets. Regular operations for the facility began in September 2008. The 2.4-meter telescope can accommodate a wide variety of instrument systems (photometry, spectroscopy, etc.), and support the fabrication, integration, and operation of new instrumentation as well as the development of new and innovative techniques in space domain awareness studies. Major science milestones include obtaining high-precision astrometry and photometry of potentially hazardous near-Earth objects, characterizing some of the fastest spinning asteroids in the Solar System, and tracking the outbound trajectory of the first-observed interstellar asteroid. The observatory is also used to enhance traditional classroom coursework through laboratory observing exercises. Tours for school and community groups are conducted throughout the year to promote science education and science/technology-based careers.

The Magdalena Ridge Observatory Interferometer (MROI) is currently in the construction and development stages. The MROI team has finished most of the design work and is currently building all the major subsystems. The MROI design has been optimized to maximize the throughput and quality of light received within the beam combining laboratory. This will allow the MROI to observe targets more than 40 times fainter than has been possible with similar facilities. Using interferometry, the same technique used at the Very Large Array (VLA) radio telescope to link 27 separate radio receivers to form one gigantic instrument, the MROI will link ten large optical and infrared telescopes to provide the resolving power of a single 347-meter telescope. The MROI project's technical goal is to produce model-independent images of faint and complex astronomical targets at resolutions over 100 times that of the Hubble Space Telescope. The astronomical science program will include the study of star and planet formation, stellar accretion and mass loss, and active galactic nuclei. The space surveillance program's aim will target imaging of Geosynchronous Satellites (GEOS), in both the commercial and military domains.

Mount Erebus Volcano Observatory (MEVO), Antarctica

www.erebus.nmt.edu

The Department of Earth and Environmental Science operates a year-round network of scientific instrumentation (seismic, infrasonic, geodetic, and environmental) on the active Mount Erebus volcano in Antarctica for fundamental research in volcanology under support from the National Science Foundation, Office of Polar Programs. Each year, Austral summer observations and surveillance are made by New Mexico Tech students and faculty from a field camp situated 3400 meters high on the volcano. Mt. Erebus, the world's southernmost active volcano, features a unique lava lake in its summit crater and has frequent eruptions. Data is telemetered to the Crary Science Lab at McMurdo Station, Antarctica, and then transferred via the Internet to Tech for year-round analysis and archiving in near real time.

National Cave and Karst Research Institute (NCKRI)

www.nckri.org

The National Cave and Karst Research Institute (NCKRI) facilitates and conducts programs in research, education, data management, and stewardship in all fields of cave and karst science. NCKRI promotes and performs projects of national and international application through dedicated staff and partners, including with programs and departments at NMT. Research projects are diverse, with recent studies focused on geophysical characterization, sinkhole collapse hazard assessment and prevention, geomicrobiological characterization, and hydrogeological evaluations.

Karst landscapes and their associated features, like caves, springs, underground rivers, and sinkholes, are fascinating. However, they are often not well understood by students and professionals in earth and natural sciences.

Karst landscapes are prevalent on 20-25% of the land worldwide, and contain fragile, rare, ecosystems. Though over 40 million US residents depend on karst aquifers for drinking water, few have ever heard of karst. This fact, along with significant scientific discoveries in caves, led to the creation of NCKRI in 1998 by the US Congress in partnership with the state of New Mexico and the City of Carlsbad. New Mexico Tech is responsible for the planning, coordination, and administration of the Institute and its programs.

NCKRI's projects and interests range quite literally from the inner space to outer space. Karst springs and aquifers can produce tremendous volumes of water, yet they are incredibly complex and the most vulnerable to contamination. Sinkholes in karst result in hundreds of millions of dollars in damages each year and occasionally the loss of lives. NCKRI scientists also study cave microbes for industrial and medical applications, and work with NASA to better understand where life might be found on other planets.

NCKRI Headquarters is located in Carlsbad, New Mexico. The building and its operating practices are testaments for living

softly on karst. It was constructed utilizing environmentally friendly products and it includes many green features such as an artificial bat roost that allows for scientific study of these highly beneficial mammals. NCKRI is currently developing a suite of exhibits to engage audiences to take a learning voyage centered on cave and karst systems. To learn more about NCKRI, visit our website at www.nckri.org or find us on Facebook.

National Radio Astronomy Observatory (NRAO)

www.nrao.edu

NRAO is not a division of New Mexico Tech (it is funded by the National Science Foundation), but its office on the New Mexico Tech campus operates two major radio telescopes: the Karl G. Jansky Very Large Array (VLA) and Very Long Baseline Array (VLBA).

New Mexico Bureau of Geology and Mineral Resources (NMBGMR)

www.geoinfo.nmt.edu

The New Mexico Bureau of Geology and Mineral Resources is the official state agency responsible by law for original investigations of geology and mineral and water resources in New Mexico. The Bureau investigates, evaluates, and disseminates information on geology, mineral, water, and energy resources, and extractive metallurgy—with emphasis on aiding the discovery and responsible development of nonrenewable resources for the benefit and well-being of the citizens of this state. The director of the Bureau also serves as State Geologist.

Although primarily a technical organization providing counsel to state and federal agencies, as well as extractive industries, the Bureau also serves all interested citizens by advancing the understanding of the state's geology and natural resources. Environmental geology and geohydrology are increasingly important parts of the Bureau's service and applied research.

The Bureau's Mineral Museum represents one of the most outstanding mineral collections in the United States. The collections contain more than 16,000 mineral, rock, mineral product, mining artifact, and fossil specimens. Specific displays highlight minerals from the New Mexican mining districts and the southwestern United States, as well as fluorescent minerals. Other significant specimens from around the world are also displayed. In addition to display specimens, a reference collection of New Mexico rocks, ores, and minerals is available for research. A museum demonstration facility allows for hands-on explorations into earth science phenomena as well as illustrating the importance of mineral products in modern society.

The New Mexico Library of Subsurface Data contains more than 6.5 million individual cuttings samples from 16,300 different oil, gas, and water wells drilled in the state. The samples, taken from different levels to show various strata, are valued at more than \$1 million. Collected for more than 50 years, the cuttings samples also represent tests for uranium, coal, and other minerals. The library also contains well logs from approximately 49,000 wells and driller's logs from more than 15,000 wells. A core library contains selected cores from petroleum and mining drill holes throughout New Mexico. All are available for study. Basic information on 100,000 wells in the state is also available.

The information assembled by the Bureau staff of scientists is provided to the public through maps, publications, and direct response to individual inquiries. Publications are distributed throughout the world on an exchange agreement with other geological surveys. Exchange publications are kept for reference in the Tech library. By furnishing vital scientific information and advice, the Bureau aids in the establishment of new mining and petroleum operations and new energy and mineral industries in the state, as well as in the expansion and diversification of existing resource industries and the state's water supplies.

The extensive laboratories of the Bureau are designed and equipped for analysis and experimentation in a wide variety of areas useful to the geosciences. These facilities are used not only in the Bureau programs, but also are available for use in instructional programs by students majoring in geology and metallurgy, and in Materials, mineral, and petroleum and natural gas engineering. A substantial number of graduate and undergraduate students are employed by the Bureau. Students work on research projects and in laboratories and offices. In addition, many of the staff also teach classes and advise on student projects.

New Mexico Bureau of Mine Safety (www.bmi.state.nm.us)

Mining is an essential element in the New Mexico economy. The Bureau of Mine Safety's (BMS) focus is to actively promote the safety of the miners of New Mexico. BMS trains thousands of miners each year, including miners trained in Spanish language classes. BMS training, involvement and initiatives have contributed to a superb safety record in New Mexico.

Directed by the State Mine Inspector, the department is a state and federally funded organization providing services to New Mexico and its miners in the following areas:

- **Mine Rescue and Emergency Response** - Coordination of incident response, equipment and human resources
- **Legislative Issues Relative to Miner Safety** - Includes being the point of contact for the Governor's office and the State Legislature on mine related issues and legislation.
- **Mine Compliance Assessment and Courtesy Inspections** – Communicating the legislated mining safety standards and ensuring compliance
- **Safety and Health Training** - Providing safety and health training to mine workers, contractors, as well as federal and state organizations involved in special mine-related activities
- **Certification of Coal Mine Officials** - Developing and providing an examination process designed to certify qualified coal mine officials

- **Safety Award, Other Education & Communication Programs** – Safe Operator of the Year, Zero [accident] Frequency Awards, Small Mine Mentoring Program, BMS website and Informational Meetings are all BMS programs designed to further awareness and actively promote the safety of New Mexico’s miners. Actively engaged in guiding the annual New Mexico Mine Health and Safety Conference
- **Coordination with the New Mexico Mine Safety Board (MSB)** – This board promulgates the rules that affect the mining industry in the State of New Mexico

New Mexico Petroleum Recovery Research Center (PRRC)

www.prrc.nmt.edu/

The Petroleum Recovery Research Center (PRRC), the only research center of its kind in New Mexico, is a world-class scientific research organization dedicated to solving problems related to the oil and gas industry. The PRRC’s mission is to develop, through theoretical and practical research, improved oil recovery methods to increase oil and natural gas recovery from New Mexico’s and the nation’s oil and gas reservoirs and to transfer new technology to the industry and to local independents.

Interaction between the educational institution and the PRRC’s research staff is extensive. New Mexico Tech offers the only petroleum and natural gas engineering degree program in the state, and students have ample opportunity to participate in ongoing front-line research at the PRRC while pursuing their academic training. The center’s current research program includes studies involving the use of gels to reduce water production and increase reservoir sweep efficiency; improved carbon dioxide (CO₂) flooding with emphasis on mechanisms that control injectivity; fundamental research on rock/fluid interactions and their influence on oil recovery, with emphasis on studies of wettability alteration and asphaltenes; reservoir characterization using artificial intelligence; CO₂ sequestration studies; and the development of membrane and sensor technologies for use in cleanup of produced water from oil and gas recovery, for high-temperature CO₂ capture, and for the efficient conversion of natural gas into more valuable higher hydrocarbons and hydrogen. Current New Mexico oil and gas production data and related information is disseminated to the public via the center’s GO-TECH web site, developed in-house, which is continually expanding as a result of ongoing collaborations with various state and federal agencies and with local independents.

The PRRC employs 20 full-time research and professional personnel, provides research assistantship support to an average of 25 graduate students year round, and employs an average of 22 undergraduate students throughout the academic year. The center’s daily operations are conducted at the John M. and Esther L. Kelly Petroleum Building which features general office space, 20 laboratories (approximately 10,000 square feet), specially designed storage areas, a core-cutting and welding facility, machine and woodworking shops, a reports and publications office, and a large seminar room.

New Mexico Tech Seismological Observatory

[\(https://geoinfo.nmt.edu/nmtso/\)](https://geoinfo.nmt.edu/nmtso/)

The New Mexico Tech Seismological Observatory (NMTSO) is dedicated to the recording and study of earthquakes and other seismological phenomena throughout New Mexico and the southwestern United States. The network consists of 21 seismometers, located primarily around the Socorro Magma Body and in southeastern NM. Data are streamed continuously to the New Mexico Tech campus and are archived at the IRIS Data Management Center (<http://ds.iris.edu>).

The NMTSO operates as part of the New Mexico Bureau of Geology and also conducts educational outreach activities, coordinating with groups including the New Mexico State Department of Public Safety, the United States Geological Survey, the Incorporated Research Institutions for Seismology, and other state seismic networks. Opportunities for students exist to work directly for the NMTSO conducting routine earthquake location activities, as well as to work on research project collaborations between the NMTSO and the Earth and Environmental Science Department.

Playas Research, Development, Test and Evaluation (RDT&E) and Training Complex

<http://ptrc.emrtc.nmt.edu/>

The Playas Research and Training Center (PRTC), located in the “boothel” of New Mexico, is a “real-world” training center for programs in prevention and response to suicide bombings, terrorist activities, and other law enforcement and security related programs. Playas is used for simulations of urban warfare, emergency preparedness drills, anti-terrorism training, military operations training in urban terrain, hostage negotiation training, Small Unmanned Aircraft Systems (sUAS) applications, and other law enforcement and defense initiatives.

The U.S Department of Homeland Security (DHS) is the longest standing funder of training activity at Playas. Other federal, state, local, and tribal government agencies, as well as private industry, are also regular clients for research, development, and training initiatives.

Student Academic Support

Joseph R. Skeen Library

www.nmt.edu/library/

The Joseph R. Skeen Library's collection and services support the educational, research, public service, and economic development mission of New Mexico Tech. The library maintains a collection of over 1.1 million eBooks and printed books, maps, government documents, and periodicals. A majority of the items in the library's collection are digital and accessible 24/7 through the library's website. The library also works to protect its users' right to privacy, supports intellectual freedom, and upholds intellectual property rights.

Housed in an attractive, three-story building with a prominent clock tower, the Skeen Library actively works to provide a safe, welcoming, and friendly environment. Food, drink, and talking are all allowed in the library, which is open 96 hours a week- and at reduced hours during the Covid-19 pandemic. When the Skeen Library is not under health restrictions it typically provides a free coffee bar; seven reservation available study rooms and other study rooms; a presentation seminar room; a variety of flexible technology-equipped group study areas; a computer lab; a popular DVD collection; and a popular reading collection. The library provides the general public with free access to Internet connected computers and WiFi Internet connections, as well as having 40 computers dedicated only for student use.

The library provides inter-library loan services to students and faculty members allowing access to the collections of over 75,000 libraries worldwide. Students and faculty who wish to visit other libraries may also request Passports to attain borrowing privileges at other university libraries in New Mexico.

The library is the custodian of archival materials relating to the history of New Mexico Tech (previously known as The New Mexico School of Mines); an extensive map collection; a historical microform collection of Socorro newspapers; an comprehensive collection of historical geologic and mining materials; the President Workman Papers; and the personal library of the late U.S. Representative Joseph R. Skeen.

To learn more about the library and its staff and services, please visit our website at www.nmt.edu/library/

Information Technology and Communications Center (ITC)

www.nmt.edu/itc/

The ITC is open to students, faculty, and staff while classes are in session. Students in all disciplines are encouraged to use the facility as a normal part of their course work. The center provides computer access to any regularly New Mexico Tech matriculated student who requests it, subject to ITC regulations and the New Mexico Tech Computer Usage Policy. Each ITC user is given an e-mail address and access to the Internet, as well as an initial storage space. The ITC has a wide range of scientific software available.

ITC operates a network of Linux, Macintosh, and Windows workstations. At the time of publication, there are more than 300 workstations, all equipped with color screens, on the academic network. In addition, there are PC labs connected to a Samba server on the campus network. There are also several computer classrooms with computers and integrated projection systems. Several labs have scanners, and all are connected to the network printing system.

The campus network is connected to the National Science Foundation Internet II nationwide computer network. The network connection gives Tech access to other New Mexico colleges, Sandia and Los Alamos national laboratories, and thousands of other sites worldwide.

In addition to the facilities found in the ITC there are many other computer systems on campus used in conjunction with departmental programs and funded research.

The ITC is an integral part of major research projects at Tech. Students and faculty who desire to use of the facilities are encouraged to contact the director of the center at 575.835.5735 or via e-mail at help@nmt.edu.

The TCC also offers free classes each semester to acquaint students with how to use the TCC and the World Wide Web.

Distance Education/ Academic Center for Technology

www.nmt.edu/act/

New Mexico Tech's Distance Education program provides live, web-based courses that allow students to participate via video and audio with instructors and other students from anywhere in the world. Tech's distance program is unique in that remote students are part of a regular class being offered on campus in one of Tech's many multimedia-enabled classrooms.

The Adobe Connect platform lets distance students see and hear everything that on-campus students can see and hear and lets them participate from desktop computers as well as most mobile devices. Using this approach, students can earn graduate degrees in Hydrology, Mechanical Engineering, Engineering Management and a Certificate in Hydrology.

Tech also offers a master's degree in Science Teaching using recorded courses and some live online and in-person courses. All distance education courses make use of Tech's learning management system, Canvas. Distance education students are charged a

fee of \$350 per course. Students need only access to a computer or mobile device with a relatively fast connection to the Internet. Some instructors require students to have a webcam and microphone.

The Academic Center for Technology, which manages distance education at Tech, operates a growing number of technologically enhanced classrooms around campus that can be used for distance education, videoconferencing and remote speakers. Distance students must be admitted to the university to take distance education courses. Admission and registration can be handled online.

For more information on the Distance Education Program, call the Academic Center for Technology at 575-835-6700 or email at act@nmt.edu. Information and course listings can be found on the ACT web site at <http://act.nmt.edu>.

New Mexico Tech Community Education

www.nmt.edu/ce

The New Mexico Tech Community Education Department provides credit and non-credit enrichment courses in Physical Recreation, Fine Arts, Lifestyle Activities, general Community Education, and Certification programs. Courses are open to New Mexico Tech students, faculty, and staff and the surrounding community. No degrees are offered through the Community Education Department.

Community Education course prefixes may be found on Banweb class schedules with the following prefixes:

- CED (Community Education Non-Credit)
- CERT (Certification non-credit)
- ARTH (Fine Arts)
- LIFE (Lifestyle non-credit)
- PHED (Physical Recreation)

Community Education classes, which are signified by a "C" following the course number, are graded on an S/U basis and can be used as elective credit in most majors. Community Education credit classes do not count towards Core General Education requirements. The Community Education Department also offers non-credit courses such as Wine Tasting, and cooking classes..

Full-time undergraduate students do not pay extra tuition when these courses are part of their 12-18 hour course load. Graduate students may enroll in a limited number of Community Education classes to supplement their full-time course load on approval from the Graduate Office. Full-time graduate students may enroll for 1 credit of Community Education coursework beyond their 12 hour credit limit, at no extra charge (see graduate catalog for restrictions).

Students who are not pursuing a degree program, such as community members or staff, are classified as special students. They are limited to a maximum of six credit hours per semester. Special students who have never taken a class at Tech need to complete an Application for Admission Form from the Admission Office or the Graduate Office if they possess a higher education diploma. After being admitted, students need to register for the class at the Office of the Registrar.

A great deal of information may be found at the department website at www.nmt.edu/ce including downloadable catalogs with course descriptions. To speak with someone about Community Education, please visit the offices in Fidel 288 or call 575.835.6581.

Office for Student Learning (OSL)

www.nmt.edu/osl

The Office for Student Learning, located in the Joseph Skeen Library, is a nexus for student academic support initiatives and includes the following services:

One on One Tutoring, Homework Help, Group Work and Moral Support

The OSL offers drop-in peer tutoring and homework help for most undergraduate classes. Additionally, the OSL works with several of the academic departments to provide ways for students to rework test problems for better comprehension. Students looking for extra help with an assignment, seeking deeper understanding of a challenging subject, or wanting to join a study group are encouraged to contact the OSL team. Through Summer Semester the services are virtually offered. It is hoped that in person services will return sometime during Fall Semester 2021. Learning Coaches work together to provide a welcoming environment with resources for academic success.

Academic and Professional Development Workshops

The OSL hosts workshops that complement academic coursework, with the goal of providing students with additional skills for academic success and for future professional careers in science and engineering. Workshop topics have included MATLAB, LATEX, Excel, Reading and Retention, Building a Competitive Resumé, Applying for Internships and REU Programs, and more.

Peer Mentoring

Peer Mentor Services are provided at this time using a Discord Platform for first year and transfer students. Students are invited to join the program, and are given a link to the Discord Platform. Mentors make contact with their Cohort Groups, and are able to support new students with information, programming tips, conversations on being at NMT, and a supportive ear.

The Writing and Communication Lab (WCL)

Located in Skeen Library, the WCL assists both graduate and undergraduate students with many forms of writing, including essays, technical papers, resumes and everything in between. The WCL also assists with oral presentations and research posters. The WCL offers both in-person tutoring and online tutoring during the fall and spring semesters, with hours and further information online at www.nmt.edu/academics/class/center.php Services are free.

Academic Advising

Academic advising is one of the most important keys to a student's success. Academic advising provides the student with the necessary information about courses and degree requirements, but more importantly, the academic advisor serves as a mentor as the student explores the discipline and develops his or her professional identity.

The advising system is designed so that:

- Each student is assigned a faculty advisor from the major department.
- Each student works with his or her academic advisor each semester to plan the next semester's courses. The advisor must approve the selected coursework and sign the registration form or provide the student with an alternate pin (APIN) to register in Banweb.
- Students seeking to minor in a subject must obtain a faculty advisor for the minor.

Undergraduate Advising

The advising system is designed so that:

- Students who have not declared a major are assigned a faculty advisor in one of several academic departments until the student decides upon a major.
- Advisor/Major changes are also initiated in the Office of the Registrar
- It is the responsibility of the student, in cooperation with the appointed academic advisor, to arrange programs so as to satisfy the common requirements for all bachelor's degrees and the specific requirements of the major department.

Graduate Advising

The advising system is designed so that:

- Each student is assigned a faculty advisor from the major department. Your academic advisor must be a regular (tenure-track or emeritus) faculty in your home department. Your academic advisor may or may not be the same as your research advisor. The default advisor assigned by the department upon graduate admission may be changed when you designate your committee in Banweb.
- Each student works with his or her academic advisor each semester to plan the next semester's courses. The advisor must approve the selected coursework and sign the registration form or provide the student with the alternate pin (APIN) to register in Banweb.
- Students seeking to minor in a subject must obtain a faculty advisor for the minor.
- It is the responsibility of the student, in cooperation with the appointed academic advisor, to arrange programs so as to satisfy the common requirements for all graduate degrees and the specific requirements of the graduate program.

Advisor/Student Responsibilities

The Academic Advisors and the students are expected to develop a professional and confidential partnership to foster a collaborative advising process leading to success at New Mexico Tech. The following is a list of responsibilities both for the Advisor and student to be mindful of to effectively facilitate this partnership.

Advisor Responsibilities

- Assist students with developing a realistic educational plan that is consistent with their career path.
- Monitor and document student progress toward program completion.
- Maintain student advising files.
- Review a student's eligibility to engage in a registered Internship/Module Abroad/Exchange Program.
- Inform and/or refer students to resources, services, and opportunities to enhance their learning experience.
- Treat students with courtesy, dignity, and respect.
- Uphold the integrity of New Mexico Tech by enforcing all school and department policies and procedures.

Student Responsibilities

- Read the Catalog and become knowledgeable about and adhere to institutional policies, procedures, and requirements.
- Clarify personal values, abilities, career interests, and goals.
- Make an appointment with an Advisor when required or when in need of professional advising.

- Notify an Advisor when you cannot make your appointment.
- Prepare for your advising session and bring appropriate materials.
- Follow through on actions identified during your advising session.
- Accept final responsibility for all decisions.
- Attend and participate in courses, workshops, advising seminars, etc.
- Meet with an Advisor to determine eligibility for an Internship/Module Abroad/Exchange Program.
- Obtain the necessary visa documents to travel to other countries.

Academic Counseling

Office of the Associate Dean for Student Success

Contact : Elaine DeBrine Howell, MA , LPCC
 Associate Dean for Student Success
 Email: Elaine.debrinehowell@nmt.edu

The Office of the Associate Dean for Student Success provides many services to assist students in succeeding academically at New Mexico Tech, including:

Academic Success Planning :Academic counseling with a focus on identification of academic strengths, learning style preference, goal setting and navigating university policies and procedures

Degree planning—assistance with informal degree audits, understanding degree requirements and departmental policies, informal academic advising

Grade Extension Agreements-- At the instructor's discretion and in the case of extenuating circumstances, additional time may be given to a student to complete additional work and/or exams in a course after the final grade is submitted. The grade extension agreements are monitored by the Associate Dean for Student Success.

Early Intervention :Academic Referral Program—process designed to identify students who are experiencing academic difficulty with the aim to assist them with those emerging problems before they become insurmountable. The teaching faculty is asked to refer students to the Associate Dean for Student Success beginning in the 3rd week of the semester.

Typical issues of concern:

- 1.Absences/lateness
- 2.Missed homework, quizzes or tests
- 3.Poor performance on homework, quizzes or tests
- 4.Inappropriate classroom behavior
- 5.Change in behavior
- 6.Any other concern you may have

Academic Warning Program — the program allows all undergraduate students whose cumulative or semester GPA falls below 2.0 the opportunity to identify and rectify obstacles to their academic success. Students on warning work with their academic advisor to complete an Academic Success plan that is reviewed and approved by the Academic Standards and Admissions Committee. A registration hold remains on the students' account for the duration of the warning semester.

Additional Support:

- 1.Academic Advising for Dual Credit and Special Undergraduate students
- 2.New Faculty Advisor Training
- 3.TA training
- 4.Macey Scholars Program Advisor
5. Fulbright Scholar Program Advisor

Student Affairs

The goal of the Office for Student Affairs is to help Tech students succeed in college and in their post college endeavors. The Office for Student Affairs includes The Office for Career Services, The Office for Minority Programs, Office for Diversity/Equity and Inclusion and The Office for International Programs. Staff is available to provide students with information and advice on resume writing, developing interviewing skills, and preparing for the biannual Career and Graduate School Fair. Students may apply to study abroad, find Co-op and internship opportunities, and find ethnic related scholarships. All students will find access to resources that promote a just, equitable and holistic approach to education. Located in the Joseph A. Fidel Center Suite 262, offices are open 8 a.m. to 5 pm daily.

Career Services

The Office for Career Services provides career counseling; resume, cover letter, and interviewing skills assistance; and listings of permanent, temporary, on-campus, internship, fellowship, and research positions. The Office for Career Services is responsible for Career Fairs, the Cooperative Education program, maintaining placement records, sponsoring workshops on aspects of graduate school and job search processes, and providing assistance to employers, including scheduling information sessions and on campus interviews. Information is available at <https://www.nmt.edu/studentaffairs/careerservices/index.php>.

Cooperative Education Program

The Cooperative Education/ Internship Program is a three-way partnership among the employer, the student, and NMT. The program is designed to provide experienced based learning to New Mexico Tech students through employment in practical, curriculum-related work assignments structured to meet students' interests, abilities, and aptitudes while meeting employers' staffing needs. Information is available at <https://www.nmt.edu/studentaffairs/careerservices/index.php>

Counseling Services

The Office of Counseling and Disabilities (OCDS) is located in the Joseph A. Fidel Center and is open weekdays from 8 a.m. to 5 p.m. OCDS provides students with individual and couples counseling, outreach programs, consultation and crisis intervention. We adhere to the Code of Ethics of the New Mexico Board of Clinical Mental Health Counselors. All services are strictly confidential and are free to students enrolled at NMT.

To schedule an appointment, email counseling@nmt.edu or call (575) -835-6619. Please fill out the Counseling Intake form before your appointment; it can be found on our website at www.nmt.edu/cds/counseling.php

For after hours emergencies please contact Campus Police at 575-835-5434.

Disability Services

Disability Services arranges academic accommodations for students who have documented disabilities that affect their ability to participate on an equal basis with students who do not have disabilities. Students with sensory, mobility, learning, psychological, or other recognized disabilities are encouraged to contact this office to assist with accommodations. The office is located in the Joseph A. Fidel Center and is open from 8 a.m. to 5 p.m. weekdays. Students are encouraged to request services well in advance of the start of the semester to allow adequate time to make needed arrangements. Students must provide current documentation to be eligible for accommodations. New Mexico Tech is committed to ensuring that the campus is accessible to all individuals.

Multicultural Programs

The Office for Multicultural Programs supports student chapters of the American Indian Science and Engineering Society (AISES) and the Society of Hispanic Professional Engineers (SHPE), as well as administer the Louis M. Stokes Alliance for Minority Participation. The Office for Multicultural Programs works to provide academic and financial support as well as providing information about opportunities within and outside NMT. The Office for Multicultural Programs is housed in the Office for Student Affairs on the second floor of the Joseph A. Fidel Center, Suite 262. <https://www.nmt.edu/studentaffairs/multicultural/index.php>

International and Exchange Programs

The Office for Student Affairs is responsible for International and Exchange Programs. The office provides advice and compliance to international students, especially with regard to visa-related matters. It also coordinates activities, both on and off campus, designed to help students from other countries make the transition to living in the United States and Socorro. These activities include orientations, international receptions, and Global Village Day.

In addition, the office maintains information about study abroad opportunities in other countries, coordinates Tech's student exchange program with a number of foreign universities, and participates in the New Mexico International Education Consortium. www.nmt.edu/studentaffairs/intlprograms/index.php

Student and Campus Life

Residential Life <https://nmt.edu/reslife/>

Residential Life is centrally located on the 2nd floor of Joseph A. Fidel Student Services Center (Fidel). During normal University business days, Residential Life is open between 8am and 5pm, Monday-Friday. You can contact us at 575.835.5900 or by email at residential_life@nmt.edu. After-hours, an on-call housing professional can be reached for urgent matters by contacting the Campus Police Dispatcher at 575.835.5434. Residential Life is one of many operations within Auxiliary Services, a department of the University Student and Relations Division.

New Mexico Tech housing consists of six traditional residence halls and three student apartment complexes. All are within walking distance to classrooms, labs, the computer center, child care, research facilities, food service, and the bookstore. If you are a regular, full-time student, you are eligible to live on campus. Four halls – Driscoll, Presidents, West, and South – sit on Tech’s tree-lined Campus Drive, close to the gym, Joseph A. Fidel Student Center, the athletic field, Student Activity Center, swimming pool, and tennis courts. Torres Hall, Baca Hall, and Altamirano Apartments and Desert Willow fall on the south side of campus. Mountain Springs Apartments are on the corner of Bullock Boulevard and El Camino Real, just two blocks from the Library.

If you live on campus, you are expected to abide by Residential Life rules and procedures, which are found in the Room and Board Agreement, and the *Community Standards for Residence Halls* webpage: <https://nmt.edu/reslife/docs/COMMUNITY-STANDARDS.pdf>

Dining and Meal Plans <https://nmt.edu/reslife/dining.php>

Dining Possibilities at New Mexico Tech

Dining at New Mexico Tech is a great aspect to living on campus. Chartwells, our food service provider, continually strives to improve the dining services to students at New Mexico Tech. We have several meal plan options available to our residents and student population. Every student who lives in a residence hall must purchase a meal plan and there are many options available sure to fit your needs.

The New Mexico Tech food service operations are located on the ground floor of the Joseph A. Fidel Center, and include the main dining room and Fire and Ice coffee shop. Both are operated by Chartwells, a division of the Compass Group. The main dining room features a variety of stations with food options ranging from international cuisines to burgers and fries to home style cooking. Special events and theme meals are offered on a regular basis. For more information about dining and specific meal times, please visit the Chartwells website <http://www.dineoncampus.com/nmt/>.

It is mandatory for all undergraduate residents to purchase a meal plan. The size of the meal plan required depends on the student's living arrangements. The number of meals in a meal plan are for an entire semester. Meals remaining at the end of the semester cannot be carried over to the next semester. No refunds will be given for meals not eaten. Tech dollars work like cash and are accepted at the Fire and Ice coffee bar, which is just outside the dining room on the ground floor of Fidel. For more information about meal plan choices, please visit our webpage: <https://nmt.edu/reslife/dining.php>

Children’s Center

The New Mexico Tech Children’s Center offers full-time and part-time quality and developmentally appropriate education and care for children of New Mexico Tech students and employees, as well as community members. Our staff has an uncompromising commitment to excellence. The Children’s Center equally places a high priority on responsiveness and close working relationships with each child and family. We offer a relaxed and casual setting for children ages two through six in our two preschool classrooms. The program in these rooms focuses on active learning and social engagement to build appropriate skills and knowledge in young children. We also have after school care for children attending the public schools in grades kindergarten through fourth grades. Our Center is open year-round, from 7:30 a.m. to 5:30 p.m., Monday through Friday with the exception of New Mexico Tech holidays/closures. Please contact the Children’s Center at 575.835.5240 or Darlene.sanchez@nmt.edu, or visit the Center located on Olive Lane next to Macey Conference Center for more information.

Student Health Center

The Health Center is a convenient and confidential way to meet the health needs of Tech students. The medical staff provides primary medical care, which includes history taking, physical examination, and lab testing as needed for both acute and chronic health problems. The nurse practitioner can diagnose, prescribe and provide treatment. Medical care outside the center’s scope of practice will be referred to a physician, nurse practitioner or registered nurse.

Office of Communications

The Office of Communications provides services to help students, employees and local residents find out what is happening on campus, market the university and its research divisions, improve the university’s web presence, manage and direct social media and serve as the main contact point for media outlets.

Students and employees are encouraged to sign up for the weekly e-newsletter, which emailed every Tuesday morning. Visit www.nmt.edu/nmt-calendar and enter your name and email address on the left-hand column to opt-in to the e-newsletter,

The Tech calendar on the web covers events, academic dates and other important items for the next few years. Visit www.nmt.edu/nmt-calendar to view the calendar. On the calendar page, users can enter new events via the “Add Event” button at the top of the page. The Office of Communications serves as the calendar moderator; new items will appear on the calendar once they are edited and approved.

Student Government Association

Students at New Mexico Tech assume important responsibilities for the regulation of their affairs. The Student Government Association provides opportunity for students looking to improve their leadership skills as well as to be more involved with the New Mexico Tech campus. The Student Government Association is made up of three branches; Executive, Legislative, and Judicial. The Executive Branch includes the President, Vice President, Chief Financial Officer, Student Activities Director, Student Activities Chair Director, and the Pay Dirt Editor and Chief. The Judicial Branch includes the Chief Justice and a minimum of two justices. The legislative branch is the governing body of the Student Government Association which is also the Student Senate, whose members are elected twice a year for one-year terms. The Student Senate regulates extracurricular activities, organizations, campus /community events, appropriating money, voicing student concerns, and improving student life on campus. The Senate carries out its functions through the creation of its own committees, and its deliberations are open to all students and other interested persons. Any enrolled student may serve in the Senate if properly elected and any student may participate in the Student Government Association through volunteering or other friendly means.

The Graduate Student Association (GSA) is comprised of all enrolled graduate students who have paid the Student Activity Fee. The GSA represents graduate students on policy-making committees, including Graduate Council, Faculty Senate, and the Student Association. The association works with the administration to address issues relating to graduate student life at Tech. They award travel grants for graduate students to present research at professional meetings and provide for extracurricular activities for graduate students and their families. The governing body for the GSA consists of officers and representatives from each department.

Physical Recreation

The Physical Recreation Department offers opportunities to experience personal growth, social development, improve physical and mental health, and to develop lifetime leisure skills for a healthier lifestyle by promoting recreational activities, intramural sports, and competitive and non-competitive club sports to the Tech community.

A number of Physical Recreation courses are offered for credit, such as yoga, basketball, soccer, bootcamp, spin, golf, zumba, belly dancing, and many more. In addition, Physical Recreation maintains a fully-equipped weight room including free weights, multi-gym, various strength machines, treadmills, elliptical cross trainers, upright bikes, recumbent bikes, rowing machines, and stairmasters. The Tech community, with a valid student, faculty or staff identification card, may use this facility at no charge.

Physical Recreation also oversees a number of club sports, including air rifle shooting, biking, caving, climbing, golf, Frisbee, soccer (men’s and women’s), paintball, rugby, and co-ed volleyball. Rugby and soccer belong to regional leagues and compete against off-campus teams. Equipment for backpacking, canoeing, camping, volleyball, and other recreational activities can be borrowed from the gym. Other recreational facilities on the Tech campus include an outstanding 18-hole golf course and a year-round swim center. There are groups in the Socorro area that hold regular events in running and mountain-biking. Many members of the Tech community participate in these.

Social and Cultural Activities

The **New Mexico Tech Performing Arts Series (PAS)** presents a wide variety of entertainment at Macey Center on the NMT campus, free to regular NMT students. Shows may include world beat, Celtic, classical, Cajun, Latin, swing, jazz, blues, folk and bluegrass music; theatre; dance; cirque, acrobats, juggling, magic, comedy and more! PAS events are a great way to spend an evening with friends or family, see professors in a social setting, and to experience an amazing array of national and international touring performers. PAS also offers student work experiences in promotion, marketing and graphic design, as well as opportunities for NMT student clubs to garner volunteer hours and/or helping with PAS community-wide events such as Socorro Fest, Community Arts Party and 4th of July Celebration. Participating in Arts & Events is a great break from academics, food for the soul!. The Student Association funds various Tech clubs.

Socorro and New Mexico

Socorro is a friendly community of over 9,000 people, located in the sunny Rio Grande valley 75 miles south of Albuquerque. The main industries in Socorro are education, research, and tourism, with the largest employers being New Mexico Tech and the National Radio Astronomy Observatory.

Outdoor activities abound in the area. The nearby Magdalena Mountains and the slightly farther Gila Wilderness Area offer hiking, camping, rock climbing, fishing, hunting, and many other activities. Developed downhill ski areas are as close as Albuquerque and include Ruidoso, Cloudcroft, Santa Fe, Red River, Angel Fire and Taos (all in New Mexico), or Wolf Creek and Durango (in Colorado). Socorro's year-round mild climate is ideal for bicycling, running, golfing, horseback riding, river rafting, and many other pursuits.

Favorite spots to visit in Socorro County include the Bosque del Apache and Sevilleta National Wildlife Refuges, San Lorenzo and Box Canyons, Quebradas Back Country Byway, the Very Large Array and El Camino Real Historic Trail Site. Favorite festivals include SocorroFest (October), 49ers (October), and Festival of the Cranes (November).

There are a variety of excellent and fun restaurants in Socorro offering everything from casual fare to fine dining.

In addition to outdoor activities, cultural amenities are also available nearby. Albuquerque offers restaurants, museums, music, theater, and many other cultural activities. Farther north, Santa Fe is a major art center. Truth or Consequences to the south is known for its hot springs. The entire state, with its long, colorful history is an enchanting place to live and to explore.

Socorro has a pleasant, sunny climate year-round. Average rainfall is about 10 inches per year, and there are occasional brief winter snows.

Student Clubs and Activities

A host of student clubs, organizations, and activities flourish at Tech. These are as broad as student interests themselves, including:

Performance Groups

- Aditi Natesa (Belly Dance)
- Chorus
- Drama Club
- Jazz Band
- Orchestra
- Spring Musical

Club Sports

- Airsoft
- Badminton
- Biking (mountain)
- Caving
- Chinese Martial Arts
- Climbing
- eSports
- Golf
- Laser Tag
- Paintball
- Rugby: Men's & Women's
- Running
- Shooting (air rifle)
- Soccer: Men's & Women's
- Street Hockey
- Taekwondo
- Tennis
- Ultimate Frisbee
- Volleyball: Co-Ed

Games

- Adventurers' Guild
- Billiards Club
- Chess Club
- League of Legends Club
- Smash Club

Just for Fun

- Anime Addicts

- Aquatic Recreation
- Ballroom Dance Club
- Bladesmithing Club
- Karaoke Klub
- Fishing Club
- KTEK (student radio station)
- Motorsport Club
- Paydirt (student newspaper)
- Robotics Club
- Society for Creative Anachronism
- Tech Amateur Radio Association

Professional Associations

- American Association of Drilling Engineers (AADE)
- American Chemical Society (ACS)
- American Indian Science and Engineering Society (AISES)
- American Institute of Aeronautics and Astronautics (AIAA)
- American Institute of Chemical Engineers (AIChE)
- American Institute of Professional Geologists (AIPG)
- American Society of Civil Engineers (ASCE)
- American Society of Mechanical Engineers (ASME)
- Association for Computing Machinery (ACM)
- Biomedical Engineering Society (BMES)
- Engineers Without Borders (EWB)
- Institute of Electrical and Electronics Engineers (IEEE)
- International Society for Optics and Photonics (SPIE)
- International Society of Explosives Engineers (ISEE)
- Society of Automotive Engineers (SAE)

- Society of Economic Geologists, student chapter (SEG)
- Society of Hispanic Professional Engineers (SHPE)
- Society of Mexican American Engineers and Scientists
- Society of Technical Communication (STC)
- Society of Women Engineers (SWE)
- Society for the Advancement of Chicanos and Native Americans in Science (SACNAS)
- Tau Beta Pi, Engineering Honor Society
- Tri Beta, Biology Honor Society

Department Clubs

- Astronomy Club
- Cooney Mining Club
- Culinary Diplomacy Club
- Environmental Engineering Club
- Geology Club
- Materials Club
- Physics Club

Social Organizations and Clubs

- American Association of University Women
- Alpha Sigma Kappa (ASK) Sorority
- Council for Climate (CFC)
- Japanese Club
- Kappa Sigma Fraternity
- NMT Democrats
- QuASAR Club
- Socorro Search and Rescue
- Students of Goliath (SCA)
- Tea Club
- Techies Stand Up
- Christian Challenge
- Newman Center
- New Mexico Tech Intervarsity Fellowship (IV)

The Undergraduate Program

At New Mexico Tech, the undergraduate program has two principal objectives:

- 1) to provide a strong general education in:
 - a) the humanities and social sciences, and
 - b) the basic sciences and mathematics; and
- 2) to offer specialization appropriate to a chosen major field of interest.

The General Education Core Curriculum, the requirements common to all bachelor of science degrees, is listed on page 78. Specific requirements for each major are listed under the academic department concerned. It is your responsibility to work out with your advisor a program that meets both the general and specific requirements. In some instances, wide flexibility is allowed in choosing electives; in others, the choice of electives is somewhat restricted.

Accelerated Master's of Science Programs

New Mexico Tech offers programs that allow students capable of above-average academic achievement to earn both a bachelor's and master's degree in five years.

Opportunities are available for students majoring in Biology, Computer Science and Engineering, Electrical Engineering, Environmental Engineering, Hydrology, Materials Engineering, Mathematics, and Physics through their major department.

Research Opportunities

Tech has a wealth of research projects on campus, many of which employ students for pay or class credit. Since over 99 percent of our faculty have Ph.D.s and conduct research, many professors hire undergraduate students to assist them. In addition, Tech has several divisions dedicated to research.

Study Abroad Opportunities

Arrangements for all types of study abroad are made through the Office for International Programs (Fidel 262). To be eligible to apply for participation, students must, at a minimum:

- have been a full-time,
- degree-seeking student at Tech for at least one year,
- have completed at least 30 credit hours at Tech,
- have a cumulative G.P.A. of at least 2.5,
- be in good academic standing,
- have a clean disciplinary record,
- and be in good financial standing.

International Student Exchange

New Mexico Tech has exchange agreements in place with multiple universities, allowing students to study in various countries around the world. Information about these opportunities is available in the Office for International Programs (Fidel 262).

International Exchange through NMIEC

Through the New Mexico International Education Consortium, students at any of New Mexico's public universities may gain access to study abroad programs available at other New Mexico universities. Students who participate in study abroad through NMIEC will pay tuition and fees to the New Mexico host university, not to New Mexico Tech.

Undergraduate Student Status

Regular Students

Undergraduate students who are pursuing a degree program are classified as regular students. Full-time regular students are those who enroll for 12 or more credit hours during the fall and spring semesters; part-time regular students are those who enroll for fewer than 12 credit hours. (This designation does not apply to graduating seniors.) These students shall be subject to the following:

- Part-time students will be eligible for financial aid only in proportion to their course loads and will be subject to restrictions imposed by federal and/or state guidelines.
- In order to maintain satisfactory progress and remain in good standing, the part-time student must meet the same standards as full-time regular students.

Classification of Regular Students

Undergraduate students are classified by the number of credit hours they have completed:

| | |
|-----------|---------------------------|
| Freshman | 0 to 29 credit hours |
| Sophomore | 30 to 59 credit hours |
| Junior | 60 to 89 credit hours |
| Senior | 90 credit hours and above |

Special (Non-Degree) Students

Students who are not pursuing a degree program are classified as special students. While special students are free to choose a program best suited to meet their individual needs, they are expected to meet the prerequisite or corequisite requirements for a course. Special undergraduate students may enroll for no more than six credit hours per semester. Special students must change to regular status in order to graduate.

Transfer Students

Students in good academic standing at other colleges and universities (2.0 minimum GPA) are eligible for transfer admission to New Mexico Tech. Credits taken at another institution will be evaluated and transferred on a course-by-course basis. See transfer section for information on how to apply for admission and transfer of credit.

Veterans

The Veterans Administration requires students on the GI Bill to carry a minimum of 12 credit hours (6 credit hours in summer) to qualify for full benefits. The minimum credit hours must apply toward the student's degree requirements. Physical Recreation (PHED), Fine Arts (ARTS), and Community Education (designated by the letter "C" in the course number) courses do not count toward the minimum credit hours for veterans.

If, for some reason, the student desires to drop a course during the semester that would bring the load below 12 credit hours, permission must first be obtained from the student's academic advisor. NMT's VA Representative must be notified that the student is dropping from full-time enrollment at the time the change of program card is returned to the Office of the Registrar.

Further information can be obtained from the VA Representative, located in the Office of Registrar Office, Fidel 288

In accordance with Title 38 US Code 3679(e), this educational institution adopts the following additional provisions for any students using the U.S Department of Veterans Affairs (VA) Post 9/11 G.I Bill® (Chapter 33) or Vocational Rehabilitation & Employment (Chapter 31) benefits, while payment to the institution is pending for VA.

This educational institution will not:

- Prevent the student's enrollment;
- Assess a late penalty fee to the student;
- Require the student to alternative or additional funding;
- Deny the student access to any resources (access to classes, libraries, or other institutional facilities) available to other students who have satisfied their tuition and fee bills to the institution.

However, to qualify for this provision, such students may be required to:

- Produce the student's enrollment;
- Provide a written request to be certified;
- Provide additional information needed to properly certify the enrollment as described in other institutional policies.

GI Bill® is a registered trademark of the U.S Department of Veterans Affairs (VA). More information about education benefits offered by VA is available at the official U.S. government website at <https://www.benefits.va.gov/gibill>

Change of Student Status

Special to Regular Status

To change from special to regular student status, the student must meet all regulations governing regular admission and must submit an *Application for Undergraduate Admission and Scholarship* through the Office of Admission. Students admitted under special status, who do not otherwise qualify for regular admission, may apply to the Office of Admission for regular status after successful completion of 30 credit hours at Tech.

Regular to Special Status

A regular student who is no longer pursuing a degree program may petition to change to special student status at the Office of the Registrar.

Summary of Undergraduate Admission Policies

The following is a summary of undergraduate admissions standards and policies. If you have not applied for admissions, please use the application forms available on the Web at <https://www.nmt.edu/admission/>. The admissions team is standing by to assist you.

New Mexico Tech seeks to admit students who have demonstrated, through previous education, aptitude tests, and interests, that they are qualified to complete a degree. Tech subscribes to the National Association for College Admission Counseling's *Statement of Principles of Good Practice*. All official documents sent to New Mexico Tech become the property of the college and will not be returned, nor can copies be provided to entities other than the student. Application forms are also available on the Web at <https://www.nmt.edu/admission/>

Regular Admission

Freshmen Admission Requirements

First-time, entering students must meet the following minimum admission requirements:

1. The student must be a graduate of an accredited high school with a minimum grade-point average (GPA) of 2.5 (on a 4.0 scale) in high school course work or have passed the general equivalency diploma (GED) examination with an average score of 500 or greater or achieve a HiSet combined score of 75 or greater to demonstrate College and Career readiness. 2. The student must have successfully completed the following high school courses (one unit equals one year of high school study):

- English—a minimum of four units with at least one unit earned in composition at the junior or senior level.
- Science—a minimum of two units of sciences, with laboratories, chosen from among biology, physics, chemistry, and earth science.
- Mathematics—a minimum of three units chosen from among Algebra I, Algebra II, Geometry, Trigonometry, or higher mathematics. Pre-calculus and calculus are recommended.
- Social Science—A minimum of three units, one of which must be history.

A student who does not meet all of these requirements may apply, but must justify any deficiencies through correspondence to the Office of Admissions.

2. The student must submit official ACT, Inc. (formerly American College Test) or SAT (Scholastic Aptitude Test) score reports. Normally, an ACT composite score of 21 or higher or a combined SAT Critical Reading and Math score of 970 or higher is required. (New Mexico Tech does not use the Written Essay portion of the SAT.) Experience has shown that a student whose scores are below these levels will encounter difficulty with the rigorous academic curriculum at Tech. (Recent ACT scores for entering freshmen averaged 26; SAT, 1080.) ACT and SAT scores are also used for course placement and advising purposes. ACT/ SAT scores are not required nor required for adult learners over the age of 23.

Procedure

To be considered for admission, an entering freshmen applicant must:

1. complete an *Application for Undergraduate Admission and Scholarship*.
2. provide an official high school transcript.
3. provide official college transcripts, if the student has taken college classes. (Students who have 30 or more college credits will be considered transfer students. See below.)
4. provide either an official ACT Student Profile Report or an SAT College Report.
5. pay a \$15 application fee.
6. Students who do not meet Tech's minimum ACT or SAT requirement but who have taken college-preparatory classes in math and science must submit letters of recommendation from at least two of their high school math and science teachers sent directly to the Office of Admission.

Home-Schooled Students

In order to qualify for admission to New Mexico Tech, the home-schooled student:

1. must supply documentation of courses completed. A minimum grade-point average (GPA) of 2.5 (on a 4.0 scale) in coursework is required. If your GPA is less than 2.5 but you believe you can succeed at Tech, see the section on Appeal of Admission Decisions.
2. must have successfully completed the following courses (one unit equals one year of study):
 - English—a minimum of four units with at least one unit earned in composition at the junior or senior level
 - Science—a minimum of two units of sciences, with laboratories, chosen from among biology, physics, chemistry, and earth science
 - Mathematics—a minimum of three units chosen from among Algebra I, Algebra II, Geometry, Trigonometry, or higher mathematics. Pre-calculus and calculus are recommended.
 - Social Science—A minimum of three units, one of which must be history.
A student who does not meet all of these requirements may apply, but must justify any deficiencies through correspondence to the Office of Admission.
3. the student must submit official ACT, Inc. (formerly American College Test) or SAT (Scholastic Aptitude Test) score reports. Normally, an ACT composite score of 21 or higher or a combined SAT Critical Reading and Math score of 970 or higher is required. (New Mexico Tech does not use the Written Essay portion of the SAT.) Retention data indicate that a student whose scores are below these levels will encounter difficulty with the rigorous academic curriculum at Tech. (Recent ACT scores for entering freshmen averaged 26; SAT, 1080.) ACT and SAT scores are also used for course placement and advising purposes. ACT/SAT scores are not required nor reviewed for adult learners over the age of 23.

Procedure

Home-schooled students must follow the same procedure as entering freshmen (above), in addition, must submit all official academic transcripts and/or documentation of courses completed as well as grades posted in those courses.

Transfer Students

You will be considered a transfer student if you have a minimum of 30 credit hours transfer from an accredited college or university. (If you have fewer than 30 credit hours of transfer credit, follow the Entering Freshman section above.) Students in good academic standing at other colleges and universities are eligible to apply for transfer admission to New Mexico Tech.

Admission Requirements

The minimum admission requirements for a student who is classified as a transfer student are as follows:

1. The student transferring from another college or university must have completed the same high school course work requirements as entering freshmen (either from high school or from equivalent courses taken since high school).
2. The applicant must present college transcripts showing a cumulative GPA of 2.0 or better.
3. The applicant must place in Math 1240 (Pre-Calculus) or higher. See page 33 for math placement information.
4. The student must be in good academic standing at the last institution attended.
5. The student must be eligible to re-enroll at the institutions from which he or she wishes to transfer. An applicant who cannot re-enroll at that institution is not eligible to enter New Mexico Tech.

Procedure

To be considered for admission, an entering freshmen applicant must:

1. complete an *Application for Undergraduate Admission and Scholarship*.
2. May be asked to provide an official high school transcript at the discretion of the Office of admission
3. provide official college transcripts from all colleges attended, selecting all course completed and in progress
4. May be asked to provide an official ACT or Sat student Profile Report if the student has fewer than 30 hours of transfer credit; and
5. pay a \$15 application fee.

If you are deemed academically qualified, then you will receive a letter of admission and the *Acceptance of Admission* form. You must complete this form and return it with the non refundable admission fee of \$50 to the Office of Admission before you are allowed to register for classes.

Appeal

Students who are denied admission may appeal the decision (see page 34).

International Students

New Mexico Tech is authorized under federal law to enroll nonimmigrant alien students.

International Undergraduate Admission Requirements

1. International students must meet the basic secondary-education requirements for entering freshmen:
 - Science: at least two years of science (biology, physics, chemistry, earth science), with laboratory work
 - Mathematics: at least three years, including algebra, geometry, trigonometry, or calculus
 - Social Science: at least three years, one of which must be history
 - Language: at least four years of language instruction in the native or national language
2. The student's grade average must equal at least a GPA of 2.5 on a 4.0 scale.
3. A student whose native language is not English must submit a TOEFL score of at least 76. Information and application forms for this test may be obtained from: The College Board at <https://www.ets.org/toefl>
4. An international student transferring from another post-secondary college or university must have completed the same secondary coursework as required of incoming freshmen. If all application Materials are submitted before the deadline, transcripts from previous institutions will be evaluated for possible credit transfer before enrollment. Evidence of coursework completed at a foreign institution must be accompanied by course descriptions from that institution, in English.

International Undergraduate Application Procedures

All documents should be sent to International Undergraduate Admission, Student Affairs. You must:

- Complete an *International Undergraduate Application*, available online at
- https://apply.nmt.edu/register/application_undergrad_admission Provide a credentials evaluation of all required academic documents compiled by an independent academic credential evaluation provider. New Mexico Tech International Undergraduate Admissions requires that all applicants use World Education Services for this service and we recommend that you review the Frequently Asked Questions listed on the WES website. You may apply for this evaluation online at www.wes.org. WES requires a fee from the applicant for processing applications. You do not need to have any documents sent from your international institution to New Mexico Tech. Your documents will go to WES, and New Mexico Tech will receive a copy of the original documents along with the evaluation. High school/Secondary school applicants should request a Document-by-Document report; college transfer applicants must request a Comprehensive Course-by-Course Report.
- If you are applying to New Mexico Tech from a U.S. institution, make sure official academic records (transcripts, mark sheets, exam results) are sent by the school you attended directly to International Undergraduate Admission, Student Affairs.
- If English is not your native language, submit an official TOEFL score.
- Send a \$15 application fee.
- Complete the *Certificate of Financial Responsibility* (available at www.nmt.edu/international-undergraduate-bs-degree-admission-requirements) showing adequate funds for at least the first year of study plus evidence of continuing ability to fund the remainder of your program.
- Supply proof of all funding listed on the *Certificate*.

Appeal

Applicants denied admission may appeal the decision to the Academic Standards and Admission Committee.

Application Deadlines

Application files must be complete (all required documentation received) by:

- May 1 for fall semester
- October 1 for spring semester

If academically qualified, you will receive a letter of admission and the *Acceptance of Admission* form. You must complete this form and return it with the non-refundable admission fee of \$50 in order to complete the admission process.

Medical Insurance

International students are required to show proof of medical insurance coverage before registration each semester. Specific requirements for students entering on J1 visas are explained at the time of admission.

Special Students (Undergraduate)

New Mexico Tech accepts, on a special basis, part-time undergraduate students (for a maximum of six credit hours per semester) who are not pursuing a degree program. International students in F or J status must be regular and full-time (not special or part-time) students.

New Mexico Tech accepts, on a special basis, part time undergraduate students (for a maximum of six credit hours per semester) who are not pursuing a degree program. International students in F or J status must be regular and full-time (not special or part-time) students.

Applicants for special undergraduate admission who wish to take courses for college credit and who have previously attended an institution of higher education must have a transcript or letter sent from the registrar of their most recently attended institution. This letter, addressed to the New Mexico Tech Office of Admission, should attest that they are in good standing at that institution. Students under probation or suspension at New Mexico Tech or any other institution of higher education will not be admitted as special students except by appeal to the Academic Standards and Admission Committee. Appeals should be addressed to the committee in care of the Office of the Registrar.

Special students and others not seeking a bachelor's degree from New Mexico Tech are expected to meet the prerequisite or corequisite requirements but are otherwise free to choose a program best suited to meet their individual needs.

Non-degree seeking students who have a bachelor's degree are regarded by New Mexico Tech as Special Graduate Students. Special Graduate Students will be charged tuition at undergraduate rates for courses numbered less than 300 and graduate tuition for all courses numbered 300 and above.

Special students who wish to begin a degree seeking program must apply for regular admission

Appeal of Admission Decisions

Experience has shown that most students who earn less than a 2.5 GPA in high school or have an ACT score of less than 21 or combined SAT Critical Reading and Math score of less than 970 do poorly at New Mexico Tech. If you do not meet the requirements for admission, but believe that you have the skills to succeed at New Mexico Tech, complete an *Application for*

Admission and Scholarship and send it with supporting documents to the Academic Standards and Admission Committee in care of the Director of Admission. These supporting documents must include:

- A statement from you indicating why you believe that you should be considered for admission and why you can succeed at Tech;
- A minimum of two letters from people (e.g., high school science and math teachers) who are very familiar with your potential for study at a technical university; and
- Other documentation (e.g., participation in science fairs, Science Olympiad, and other relevant technical activities) that you believe bears on the matter of your preparation for bachelor's-level study.

Waiver, Placement and Challenge Exams

Students may satisfy degree requirements and/or credit hour requirements based on waivers, challenge exams, placement exams, transfer credits, military training, or articulation agreements contained within, for example, a dual degree program or partnership.

Waivers

Waivers do not constitute a reduction in the minimum hours required in a New Mexico Tech degree or certificate program. Waived courses must be replaced with an equal number of elective credits or an approved core course from another approved New Mexico Tech program that does not duplicate a course already completed.

The New Mexico Tech waiver policy applies to all credit-bearing programs (degrees, certificates, etc.). A waiver is official recognition that a graduation requirement has been satisfied through previous course work (waiver by documentation) or testing (ACT/SAT/AP/IB/Challenge exams). All documentation for a waiver must be submitted and approved the week before classes begin.

ACT/SAT English Waiver

Students who score 27 or higher on the ACT English test or 610 or higher on the SAT Critical Reading or 650 or higher on the Redesigned SAT Writing/Critical Reading test will have English 1110 waived as a requirement. ACT/SAT scores older than three years will be reviewed. Adult Learners (those who have been out of college more than three years) are not required to submit an SAT/ACT score.

Placement

Math Placement

Mathematics is the backbone of all coursework at New Mexico Tech, and the selection of your initial math courses is critical to your success at Tech. Placement is determined by your ACT/SAT math score or the optional math placement test, described below.

ACT Math Score SAT Redesign Math Score Initial Math Course

| | | |
|--------------|---------------|-----------|
| 21 or lower | 530 or below | MATH 1215 |
| 22 to 24 | 540 to 580 | MATH 1220 |
| 25 to 29 | 590 to 690 | MATH 1230 |
| 25 to 29 | 590 to 690 | MATH 1240 |
| 30 or higher | 700 or higher | MATH 1510 |

You are transferring college credit in pre-calculus and trigonometry.

Placement based on AP Math Score:

1. **Students with a 3, 4 or 5 on AB exam:** Students scoring a 3 will receive credit for Math 1240, Pre-Calculus. Students scoring a 4 or 5 will receive credit for MATH 1510, Calculus I.
2. **Students with a 3, 4, or 5 on the BC exam:** Students scoring a 3 will receive credit for Math 1510, Calculus I. Students score a 4 or 5 will receive credit for MATH 1510, Calculus I, and MATH 1520, Calculus II.

Optional math placement test(s), covering intermediate algebra, college algebra, pre-calculus, and trigonometry, is available to students who score below 30 on the ACT math test or received below 670 on the SAT mathematics test or below 700 on the SAT redesigned mathematics test. **Waivers into 1000 level math classes are not granted. You must take the math placement exam if you want to enroll in any math class other than those listed above for your ACT or SAT math score.** Please contact mathplacement@nmt.edu for information about the math placement test.

College Level Examination Program

The College Level Examination Program (CLEP) is a national program of credit by examination that offers the opportunity for college level achievement wherever or however the student learned. No credit is given for CLEP exams. However, challenge exams are available in select courses.

Challenge Examinations

Challenge exams are available to students who are able to demonstrate proficiency in the course **learning** outcomes through **education** or experience, but may be ineligible for transfer of credit. Students may request an opportunity to receive credit for or a waiver of the requirement for a course by passing a comprehensive test of the course material (challenge examination). Each department determines what courses are eligible for a challenge exam and what grade options are available (such as Pass/Fail or letter grade). There is a challenge examination fee charged on a per credit hour basis. NMT Graduate Students may challenge credit specific to your graduate program through the Graduate Center.

The following regulations will apply to all challenge examinations:

1. You have not graduated from NMT.
2. You are not currently suspended from NMT.
3. Students who have attempted and received a grade in a class including “W” and “Audit” offered at NM Tech may not take a challenge exam in that course.
4. Permission of the instructor of the course is required and the examination is given at a time of the instructor’s choosing.
5. The form of the examination (written, oral, practical, combination, etc.) will be determined by the instructor.
6. Information as to the nature of the challenge examination will be made available to a student upon request.
7. The student will be told the grade earned and has the right to decide whether the credit and grade will be entered on the transcript.
8. At the option of the student and instructor, the examination may be graded on either the standard or S/U basis, and the examination points earned will be equivalent to a final grade in the course.
9. Credit hours and grade points earned in this way are exactly equivalent to those earned through successful completion of that course.
10. Exams must be taken, graded, and processed by the Registrar’s office before the last day to add a course for the Fall and Spring terms.
11. Once the grade option is processed by the Registrar’s Office it is final and cannot be changed.
12. Results of challenge examinations shall not be included in the student’s class load for the semester in which the exam is taken

Advance Placement

Students who have completed college-level courses in secondary schools and have taken the Advanced Placement Examinations of the College Examination Board with resulting composite scores of 3, 4, or 5 may receive college level credit. The amount of credit and the equivalent university courses for which credit will be granted is listed in the table below. Such credit will be treated as transfer credit without a grade, will count toward graduation, and may be used in fulfilling specific curriculum requirements. AP scores older than three years will be reviewed by the faculty advisor with the prospective student. Individuals who have taken a break between High School and College or from entering college for more than three years, do not have to submit an AP score.

International Baccalaureate

Students who have completed college-level courses in secondary schools and have taken the International Baccalaureate (**IB**) Examinations may receive college level credit. The amount of credit and the equivalent university courses for which credit will be granted is listed in the table below. Such credit will be treated as transfer credit without a grade, will count toward graduation, and may be used in fulfilling specific curriculum requirements. BI scores older than three years will be reviewed by the faculty advisor with the prospective student. Individuals who have taken a break between High School and College or from entering college for more than three years, do not have to submit an BI score.

ADVANCED PLACEMENT PROGRAM

New Mexico Tech participates in the Advanced Placement Program of the College Entrance Examination Board. Credit and/or advanced placement are granted according to the departmental policies listed below. Advanced Placement credit is not awarded for **scores** of 1 or 2.

| Subject | AP Score | Credits Earned |
|--|-----------------|---|
| ART | | |
| Art History | 3 | (3) ART REQ or HUMA REQ |
| | 4 and 5 | (3) ART REQ & (3) HUMA REQ |
| Studio Art: 2-D Design Portfolio | 3 | (3) GEN ELECT |
| | 4 and 5 | (6) GEN ELECT |
| Studio Art: 3-D Design Portfolio | 3 | (3) GEN ELECT |
| | 4 and 5 | (6) GEN ELECT |
| Studio Art: Drawing Portfolio | 3 | (3) GEN ELECT |
| | 4 and 5 | (6) GEN ELECT |
| BIOLOGY | | |
| Biology | 3 | (3) SCI ELECT or GEN ELECT |
| | 4 and 5 | (3) BIOL 2110 Lecture only* |
| * Lab waiver only if AP course had a lab. If no lab, student must take lab at NMT. It is the student's responsibility to consult with Biology Department Chair to determine lab waiver eligibility. | | |
| CALCULUS | | |
| Calculus AB | 3 | (3) MATH 1240 and placement into MATH 1510 |
| | 4 and 5 | (4) MATH 1510 |
| Calculus BC | 3 | (4) MATH 1510 |
| | 4 and 5 | (4) MATH 1510 and (4) MATH 1520 |
| CHEMISTRY | | |
| Chemistry | 3 | (3) SCI ELECT or GEN ELECT |
| | 4 | (3) CHEM 1215 Lecture only* |
| | 5 | (3) CHEM 1215 and (3) CHEM 1225 Lectures only* |
| * Lab waiver only if AP course had a lab. If no lab student, must take lab at NMT. It is the student's responsibility to consult with Chemistry Department Chair to determine lab waiver eligibility. | | |
| COMPUTER SCIENCE | | |
| Computer Science A | 3 | (4) CSE 107 |
| | 4 and 5 | (3) CSE 213 |
| Computer Science Principles | 3, 4 and 5 | (2) CSE 101 |
| ECONOMICS | | |
| Macroeconomics | 3, 4 and 5 | (3) ECON 2110 |
| Microeconomics | 3, 4 and 5 | (3) ECON 2120 |
| ENGLISH | | |
| English Lang | 3, 4 and 5 | (3) ENGL 1110 |
| English Lit | 3, 4 and 5 | (3) HUMA REQ |

| | | |
|--|------------|--|
| ENVIRONMENTAL SCIENCE | | |
| Environmental Science | 3, 4 and 5 | (3) SCI ELECT or GEN ELECT |
| FOREIGN LANGUAGES | | |
| Foreign Languages | 3 | (3) LANG ELECT or HUMA REQ |
| | 4 | (6) LANG ELECT or HUMA REQ |
| | 5 | (6) LANG ELECT or HUMA REQ and (3) GEN ELECT |
| GEOGRAPHY | | |
| Human Geography | 3, 4 and 5 | (3) SS REQ |
| HISTORY | | |
| European History | 3 | (3) HIST 1150 |
| | 4 and 5 | (3) HIST 1150 and (3) HIST 1160 |
| US History | 3 | (3) HIST 1110 |
| | 4 and 5 | (3) HIST 1110 and (3) HIST 1120 |
| World History | 3 | (3) HIST 1130 |
| | 4 and 5 | (3) HIST 1130 and (3) HIST 1140 |
| MUSIC THEORY | | |
| Music Theory | 3, 4 and 5 | (3) MUSC 2420 |
| PHYSICS | | |
| Physics 1 | 3, 4 and 5 | (3) SCI ELECT or GEN ELECT |
| Physics 2 | 3, 4 and 5 | (3) SCI ELECT or GEN ELECT |
| Physics C: Mechanics | 3, 4 and 5 | (4) PHYS 1310 Lecture only* |
| Physics C: Elctrcty & Mgntsm | 3, 4 and 5 | (4) PHYS 1320 Lecture only* |
| * Lab waiver only if AP course had a lab. If no lab, student must take lab at NMT. It is the student's responsibility to consult with Physics Department Chair to determine lab waiver eligibility. | | |
| POLITICAL SCIENCE | | |
| Comp Gvrnmnt & Pltcs | 3, 4 and 5 | (3) SS REQ |
| US Gvrnmnt & Pltcs | 3, 4 and 5 | (3) SS REQ |
| PSYCHOLOGY | | |
| Psychology | 3, 4 and 5 | (3) PSYC 1110 |
| STATISTICS | | |
| Statistics | 3, 4 and 5 | (3) MATH 2350 |

NMT Policies for International Baccalaureate (IB) Program

New Mexico Tech accepts IB (International Baccalaureate) credit according to the departmental policies below.

HL (high level) Examination only

| Examination | score required | prefix | Course Equivalency | Common Course # | credit | Title |
|---|----------------|-----------|--------------------|-----------------|--------|----------------|
| Biology HL | 5 or higher | BIOL | 111 | 2110 | 3 | Gen Biol I |
| Lab | | BIOL | 111L* | 2110L* | 1 | |
| Chemistry HL | 5 or higher | CHEM | 121 | 1215 | 3 | Gen Chem I |
| Lab | | CHEM | 121L* | 1215L* | 1 | |
| Computer Science HL | 5 or higher | CSE | 107 | CSE 107 | 4 | Intro to CS |
| English A: Literature HL | 5 or higher | ENGL | 111 | 1110 | 3 | English |
| Economics HL | 5 or higher | ECON | 251 & 252 | 2110 & 2120 | 6 | Macro/Micro |
| History HL | 5 or higher | HUMA | REQ | HUMA REQ | 3 | |
| Mathematics | | | | | | |
| HL Topics 5 & 7 | 5 or higher | MATH | 283 | 2530 | 3 | Statistics |
| HL Topics 6 | 5 or higher | MATH | 131 | 1510 | 4 | Calc I |
| HL Topics 9 | 5 or higher | MATH | 132 | 1520 | 4 | Calc II |
| Physics HL | 5 or higher | PHYS | 121 | 1310 | 4 | Gen Phys I |
| Lab | | PHYS | 121L* | 1310L* | 1 | |
| Psychology HL | 5 or higher | PSYC | 121 | 1110 | 3 | Intro to Psych |
| Languages HL | 5 or higher | LANG/HUMA | REQ | LANG/HUMA REQ | 3 | |
| * Lab credit will be considered upon submittal of lab course work documentation to the appropriate department | | | | | | |

Transfer Credit

Undergraduate Transfer Credits

New Mexico Tech accepts academic credits from regionally accredited institutions of higher education. All credits will be evaluated and transferred on a course-by-course basis.

- Courses to be considered for transfer credit must have been taken for a letter grade.
- Courses must be passed with a grade of “C” or higher to be considered for transfer credit at the undergraduate level.
- Grades earned at other universities are not transferred to New Mexico Tech.
- Credit earned at any institution while a student is on academic or disciplinary suspension will not be accepted at New Mexico Tech.
- A list of courses offered at other New Mexico colleges and universities and their Tech equivalents is online at <https://ccns.hed.state.nm.us/>

Graduate Transfer Credits

For graduate degrees, NMT accepts at most 12 academic credits from regionally accredited institutions of higher education. All credits will be evaluated and transferred on a course-by-course basis. Only courses at the 300 level and above with a grade of “B” or higher are eligible for transfer credit for graduate degrees

Terminal Transfer Credits

Terminal transfer credits, credits earned at another college or university in order to complete the last degree requirements at NMT, are not allowed except when specified by a particular degree program, or when unusual circumstances appear to justify it. In no case will more than 12 credit hours of terminal transfer credits be allowed. A student who anticipates the need for requesting terminal transfer credit should do so as soon as practical and in no event later than the time of filing the Intent to Graduate for a degree. The request should be addressed to the Vice President for Academic Affairs. It should contain a statement of the circumstances which, in the student’s judgment, justify the request and a specific statement of the program proposed for obtaining the terminal credits. Approval, if granted, will be of a specific program.

Transfer among New Mexico Higher Education Institutions

During the 2005 New Mexico legislative session (Senate Bill 161), and continuing with the passing of SB 103 in 2017 legislative session, courses successfully completed with a grade of C or higher at any regionally accredited public institution of higher education in New Mexico and recognized through a state approval process as general education at that institution are guaranteed to transfer to any other New Mexico two- or four-year public institution as general education coursework. Effective in fall 2019, New Mexico requires a minimum of 30-31 hours of general education coursework for students to be designated as “General Education Complete” at any NM institution for all Associates or Bachelor’s degrees, taken from the approved General Education areas listed on the New Mexico Higher Education Department (HED) website (<https://hed.state.nm.us/>). Students who have decided on a major and/or an institution at which to complete their studies should consult with an academic advisor at that particular institution to determine the most appropriate course selections. Students enrolling for the first-year of study at a New Mexico college or university and considering possible transfer into a certificate and/or degree program at another institution are encouraged to take the courses approved for transfer during their freshman and sophomore year of study. Students transferring to NMT should also be aware that while they may have completed their New Mexico General Education requirements at the originating school, they may still be required to complete Institute Requirements for New Mexico Tech degree programs.

Student Responsibility

New Mexico’s colleges and universities have collaborated to produce guides to assist students who plan to transfer before completing a program of study. Course modules are designed to help students select courses carefully so that they may transfer with little or no loss of credit. However, planning for effective transfer with maximum efficiency is ultimately the **student’s responsibility**. Responsible transfer planning includes early and regular consultation with the intended degree-granting institution to assure that all pre-transfer coursework will meet the requirements of the desired degree.

Inter-institutional Transfer Guides and Catalogs

Students who have selected a field of study and/or the institution where they wish to graduate are advised to consult the transfer guide or catalog for that institution for more current and detailed advice to guide their course selection.

Complaint Procedure for Transfer Students

All New Mexico public post-secondary institutions are required to establish policies and practices for receiving and resolving complaints from students or from other complainants regarding the transfer of course work from other public institutions in the state. Complaints can be filed with:

New Mexico Higher Education Department
2044 Galisteo Street,
Santa Fe, NM 87505-2100
505.476.6500
<http://hed.state.nm.us/>

Dual Credit Program for High School Students

Dual credit is a program that provides public high school students the opportunity to receive credit for both a high school course and a college course by taking a single qualifying course. Dual credit is a state statute, revised in 2007 by the State Legislature – Senate Bill 943, Statutory Authority, Section 9-25-8 NMSA (01/01/08). Concurrent enrollment functions similarly but does not require that the college course be aligned with a corresponding high school course. Consequently, the student is not guaranteed that the high school will accept the college credit toward high school graduation requirement.

The purpose of the Dual Credit Program at New Mexico Tech is to increase the educational opportunities and options for high school students and provide students an early glimpse of college life and college-level studies.

Students interested in participating in the Dual Credit Program at New Mexico Tech must be prepared for the following:

- Students are responsible for their own transportation to and from New Mexico Tech’s campus
- Students are expected to adhere to New Mexico Tech’s student handbook while on New Mexico Tech’s campus and attend the class or classes in which they are registered even if the high school is not in session that day
- New Mexico Tech’s academic calendar starts and ends differently than most high school calendars
- Students who take courses that are not part of the approved course list agreed upon between the District and New Mexico Tech will be responsible for all costs of attendance including tuition, fees and textbooks
- Students must follow New Mexico Tech’s Registration schedule each semester
- Students are required to participate in the Dual Credit Program Orientation the first semester they participate in the Dual Credit Program

Grades earned through the Dual Credit Program at New Mexico Tech are part of your permanent academic record.

Types of Dual Credit

Dual credit courses provide an accelerated path to success in college or career. Developmental or remedial courses and physical education courses cannot be taken for dual credit.

College Offered

1. One form of dual credit, referred to as college-offered, requires that the student attend regularly scheduled New Mexico Tech courses, either on campus or at an off-site location, which may include the high school site after hours. *School Offered*
2. Another form of dual credit, referred to as school-offered, allows students to receive college credit for courses they are taking at the high school.

Application Process

Admission to the dual credit program does not constitute regular admission to New Mexico Tech. To be considered for dual credit or concurrent enrollment it is necessary for the student to meet the following minimum eligibility requirements:

To qualify for college-offered or school-offered dual credit, a high school student must:

1. Be a public high school, private high school, or home school student;
2. For college-offered courses, be at least 16 years old (exceptions can be made in certain situations with approval of a parent, high school principal, and college dean or Associate Vice President for Academic Affairs);
3. For college-offered courses, achieve minimum qualifying score on the ACT, PSAT, SAT, or take the appropriate departmental placement exam;
4. For school-offered courses, there are no age or grade restrictions; and
5. Have a minimum 2.5 GPA;
6. Submit the following each semester:
 - Completed Dual Credit Request Form (signed by your high school counselor)
 - Current official high school transcript
 - Family Educational Right to Privacy Act Release Form (signed by the student and the student’s parent/guardian) Copies of the forms are available at the high school counseling office.

Students who are denied participation in the dual credit program may appeal through the same process as regular NMT students, or through the New Mexico Public Education Department’s Dual Credit Committee.

Eligibility

In accordance with the New Mexico State Public Education Policy & Procedures for Dual Credit, in order to maintain dual credit eligibility, students must:

- continue to demonstrate readiness for college coursework;
- make continued progress toward high school graduation;
- maintain half-time high-school enrollment until graduation requirements are completed;
- obtain a course grade of C or better for each course taken, not obtain withdrawals or incompletes for dual credit courses, and not enroll in a dual credit course to audit or for an S/U grade.

If these conditions are met, students may enroll in two dual-credit courses per semester (including recitation and labs) until all core high school graduation requirements (other than electives) are completed. Students who have completed all core high school courses may enroll in up to four dual credit courses. Home school and private school students are limited to two courses per semester according to the New Mexico Public Education Department's Dual Credit Policy & Procedures.

Students who have not met the above requirements will retain "provisional dual credit eligibility." Students with provisional eligibility may register and enroll in one dual credit course per semester until they meet the above requirements.

Financial Aid

Dual Credit students are not eligible for federal financial aid

Course Selection

Course selection will vary based on the Master Agreement with each high school district and New Mexico Tech. Students interested in enrolling in a math class are required to take the Math Placement Exam to determine course placement prior to registering for the class. Students are also required to meet with the Associate Dean for Student Success at New Mexico Tech prior to enrolling in any course and must satisfy prerequisites/co-requisites for the class.

Continued Eligibility

In accordance with the New Mexico State Public Education Policy & Procedures for Dual Credit, in order to maintain dual credit eligibility, students must:

- continue to demonstrate readiness for college coursework;
- make continued progress toward high school graduation;
- maintain half-time high-school enrollment until graduation requirements are completed;
- obtain a course grade of C or better for each course taken, not obtain withdrawals or incompletes for dual credit courses, and not enroll in a dual credit course to audit or for an S/U grade.

If these conditions are met, students may enroll in two dual-credit courses per semester (including recitation and labs) until all core high school graduation requirements (other than electives) are completed. Students who have completed all core high school courses may enroll in up to four dual credit courses. Home school and private school students are limited to two courses per semester according to the New Mexico Public Education Department's Dual Credit Policy & Procedures.

Students who have not met the above requirements will retain "provisional dual credit eligibility." Students with provisional eligibility may register and enroll in one dual credit course per semester until they meet the above requirements.

Military Training

NMT is dedicated to ensuring the success of our active duty and veteran students. If you attended a military service school, received training, or served in an occupation specialty you may be able to earn credit towards your program at NMT.

1. Check Your Eligibility

In order to request credit or an evaluation of your military experiences, you must:

- Be accepted as a student at NMT
- Have a declared program of study to which the credit awarded will apply
- Request your official **Joint Service Transcript (JST)** and have it submitted directly to the NMT Articulation and Transfer Office if you are or were a member of the Army, Coast Guard, Navy, Marine Corps, or Reserve.

Financial Aid for Undergraduate Students

[Contact: Financial Aid Office, New Mexico Tech, 801 Leroy Place, Socorro, N.M. 87801; 575.835.5333; email: financial_aid@nmt.edu]

New Mexico Tech makes every effort to make our undergraduate education affordable for everyone: new students, returning students, and transfer students. Assistance comes in the form of institutional scholarships, state scholarships, financial aid, and student employment.

1. **Institutional scholarships** are based solely on your grades (high school GPA, standardized test scores, and college GPA if you are a transfer student). Institutional scholarships include

First-Time Students (Presidential, Gold, Silver, Copper)

Transfer Students (Phi Theta Kappa, Regents, Transfer Excel, Tech Transfer)

Tuition Reduction Programs for Non-Residents (Competitive, Colorado Reciprocity, Western Undergraduate Exchange)

You do not need to demonstrate financial need for an institutional scholarship—only your own academic merit.

2. **State scholarships** are awarded to New Mexico residents and include the Legislative Lottery Scholarship

3. In addition to scholarships, we offer **financial aid**, which includes

- Federal grants (e.g., Pell Grant and SEOG Grant)
- Federal loans (e.g. Direct Stafford Loan, PLUS Loan)
- Federal work study
- New Mexico grants (State Student Incentive Grant, College Affordability Grant)
- New Mexico work-study

Details on this year's institutional scholarships and financial aid programs, including dollar amounts, are available at <http://www.nmt.edu/finaid/index.php> or in a brochure available from the Office of Admission.

Institutional Scholarships

When you are admitted to New Mexico Tech, your application is automatically reviewed for an institutional scholarship. ***(Tech gives only one institutional scholarship per person. If, by accident or oversight, you are offered two institutional scholarships, you may keep only one.)***

The deadline for consideration of scholarships for the fall semester for first-time students is March 1. For consideration for a scholarship for the spring semester, the deadline is November 1. The deadline for scholarships for transfer students is April 1 for the following fall semester and November 1 for the spring semester. If you did not qualify for an institutional scholarship when you entered Tech and you complete two semesters at Tech, earning a minimum of 24 credit hours with at least a 3.0 GPA, you may be eligible for an Endowed Scholarship. Inquire at the Financial Aid Office.

Generally for scholarship consideration, a student must:

- Be a U.S. citizen or an eligible non-citizen; or be an international student in legal F1 or J1 student status. (International students are eligible only for transfer scholarships and certain tuition reduction programs.)
- Be pursuing a first bachelor's degree;
- Be enrolled in a regular degree program at New Mexico Tech; and
- Carry at least 12 credit hours per semester. Students receiving the Legislative Lottery Scholarship must carry at least 15 credit hours per semester.
- Have a High School Diploma or a recognized equivalent.

Institutional Scholarship Renewal

Each year, your institutional scholarship is automatically renewed. You must maintain the GPA specified by your specific scholarship to keep the scholarship and have earned a minimum of 24 credit hours in the regular academic year. The requirements for your institutional scholarship are listed below under the Scholarship Conditions and Requirements. Please note that you may not qualify for a scholarship higher than the one you were awarded when you entered New Mexico Tech.

Scholarship Conditions and Requirements:

Students must earn 24 credit hours in the academic year (fall & spring), in addition to the GPA Requirements listed below, to meet retention criteria. Credit hours completed during the summer semester may count as completed credit hours for purposes of Institutional scholarship reinstatement. It is your responsibility to request reinstatement at the end of the summer semester.

| CUMULATIVE GRADE POINT AVERAGE REQUIRED FOR RETENTION OF SCHOLARSHIP | | | | |
|--|--|---|--|--|
| | CATEGORY OF SCHOLARSHIP | | | |
| | Presidential Gold PTK Regents | Endowed NM Scholars International Competitive* | Silver Transfer Excel Competitive (U.S. Citizens) | Copper Tech Transfer CORE WUE NM Lottery** |
| GPA Requirement | 3.25 | 3.00 | 3.00 | 2.50 |

RETENTION OF AWARD:

- Scholarship recipients must maintain a minimum of twelve (12) credit hours of course work for each Fall and Spring semester. *Lottery Students and International Competitive recipients must maintain fifteen (15) credit hours per semester. Grades of *U*, *F*, *W*, and audits do not count as completed credits for scholarship retention purposes.
- Scholarship eligibility is reviewed yearly at the end of the spring semester. (If a student attends summer school, eligibility will be reviewed again at the end of the summer semester to ensure GPA requirements are maintained.)
- Inability to meet minimum requirements by the end of the spring semester will result in scholarship loss for the following academic year.
- Students who lose scholarship eligibility may submit a written appeal (by the posted deadline) of extenuating circumstances with appropriate documentation.
- If a scholarship is cancelled for academic ineligibility and the student later regains eligibility, it is the student's responsibility to request reinstatement of the scholarship. Renewal of a scholarship is made only if the originally specified consecutive time period has not expired. Reinstatement requests are only accepted after the spring and summer semesters.

Competitive Scholarships, CORE, and WUE program participants will lose their respective awards if the established retention criteria are not met; no scholarship replacement will be offered. The student's tuition rate will then revert to non-resident status.

Note: Students awarded the Competitive Scholarship or who are participating in the CORE or WUE programs are not eligible to establish New Mexico residency while on the program or use any time in New Mexico while on the program toward meeting the requirement for New Mexico residency.

Time Limits

Institutional scholarships are offered for a maximum of four years for first-time students and a maximum of three years for transfer students. The length of your scholarship is listed on your scholarship offer. Work closely with your advisor and check with the Registrar's Office to make sure you are on track to finish your program in the time specified. If you need additional funding to finish your bachelor's degree, you should consider applying for financial aid.

If your scholarship is cancelled due to academic ineligibility, and you then re-establish eligibility, you may apply for reinstatement of the scholarship. This request should be made as soon as possible after the spring or summer semester, whichever is applicable. The originally specified time period of the scholarship is not extended.

State Scholarships

Legislative Lottery Scholarship

The Legislative Lottery Scholarship pays a portion of tuition at NM Tech for students who meet the following requirements: Must be a New Mexico resident; must have graduated from a New Mexico public high school, an accredited New Mexico private high school, or have obtained a New Mexico GED; must be enrolled in and earn 15 or more credit hours at an eligible New Mexico public college or university in the first regular semester immediately following their high school graduation; must obtain a 2.5 GPA during their first college semester. Eligible students do not begin receiving the award until their second semester of full-time enrollment, provided that all eligibility requirements have been met. A student may be eligible for up to seven consecutive semesters of support or until the student graduates with a bachelor's degree from an eligible institution, whichever is sooner.

Renewal - The Legislative Lottery Scholarship is renewable for up to seven (7) semesters with the following conditions/requirements:

- 1) Successfully complete the first semester (eligibility semester) with 15 credit hours and a GPA of 2.5 or higher. Grades of U, F, W, I and audits do not count as completed credits for scholarship retention purposes.
- 2) Completion of 15 credit hours with a cumulative GPA of 2.5 or higher each semester thereafter.
- 3) Scholarship eligibility is reviewed at the end of each semester.
- 4) Students who do not meet these requirements can appeal and provide documentation of exceptional mitigating circumstances beyond the student's control.
- 5) Approved appeals for first semester requirements will result in deferring the qualifying semester to the semester immediately following the semester in which the student did not meet the eligibility requirements.
- 6) All appeals will be held to state regulations.
- 7) All students attending summer school will be evaluated to ensure GPA has been maintained.

Extenuating Circumstances

Students who have exceptional mitigating circumstances as determined by the Director of Financial Aid may have their scholarship reinstated with conditions under the following circumstances:

- 1) The student shall submit an appeal certifying the nature of their exceptional mitigating circumstances to the Financial Aid Office.
- 2) The Director of Financial Aid shall exercise professional judgment to determine whether the exceptional mitigating circumstance was beyond the student's control and precluded the student from meeting the requirements of the scholarship.

Financial Aid

To apply for financial aid you must complete the **Free Application for Federal Student Aid (FAFSA)**. You may apply online at www.fafsa.gov. New Mexico Tech's Title IV code for the FAFSA is 002654.

For maximum consideration, please submit your FAFSA for processing before March 1, if you plan to enter the following fall.

Approximately 30 percent of all applications are selected for review in a process called verification. If your file is selected for verification, additional documents will be needed. The financial aid office will notify you if additional paperwork is needed and inform you what that paperwork is. Verification must be completed before a financial aid package will be calculated for the student.

The FAFSA results from the federal processor contain your Expected Family Contribution (EFC) number. This number is used to determine your eligibility for the various financial aid programs.

We will offer you a package to try to meet your needs at New Mexico Tech. Our offer to you may include grants, loans, work-study, and/or an institutional scholarship. To accept our offer, [please log into your New Mexico Tech BanWeb account](#).

To qualify for financial aid at Tech, you must:

- 1) Be a U.S. citizen or an eligible non-citizen
- 2) Show satisfactory academic progress
- 3) Be enrolled in a regular degree program at Tech
- 4) Not be in default on a federal student loan or owe a repayment on a federal grant
- 5) Have a High School Diploma or a recognized equivalent

Continuing Your Financial Aid at Tech

Each year, you must fill out the FAFSA. This form should be filed as soon as possible after October 1. For maximum consideration you should fill out the FAFSA before our priority deadline of March 1.

Satisfactory Academic Progress for Financial Aid

Financial Aid Offices are required to have a policy regarding Satisfactory Academic Progress. The purpose of this policy is to measure a student's academic progress in both a qualitative and quantitative way. This is done by measuring both cumulative grade point average and credit hours earned. To continue receiving Federal and/or State Financial Aid, students must meet the minimum requirements set in New Mexico Tech's Satisfactory Academic Progress Policy. Be aware that these standards are not the same as New Mexico Tech's standards for academic probation and suspension.

At New Mexico Tech, satisfactory academic progress is reviewed at the end of each payment period (semester). The Satisfactory Academic Progress Policy applies to both undergraduate and graduate level students who participate in the following programs: Federal Pell Grant, Supplemental Grant, New Mexico State Student Incentive Grant, College Affordability Grant, Federal Work Study, New Mexico Work Study, New Mexico Non-need Work Study, Perkins Loan, Federal Direct Stafford Loan, Federal Direct Grad PLUS Loan, and Direct PLUS loan.

Qualitative Standard– Students must meet the following GPA requirements

| Degree | Attempted Credit Hours | Minimum NMT GPA |
|-----------------------------|--|--|
| <u>Bachelor's</u> | (Includes all transfer hours.) <u>0-29</u> <u>30-59</u> <u>60 or more</u> | <u>1.6</u> <u>1.8</u> <u>2.0</u> |
| <u>Second Bachelor's</u> | <u>All hours attempted at NMT after first Bachelor's degree was earned.</u> | <u>2.0 – calculated on the grades earned after first Bachelor's degree was earned.</u> |
| <u>Master's</u> | <u>All</u> | <u>3.0</u> |
| <u>Doctor of Philosophy</u> | <u>All</u> | <u>3.0</u> |

Quantitative Standard

Students must earn (successfully complete) at least 67% of the total credit hours they attempt.

This is calculated

- Cumulative hours successfully completed
- Cumulative hours attempted

Total hours attempted includes grades of A, A-, B+, B, B-, C+, C, C-, D+, D, F, S, U, W, WO, IN, SA, UA, PR NG and all transfer credits.

Total hours earned includes grades of A, A-, B+, B, B-, C+, C, C-, D+, D, S, PR, and all transfer credits.

Repeat courses - count as attempted hours, but the hours can only be earned once. For example, if a student takes a 3 credit hour course one semester and earns a D, the hours are counted as attempted and earned. If the student later repeats the course, the 3 hours are added to the attempted, but hours earned will not increase because of the repeat; however, because a grade of F does not count as earned hours, a student repeating a grade of F at a later time and earning a D will have the hours count as attempted and earned when the course is repeated.

NR, NG grades - It is the student's responsibility to notify the Financial Aid Office when a grade of NR, NG is changed to a grade by the instructor so Satisfactory Academic Progress can be re-evaluated.

Maximum Time Frame

- Students seeking their first bachelor's degree may be eligible for Title IV aid up to a maximum of 195 attempted credit hours.
- Students pursuing a second bachelor's degree have a maximum timeframe of 150% of the number of hours needed to complete the degree. This is determined through a credit evaluation done by the Registrar's Office. For instance, if the student has 140 credit hours and needs 60 hours to earn a second degree, the student will have financial aid eligibility for a maximum of 90 attempted credit hours.
- Students pursuing a master's degree may be eligible up to a maximum of 45 attempted credit hours. This includes all hours attempted as a graduate student regardless of the course level.
- Students pursuing a doctor of philosophy degree may be eligible up to a maximum of 75 attempted credit hours. This includes all hours attempted at that level.
- When you fall below the SAP policy requirements, you will automatically be placed on financial aid warning for your next semester of enrollment. During this semester you will be eligible to receive aid.
 1. If you are still below the policy standards after the financial aid warning semester, you are no longer eligible for Title IV aid.
 2. Once a student is on financial aid suspension, he/she is not eligible for any Federal or State Financial Aid until the standards of the Satisfactory Academic Progress Policy have been met or an appeal is approved.

Appeals for Exception to Standards of Satisfactory Academic Progress Policy

Students have the opportunity to appeal the determination that they are not making satisfactory academic progress. To appeal, the student will need to complete an Appeal Form. On that form, the student will need to explain why he/she failed to meet our Satisfactory Academic Progress standards and what has changed that will allow him/her to meet the standards by the end of the next semester.

If an appeal is approved the student's SAP status will change to either Probation or Probation with a plan.

A student can remain eligible for aid once they have had an appeal approved with conditions (probation with a plan) as long as the student continues to meet the individual "plan" that was set forth for them in the appeal response.

Satisfactory Academic Progress is measured at the end of each semester. Summer is considered a separate semester. If a student's earned hours or cumulative GPA falls below the minimum standard indicated in the policy, he/she will be notified in writing. The student will also be notified if he/she has met the maximum time frame.

Satisfactory Academic Progress Status

| <u>Result of SAP measurement</u> | <u>Status</u> | <u>Description</u> | <u>Eligibility</u> |
|--|----------------------|---------------------------|--------------------------------------|
| <u>Never received Title IV aid before</u> | <u>X</u> | <u>Not reviewed</u> | <u>Eligible</u> |
| <u>Meeting SAP policy standards</u> | <u>OK</u> | <u>Satisfactory</u> | <u>Eligible</u> |
| <u>1st Failure to meet SAP policy standards</u> | <u>WARN</u> | <u>Warning</u> | <u>Eligible for 1 payment period</u> |
| <u>Failure to meet SAP policy standards at end of warning period</u> | <u>SUSP</u> | <u>Suspension</u> | <u>Not eligible</u> |

Financial Aid Policies

Return of Title IV Funds Policy

This policy applies to all students that participate in the following Title IV financial aid programs.

- Federal Pell Grant
- Supplemental Grant
- Federal Direct Stafford Loan
- Federal Direct Grad PLUS Loan
- PLUS Loan

Federal regulations require that if a recipient of Title IV financial aid funds (those programs listed above) withdraws from New Mexico Tech after beginning attendance for the semester, the amount of Title IV assistance earned by the student must be determined. This is done through a calculation developed by the United States Department of Education. If the amount disbursed to the student is greater than the amount the student earned, unearned funds must be returned. If the amount disbursed to the student is less than the amount the student earned, and for which the student is otherwise eligible, he or she is eligible to receive a post-withdrawal disbursement of the earned aid that was not received.

The amount of assistance the student has earned is based upon the percentage of the semester in which the student was enrolled. Enrolled days / total number of days in the semester = % of aid earned. Once the student has completed more than 60% of the semester, he/she is considered to have earned all of the funds awarded and is not subject to the calculation.

There are two types of withdrawals for Title IV financial aid purposes:

- **Official Withdrawals**—If the student officially notifies New Mexico Tech of his or her intentions to withdraw, this date is considered to be your last date of attendance and will be the official withdrawal date for calculating the amount of Title IV financial aid funds earned. This applies to both withdrawal (W) and withdrawal without prejudice (WO).
- **Unofficial Withdrawals**—If a student receives grades of all F, U, or UA for a semester, the student is considered to have unofficially withdrawn from New Mexico Tech. The midpoint of the semester is used as the student's unofficial withdrawal date unless documentation is submitted to show a different last date of attendance at an academically related activity.

Entrance Loan Counseling Policy

According to federal law, if you intend to borrow money on the Perkins Loan or Federal Direct Loan programs, you must complete entrance loan counseling. Go to www.studentloans.gov and sign in to complete Entrance Loan Counseling. Complete the entrance loan counseling for the type(s) of student loans you intend to borrow or have been offered.

Exit Loan Counseling Policy

If you receive an education loan and you graduate, withdraw, drop below six credit hours, or do not re-enroll; you must complete exit loan counseling. Go to www.studentloans.gov and click Student Loan Counseling interview on the left side. Complete the exit loan counseling for the type(s) of student loans you borrowed.

Student Employment Policy

All student employment is limited to a maximum of 20 hours per week during the fall and spring semesters. Maximum hours per week during the summer semester depend on the number of credit hours the student is taking. Any student employed under the work-study program must demonstrate satisfactory academic progress for financial aid. Students employed on a part-time basis must be enrolled as regular, full-time students. Students attending less than full-time are subject to IRS regulations regarding FICA/Medicare deductions.

A Student Employee Handbook is available online at <http://www.nmt.edu/finaid/index.php> and at the Financial Aid Office.

(A cooperative education program is available, in which students alternate periods of off-campus, full-time employment with on-campus, full-time study. See the Director of Student Affairs for more information.)

Tuition and Fees

The information below is for the 2021-2022 school year. For current information on Tuition and Fees, check our web page at www.nmt.edu or call the Office of Admission at 1.800.428.TECH. All fees are subject to change without prior notice.

| Nonrefundable charges | | | |
|---|---|---|--|
| Application Fees | | Admission Fees | |
| \$15 | Undergraduate | \$50 | Undergraduate |
| \$45 | Graduate | \$25 | Graduate |
| Miscellaneous Fees | | Graduation Fees | |
| \$10 | Challenge Exam fee (per semester hour) | \$30 | Associates Degree |
| \$25 | Deferred Payment Plan Fee | \$40 | Bachelors Degree |
| \$25 | ID Card Replacement Fee | \$50 | Masters Degree |
| \$30 | Late Registration Fee (per day) | \$60 | PhD Degree |
| \$40 | Orientation Fee | | |
| \$15 | Transcript Fee (paper transcript) | | |
| \$3.82 | Withdrawal Fee | | |
| Refundable Charges | | | |
| Tuition per semester, Full Time Resident | | Tuition per semester, Full Time Non-Resident | |
| \$3,515.40 | Undergraduate (12 - 18 credit hours) | \$11,430.00 | Undergraduate (12 - 18 credit hours) |
| \$3,672.00 | Graduate (9 - 13 credit hours) | \$12,146.22 | Graduate (9 - 13 credit hours) |
| Tuition per semester, Part Time Resident, per credit hour | | Tuition per semester, Part Time Non-Resident, per credit hr | |
| \$292.95 | Undergraduate | \$292.95 | Undergraduate, 1 to 6 credit hrs |
| \$292.95 | Graduate (299 or below) | \$408.00 | Graduate, 1 to 6 credit hrs |
| \$408.00 | Graduate (300 level or above) | \$952.50 | Undergraduate, 7 to 11 credit hrs |
| Fees and Deposits | | \$1,349.58 | Graduate, 7 to 8 credit hrs |
| \$6.00 | Auxiliaries Fee (per credit hour) | | |
| \$1.00 | Institute Activities Fee (per credit hour) | | Qualified veterans may be eligible for |
| Variable | Laboratory Usage Fee | | in-state tuition. Please see the |
| \$4.50 | Sports Activity Fee, (per credit hour) | | Veterans Administrator for more |
| \$93.00 | Student Activity Fee, Undergraduate, 7 credit hours or more | | information. |
| \$46.50 | Student Activity Fee, Undergraduate, 6 credit hours or less | | |
| \$82.84 | Student Activity Fee, Graduate, 7 credit hours or more | | |
| \$41.43 | Student Activity Fee, Graduate, 6 credit hours or less | | |
| \$6.50 | Student Center Fee (per credit hour) | | |
| \$5.00 | Student Center Base Fee, (per student) | | |
| \$30.00 | Health Center Fee (per semester) | | |
| \$26.00 | Student Counseling Fee (per semester) | | |
| \$200.00 | Room Reservation/Damage Deposit | | |
| \$90.00 | Bond Retirement Fee (per semester) | | |
| \$205.00 | Technology Support Fee | | |
| \$200.00+\$50.00 | Family Housing Deposit for each family member | | |

Housing and Meal Plan Charges

See the current rate sheet at: <https://www.nmt.edu/reslife/docs/20-21%20housing%20and%20meal%20rates.pdf>

The minimum estimated expenses which must be met **per semester** by single, full-time students living on campus at New Mexico Tech during the 2021-2022 school year are:

| Undergraduate Costs per Semester | | |
|---|--------------|--|
| Resident | Non Resident | |
| \$3515.40 | \$11,430.00 | Tuition (based on 12-18 credit hours) |
| \$32.00 | \$32.00 | Student Loan fees |
| \$1,172.00 | \$1,172.00 | Personal Expenses (estimated total) |
| \$4,312.00 | \$4312.00 | Room and board (double-room, 150+75 tech dollar meal plan) |
| \$300.00 | \$300.00 | Books and Supplies |
| \$10,606.00 | \$18,520.00 | Total Estimated Minimum Cost Per Semester |
| | | |
| Graduate Costs per Semester | | |
| Resident | Non-Resident | |
| \$4,613.00 | \$12,843.00 | Tuition (based on 9-13 credit hours) |
| \$32.00 | \$32.00 | Student loan fees |
| \$1,172.00 | \$1,172.00 | Personal expenses (estimated total) |
| \$4,312.00 | \$4,312.00 | Room and board (double room, 150 + 75 Tech Dollar meal plan) |
| \$300.00 | \$300.00 | Books and supplies (estimated) |
| \$10,801 | \$19,275 | Total Estimated Minimum Costs per Semester |
| | | |

The student should add travel costs and laboratory and special fees where applicable. **Tuition, fees, and charges for room and board are subject to legislative and administrative change at any time.** Charges for damage to property beyond normal wear and tear may be levied at the discretion of Tech.

A complete list of possible charges and an explanation of each appears on the next pages. Schedules outlining refund procedures follow. All charges are due and payable on or before registration or whenever they are incurred.

Tuition

Undergraduate Students

Any undergraduate who registers for 12 to 18 credit hours pays full tuition. Additional tuition for all hours carried above 18 credit hours will be charged at the semester hourly rate for residents or nonresidents as applicable. Students registered for 11 credit hours or less pay tuition at the semester hourly rates.

Graduate Students

Any graduate student who registers for 9 to 13 credit hours pays full tuition. Additional tuition for all hours carried above 13 credit hours will be charged at the semester hourly rate for residents or nonresidents as applicable. Graduate students registering for fewer than nine credit hours pay tuition at the semester hourly rates.

Auditors, Special Students, and Senior Citizens

Students who **audit** courses (those who enroll in one or more courses for no credit) pay the same tuition and fees as credit students.

Special students, as classified by the Office of Admission or Registrar, pay required tuition and fees per credit hour. Special students may not register for more than six credit hours per semester. Non-resident tuition is waived for special students enrolled for no more than six credit hours.

Non-degree-seeking student who has a bachelor's degree is regarded by New Mexico Tech as a Special Graduate Student. Special Graduate Students will be charged tuition at undergraduate rates for courses numbered less than 300 and graduate tuition for

all courses numbered 300 and above. Tuition for students 65 or older is \$5.00 per credit hour and must be requested at time of registration. Applicable fees must also be paid.

Residency

You are considered a resident of New Mexico if your parents or legal guardians are residents of New Mexico. If you are over 18 years of age, you may become a legal resident of New Mexico while attending New Mexico Tech. Non-resident aliens cannot obtain New Mexico residency.

With the exception of graduate students employed as teaching or research assistants, international students do not qualify for in-state tuition.

Navajo Residency

Registered members of the Navajo Tribe who reside anywhere within the Navajo Nation are considered New Mexico residents for tuition purposes.

Refunds

Tuition and Applicable Fees, Fall and Spring Semesters

The student who drops all fall and spring classes at New Mexico Tech prior to 5 p.m. on the third Friday after classes begin will receive a refund according to the following schedule:

| Refund of tuition and fees | |
|--|--|
| Registration week (days 1 through 5) | 100% |
| Days 6 through 12 | 75% |
| Days 13 through 19 | 70% |
| Days 20 and beyond | 0% |
| After the third Friday after classes begin | No refunds are made after the third Friday after classes begin for fall or spring semester |

Students who drops some, but not all, classes (reduction in class load) prior to 5 p.m. on the third Friday after classes begin will receive a 100% refund for the classes dropped.

| Tuition and Applicable Fees, Summer Semester | |
|--|--|
| <ul style="list-style-type: none"> Prior to 5 p.m. on the second Tuesday after summer classes begin | The student who drops any or all summer classes at New Mexico Tech prior to 5 p.m. on the second Tuesday after classes begin will receive a 100% refund. |
| <ul style="list-style-type: none"> After the second Tuesday after classes begin | No refunds are made to students who drop or withdraw from any or all summer classes after the second Tuesday after classes begin. |
| <ul style="list-style-type: none"> Financial Aid Implications | Student receiving financial aid who withdraw from all classes are subject to a Return of Title IV Funds policy, which returns funds to the financial aid programs. For further information, see Return of Title IV Funds, page 42. |
| | |

Room (Apartment or Residence Hall) Cancellation Policy Entering Students

1. Students entering University housing for the proceeding semester may cancel their Room & Board Application and License Agreement without financial penalty by June 1 (for the proceeding fall term), December 1 (for the proceeding spring term) and May 1 (for the proceeding summer term).
2. Between above dates and Opening Day for those respective terms, the student will be charged a \$400 fee for breaking the Agreement/ not checking in by the first day of classes.

3. Room cancellations made after the first day of classes are not eligible for refund of room or board. Fall semester residents who request cancellation of their room & board for the following Spring semester will still be charged for room & board if they remain enrolled at the University.
4. Term dates are available on the current Residential Life Rates Sheet.
5. Cancellations must be in writing. No cancellations will be accepted over the phone. Students with extenuating circumstances for canceling the Agreement may request a waiver of the cancellation fee and/or room & board charges by submitting a written waiver request to Residential Life. The request will be reviewed by a committee.

Returning Students

1. Returning students may cancel their agreement for the upcoming academic year prior to June 1st without penalty.
 2. Agreements canceled after June 1st will incur a \$400 penalty.
 3. Room cancellations made after the beginning of the Apartment/Residence Hall term will receive no refund on their room rent.
 4. Fall semester residents who cancel their room for the following Spring semester will still pay the cost of the room.
- Term dates are available on the Residential Life web site, <https://www.nmt.edu/reslife/>
 Cancellations must be in writing. No cancellations will be accepted over the phone. Students with extenuating circumstances for canceling their residence hall agreement must request a waiver of the penalty fee in writing to the Residential Life Office. The request will be reviewed by a committee.

Boarding Plans

You may not cancel not make any changes to your board plan after the first Friday after registration each semester. Students with extenuating circumstances for canceling the room and board agreement must request, in writing from the Residential Life Office, a waiver for board refund.

Payment of Fees

1. Tuition and fees must be paid by registration or the student must be enrolled in a payment plan available on NMT's secure TouchNet site accessed through their account on Banweb (see no. 4). Financial aid that has been awarded to the student will be credited to the student's account at this time.
2. Students with delinquent accounts will not be allowed to register for a new semester.
3. Payment for bookstore merchandise must be made in full at the time of purchase. (The bookstore accepts most major credit cards.)
4. Students are able to set up deferred payments for the semester and have the option to sign up through New Mexico Tech's e-billing system. Currently, a three installment plan is available. Students can establish a payment plan on all costs – tuition, room-and-board and student fees – with a 20 percent down payment due at registration. A non-refundable \$25 setup fee will be charged for students who elect to enroll in the deferred payment plan.
 To log in to the Tech e-billing page, visit https://secure.touchnet.com/C22533_tsa/web/login.jsp
5. Students whose accounts are not paid in full by the due date or who have not made alternate arrangements with the Student Accounts Office are subject to permanent loss of academic credit, as well as disenrollment from all classes. Students have the right to appeal to the Dean of Students in writing no later than one week (five working days) before the final payment date.
6. A check will automatically be issued to students with a credit balance of \$100 or more. Refund checks will be issued twice during registration week (actual days will be determined on a semester-by-semester basis) and every Friday afternoon thereafter. Students who have a credit balance of less than \$100 must request the refund at the Student Accounts office. Checks will be held at the Cashier's window for pick up by the student. A current, valid student ID must be presented. Students can also elect to have their refunds direct deposited to their checking or savings account via the e-billing system.
7. All financial aid—including scholarships, loans, and grants—is applied during the semester in which it is awarded. Aid cannot be applied retroactively.
8. Rent for Student Family Housing must be paid in advance. Students with delinquent housing accounts may be asked to vacate campus residences.
9. Telephone charges must be paid by the tenth of the month, or service may be terminated.

Definitions of Fees

Admission Fee

An Admission Fee is payable when the applicant is admitted and ensures the student's inclusion in the registration procedures. The fee is not refundable.

Application Fee

Each student applying for admission to New Mexico Tech must submit an application fee for undergraduate or graduate admission. This nonrefundable fee must be received before the application can be processed.

Auxiliary Services Fee

This fee defrays expenses of various auxiliary services on the campus, including the Swim Center, Macey Center, Golf Course, Children's Center, and Student Activity Center.

Bond Retirement Fee

This fee goes toward paying off bonds issued for general purpose facilities built on campus

Challenge Examination Fee

Special or challenge examinations must be arranged in advance and a fee per semester hour is charged for each.

Computer Usage Fee

The Tech Computer Center charges a basic fee to each student who uses the machines. Additional fees for file storage space and printouts beyond the minimum will also be charged.

Deferred Payment Plan Fee

A fee is charged to students who qualify for a deferred payment plan covering room and board. If the student chooses not to use the online payment plan system for these charges, One-third of the total amount is due at registration and the balance is due in accordance with a schedule set by the Business Office. Students will not be allowed to register for a new semester until their accounts are paid in full for the previous semester. Students who have delinquent accounts are subject to administrative withdrawal of current registration and loss of credits for the semester.

Graduation, Thesis, and Dissertation Fees

When candidates for the associate's or bachelor's degree file their candidacy declaration, they pay a graduation fee to cover the cost of diploma and other expenses related to graduation. Students completing the master's and doctoral degrees are charged designated graduation fees.

Health Center Fee

The Health Center Fee provides a base for the support of the Student Health Center including staffing.

I.D. Card Replacement

A fee is charged for the replacement of lost student identification cards. Broken or worn cards are replaced for no charge but must be turned in to the Registrar's Office at the time that the new card is issued.

Institute Activities Fee

The Institute Activities Fee provides a base for the support of student social and cultural activities and corresponding facilities.

Late Registration Fee

Students who fail to register during the designated period are charged a late fee. This stipulation applies to all regular undergraduate and graduate students. Special students are not charged this fee.

Orientation Fee

A fee is charged for new student orientation.

Readmission Fee

A fee is charged for processing readmission to Tech for students who are readmitted through the Academic Standard Committee.

Room and Board

Room and board are charged through the Residential Life Office. The total amount varies depending upon the type of room occupancy and meal contract. The base rate is calculated for double occupancy of room with 150 block meal plan. Other meal plans are available. At an additional charge, single occupancy is offered when space permits. Students must supply all linens, including a mattress pad protector. More information is provided in the housing agreement, which must be executed for each academic year.

The semester charge for room and board does not include meals during recesses nor during the few days at the beginning and end of each semester when most students are away from the campus. The student may only occupy the room during break periods if they live in an apartment (Altamirano, Desert Willow, and Mountain Springs). The traditional halls (Driscoll, Presidents, West, South, Baca, and Torres) are closed between fall and spring semesters and may be closed at other times between terms when conditions warrant. Schedules for residence halls and dining facilities are published on the Residential Life rate sheet.

Room Reservation/Damage Deposit Fee

A Room Reservation/Damage Deposit is required before housing will be assigned. The deposit will be refunded under the following conditions:

- 1)The student has been declared academically ineligible to enter, continue, or return to New Mexico Tech.
- 2)The term of the student's Room and Board Agreement has been completed (i.e., the student has remained in the Residence Hall the entire academic year), and no damage has been noted.

If the student has filled out the necessary paperwork to ensure himself/herself a room for the semester but cancels the room reservation or does not show up for check-in by the first day of classes, the student is subject to the Room Cancellation Policy. If a student is unable to check in by the first day of classes, he or she must request, in writing, to have the room set aside for a specific day. This specific day should not exceed a week from the first week of classes.

Sports Activities Fee

This fee is charged each semester in support of the intramurals program and corresponding facilities.

Student Activities Fee

All students pay a Student Activities Fee each semester. The funds collected are disbursed to the student organizations and activities according to a budget prepared by the Student Association and approved by the administration.

Student Center Fee

A Student Center Fee provides monies to amortize and support the Joseph A. Fidel Center.

Student Counseling Fee

Approved by the Student Association, this fee provides a base to make counseling and support available to the students of New Mexico Tech.

Technology Support Fee

The Technology Support Fee provides a base for the support and services to maintain wireless and computer technology across the campus.

Withdrawal Fee

Students who withdraw from a class or classes after registration closes must pay a withdrawal fee for every withdrawal authorization form.

Registration

[Contact: Office of the Registrar, New Mexico Tech, 801 Leroy Place, Socorro, NM 87801; 575.835.5133; fax: 575.835.6511; registrar@nmt.edu]

Orientation

Undergraduate Orientation

Undergraduate orientation is held over the summer months for incoming students and begins the transition from high school or other colleges to New Mexico Tech. Students will have a chance to meet with other students, learn about the campus, the requirements and support offices for students in their undergraduate studies. Students will be able to meet with the different major department representatives and/or advisors, can pay their tuition and register for classes.

Graduate Orientation

Graduate orientation for incoming students begins the transition to New Mexico Tech graduate school. You'll have a chance to meet other graduate students, learn about requirements and support for graduate studies, and meet staff who will assist you during your studies. Orientation is held at the beginning of fall semester. If you begin during the summer or spring semester, contact the Center for Graduate Studies to watch the orientation video.

Teaching assistantship (TA) orientation is *required* for all teaching assistants before they begin teaching and is held at the beginning of fall semester. If you begin during the summer or spring semester, contact the Center for Graduate Studies to watch the TA orientation video.

Registering for Courses

Regular students can register online at <http://banweb.nmt.edu>. You must obtain your "alternate PIN" from your advisor before registering. Instructions for registering online can be found at the registrar's web page, www.nmt.edu/registrars-office.

Specific days are set aside for registration (see Academic Calendar). You may register online or in person through the second Tuesday of instruction which is the last day to add any classes to a student's schedule.

The last day to drop any courses without financial responsibility is the third Friday of the semester. After this date no schedule changes will be allowed without approval from the Vice President of Academic Affairs, and will only be considered under extreme or unusual circumstances and on a case by case basis.

Schedules of course offerings, with time and place of meeting and the name of the instructor in charge, are available at <http://banweb.nmt.edu> before the registration period of each semester or summer session.

A course may be cancelled if demand or resources are insufficient. Students are encouraged to discuss with their advisors their interest in courses not currently offered. You must be enrolled in a class to attend that class. Students may not "sit in" on a class for which they are not registered at New Mexico Tech.

Validation

Undergraduate Validation - You must settle your financial status (validate) with the NM Tech Business Office before your registration will be considered complete. Students who have not validated by the Wednesday (fall and spring semesters) and on Friday (summer semester) before the close of registration are subject to disenrollment from classes.

Graduate Validation - If you have a teaching or research assistantship contract, you may validate through the Graduate Deferment Payment plan with Student Accounts.

Prerequisites and Co-requisites

Some courses have prerequisites, courses you must successfully complete before enrolling in that course. Exceptions can be made with approval of your advisor and instructor. If you enroll in a course in which you do not have the prerequisites without permission from your advisor and instructor, you will be disenrolled from the course with notification.

Corequisites are courses that should be taken during the same semester.

Prerequisites and corequisites are not determined by the student's individual catalog, but rather by the catalog in effect at the time that the course is taken.

Registration Fees

Late Registration Fee

Students who fail to register during the designated period are charged a late fee per day. This stipulation applies to all regular undergraduate and graduate students. Special students are not charged this fee.

Changes in Registration

A student may change their registered courses by filing a Change-of-Registration form with the Registrar. No classes may be added after the second Tuesday following the beginning of classes. During the first three weeks of a fall or spring semester, and through the second Tuesday of the summer session, a student may drop a class without penalty, and the course will not appear on the permanent record. After the third week of classes in a fall or spring semester or the second Tuesday of a summer session, the student must file a Withdrawal Authorization Form and pay the withdrawal fee. The grade "W" will appear on the student's permanent record. A student may not withdraw (W) from a class after the tenth week of a fall or spring semester, or the fifth week of a summer session. You may change to audit or S/U up to the end of the tenth week of the semester or the fifth week of the summer session.

Purpose:

The purpose of Cross Enrollment Agreement(s) are to allow qualified and approved students to concurrently enroll in a limited number of undergraduate or graduate courses/credit hours at another College/University within the State of New Mexico while reducing admissions processes and fees should a student apply to both institutions separately. While the primary concept was to allow graduate students to enroll in courses at another institution to enhance their learning experience and leverage access to expertise, some agreements have been made that select specific undergraduate courses.

Auditing a Class

Students may attend classes as auditors; that is, they may enroll in a course for no credit, with the permission of the instructor of the course. Auditors pay tuition and fees on the same basis as those who enroll for credit. No student will be allowed to change registration from credit to audit or from audit to credit after the tenth week of a regular semester or the fifth week of the summer session. Students may not change from credit to audit or audit to credit more than once in a class. Auditors receive grades of SA (satisfactory audit) or UA (unsatisfactory audit) as determined by the instructor.

Graduate Auditing a Class

Graduate students may attend at most one three credit class as an auditor per semester.

Repeating a Class

A computable grade is a grade with a numerical equivalent: A, A-, B+, B, B-, C+, C, C-, D+, D, or F. A non-computable grade is a grade with no numerical equivalent: SA, UA, S, or U. See page 58 for numerical equivalents of grades. Students may not repeat courses at other institutions.

Undergraduate Repeating a Class

If you received

Then

A, A-, B+, B, B-
C+, C, or S

You may not repeat the class for a grade or credit unless the course description specifically says you may.

C-, D+, D, or F

You may repeat the class for a new letter grade and credit. (You may not repeat on an S/U basis.) The original grade will remain on your permanent record. The new grade will replace the old grade in calculation of your GPA, even if the new grade is lower. If you receive an F, you will receive 0 credit hours for the course, **even if you previously received credit. You may not repeat the class at an institution other than New Mexico Tech.**

SA, UA, or U

You may repeat the course for a grade and credit. If you repeat a course in which you received a U, you **must** take it for a computable grade.

Graduate Repeating a Class

If you received

Then

A, A-, B+, B, B-
C+, C, or S

You may not repeat the class for a grade or credit unless the course description specifically says you may. If a student's overall graduate GPA is below a 3.0, permission to repeat specific courses (with grades of B-, C+ or C) may be requested from the Graduate Dean to meet graduation requirements.

C-, D+, D, or F

You **must** repeat the class for a new letter grade and credit. (You may not repeat on an S/U basis.) The

original grade will remain on your permanent record. The new grade will replace the old grade in calculation of your GPA, even if the new grade is lower. If you receive an F, you will receive 0 credit hours for the course, **even if you previously received credit.** *You may not repeat the class at an institution other than New Mexico Tech.*

SA, UA, or U

You may repeat the course for a grade and credit. If you repeat a course in which you received a U, you **must** take it for a computable grade.

Withdrawing from a Course

You may withdraw and receive the grade of “W” from a course until the tenth week during the fall or spring semester (or the fifth week in the summer session). Talking with your instructor and advisor about your progress at midterm will help you make this decision. Other options include:

- Change to Satisfactory/Unsatisfactory (S/U), which will not affect your GPA. Note: *Graduate students cannot apply graded courses taken for S/U to graduate programs.* See below for more information on S/U grading.
- Change to Audit. (See page 56 for information on audit grades.) You are required to file the appropriate form with the Office of the Registrar in order to withdraw from a course or change to S/U or Audit.

Graduate Withdrawing from a Course

Graduate students must ensure that they successfully complete sufficient credits each semester; check with the Center for Graduate Studies if you have questions before withdrawing from a class.

Graduate students may audit *at most* one class (3-4 credits) per semester and do not earn credit for audits; audit credits do count toward full-time graduate registration.

Attendance

A student is responsible for all material covered in class; however, it is the decision of the individual instructor whether attendance is mandatory or optional. It is the student’s responsibility to ascertain this.

Undergraduate Attendance

Illness or other circumstances that necessitate extended absence from class work should be reported as promptly as possible to the Dean of Students or designated representative who will notify the student’s instructors on valid and confirmed situations. Students called to Military Active Duty must notify the Dean of Students or designated representative and provide appropriate documentation.

Graduate Attendance

Illness or other circumstances that necessitate extended absence from class work should be reported as promptly as possible to the Graduate Dean or designated representative who will notify the student’s instructors. Students on Military Active Duty must notify the Graduate Dean or designated representative and provide appropriate documentation.

Academic Policies

[Contact: Office of the Registrar, New Mexico Tech, 801 Leroy Place, Socorro, NM 87801; 575.835.5133; fax: 575.835.6511; registrar@nmt.edu]

Grading System

A grade is reported for each course in which a student has enrolled to indicate the quality of performance in that course. The grading system used at NM Tech is as follows:

| Grade Point Per Semester Hours | Grade | Definitions |
|--------------------------------|-------|------------------------------|
| 4.00 | A | |
| 3.67 | A- | |
| 3.33 | B+ | |
| 3.00 | B | |
| 2.67 | B- | |
| 2.33 | C+ | |
| 2.00 | C | |
| 1.67 | C- | |
| 1.33 | D+ | |
| 1.00 | D | |
| 0 | F | |
| n/a | S | Satisfactory (C- or better) |
| n/a | U | Unsatisfactory (D+ or worse) |
| n/a | SA | Satisfactory Audit |
| n/a | UA | Unsatisfactory Audit |
| n/a | W | Withdrawal |
| n/a | WO | Withdrawal without Prejudice |
| n/a | PR | Progress |
| n/a | NR | Not Reported |
| n/a | NG | Not Graded |

Grade Point Average (GPA)

The total institutional semester hours in which grades of A, A-, B+, B, B-, C+, C, C-, D+, D, and F have been received are divided into the corresponding total grade points earned to determine the student's cumulative grade-point average (GPA). Likewise, the student's GPA for any time period is found by dividing the credit hours in which grades other than S, U, SA, or UA were received into the total grade points earned during that period. The student's GPA indicates scholastic standing. Results of challenge examinations shall not be included in the student's class load for the semester in which the exam is taken. Transfer credit is not included in the GPA.

Satisfactory/Unsatisfactory (S/U)

Courses may not be taken S/U without consent of the student's academic advisor, the student's major department, and the department in which the course is taken. Approval for the S/U grade basis must be obtained within the first ten weeks of classes. Decisions made at that time for either letter grade or S/U grade evaluation may not be subsequently changed. Students who receive a grade of S will receive credit for the course but that credit will not be applied to any graduate program requirements. The student is not eligible to repeat the course unless the course description specifically says they may. Students who receive a grade of U will not receive credit for the course.

Undergraduate S/U

Students may take up to a total of 18 credit hours on an S/U basis in courses not normally graded S/U, with a limit of 7 credits in any one semester. Some degree programs do not allow courses taken S/U to count for degree requirements.

Graduate S/U

Courses that are normally graded may not be taken on an S/U basis and applied to any graduate program. Graduate students in good standing may take up to a total of 3 credit hours on an S/U basis in courses not normally graded S/U in a given semester. However, such courses cannot be applied to any graduate program requirements.

PR (Progress)

A grade of “PR” for independent study, thesis, or dissertation is given when satisfactory progress on research has occurred during the semester. If research progress has not been satisfactory, a grade of “U” (unsatisfactory) is issued. Students who earn unsatisfactory grades are not making satisfactory academic progress.

Withdraw (W)

A student may not **withdraw (W)** from a class after the tenth week of a fall or spring semester, or the fifth week of a summer session. A W can only be assigned after consulting with the instructor and completing and submitting the appropriate form to the Office of the Registrar. Under no circumstances can an instructor assign a W in a course.

Accessing Final Grades

Final grades are viewable in the secure area of Banweb (<https://banweb7.nmt.edu>) at the end of every semester. Grades are viewable shortly after the instructor submits them, however the students’ GPA and academic standing are not official until the Friday following the last day of the semester.

Change of Grade

The instructor of a course has the responsibility for any grade reported. Once a grade has been reported to the Office of the Registrar, it may be changed only in the case of clerical error or in the case of documented extenuating circumstances. The instructor who issued the original grade must submit in writing the reasons for the change. The change of grade must also be approved by the department chair. Changes in grade must be made within five weeks after the start of the next semester. After this date grade changes can only be done with the approval from the Vice President of Academic Affairs.

Grade Appeal Procedure

A grade must be appealed no later than the end of the semester following the semester in which the student took the class. All questions can be referred to the Office of the Registrar.

Undergraduate Grade Appeal Procedure

Undergraduate students seeking grade changes must speak first with the instructor, next with the department chair, and finally with the Vice President of Academic Affairs.

Graduate Grade Appeal Procedure

Graduate students seeking grade changes must speak first with the instructor, next with the department chair, and finally with the Dean of Graduate Studies.

Withdrawal without Prejudice (WO)

(See also [Withdrawing from a Course, page 57](#))

Under extremely unusual circumstances (for example, serious illness or death in the student’s immediate family), a student may petition for a withdrawal without prejudice. Students may not withdraw without prejudice from a course they are failing due to plagiarism, cheating, or other disciplinary issues. Charges for tuition and fees are not altered by such a withdrawal.

Undergraduate Withdrawal without Prejudice

A petition for an undergraduate withdrawal without prejudice should be submitted to the Dean of Students for review and consideration. The petition must include the completed Withdrawal Without Prejudice Request Form, a written letter explaining the circumstances, and supporting documents (a statement from a physician, obituary, etc.). The deadline for submission of the petition is the Friday before the start of final exams. In rare cases the Dean of Students may consider requests after the deadline.

Graduate Withdrawal without Prejudice

A petition for a graduate withdrawal without prejudice should be submitted to the Graduate Dean for review and consideration. The petition must include the completed Withdrawal Without Prejudice request form, a written letter explaining the circumstances, and supporting documents (a statement from a physician, obituary, etc.). The deadline for submission of the petition is the Friday before the start of final exams. In rare cases the Graduate Dean may consider requests after the deadline.

Graduate Satisfactory Academic Progress

Graduate students must achieve at least a 3.0 GPA every semester and earn no grade below C to maintain satisfactory academic progress. In addition, fulltime graduate students must enroll in at least 9 credits in the fall and spring or 12 credits if on contract and 6 credits in summer. In the last semester, fulltime graduate students, with prior approval may use a one-time reduced registration for as few as three credits (with advisor approval). After a successful thesis or dissertation defense, a graduate student may use a one-time post-defense registration for as few as one credit (with advisor approval). If a student does not complete during reduced registration, they must register for a full load (as described above) in subsequent semesters. Finally, students must achieve satisfactory progress in each research course / project. Failure to meet any of these requirements results in a failure to achieve satisfactory academic progress in the associated semester.

At program completion (for certificates, Masters, and Ph.D. degrees) graduate students must have at least a 3.0 cumulative and have no grade below C on their graduate transcript. Graduate students who do not meet these GPA requirements must retake the associated course (s).

Readmission

A student who has not been continuously enrolled (excluding summer session) must submit an application for readmission to the Office of the Registrar. In addition to the application, a student who left while on academic probation or academic suspension must submit the following documents:

- A one-page appeal letter that persuasively makes a case for readmission;
- A supporting letter from the student's advisor;
- An Academic Warning Plan completed with input from the student's advisor;
- Such other documents as the student thinks are relevant, such as medical documents or letters of support from faculty, counselors, or the Dean of Students.

A student in good standing will be readmitted by the Registrar. Application and material submitted by a student who left while on academic probation or academic suspension will be reviewed by the Academic Standards and Admission Committee and written notice of the decision will be given to petitioner.

Students will not be readmitted after their third suspension except in very unusual circumstances.

The deadline for all readmission Materials is the Wednesday at 5pm prior to the first day of classes.

Conditions of Readmission

A readmitted student must choose degree requirements to be satisfied from the catalog in effect when the student was readmitted or any subsequent catalog, provided the student be continuously enrolled after readmission. A student readmitted by the Academic Standards and Admission Committee must follow the guidelines set by the committee. If accepted for readmission, a student on academic probation or suspension will be automatically placed on academic probation for 3 semesters excluding summer semesters and subject to all the rules and regulations of a student on probation.

Academic Probation and Suspension

Note: Disciplinary probation and suspension are different than academic probation and suspension. Please see the Responsible Conduct section of the Student Handbook for information about disciplinary probation and suspension.

Academic Regulations

The academic regulations have a two-fold purpose:

- 1) to prevent the dissipation of the resources and time of students who fail to make reasonable progress in their academic programs at New Mexico Tech, and
- 2) to facilitate the maintenance of high academic standards at New Mexico Tech.

Academic Probation

Undergraduate Academic Probation

A student whose semester GPA falls below the minimum requirements needed for good standing will be placed on academic probation for the next regular semester of enrollment. Students are continued on probation if they withdraw from New Mexico Tech while on probation.

Graduate Academic Probation

A graduate student who fails to achieve satisfactory academic progress will be placed on academic probation for the next regular semester of enrollment. Students are continued on probation if they withdraw from New Mexico Tech while on probation .

Academic Suspension

Undergraduate Academic Suspension

Students who fail to achieve the minimum semester GPA for a second consecutive semester will be placed on academic suspension unless their cumulative GPA is 2.0 or better. A student on academic suspension is denied the privilege of enrolling at New Mexico Tech for the specified period of time.

Graduate Academic Suspension

Graduate students who fail to achieve satisfactory academic progress for a second consecutive semester will be placed on academic suspension. A graduate student on academic suspension is denied the privilege of enrolling at New Mexico Tech for the specified period of time.

Notification of Academic Suspension

Notification to the student of academic suspension will be made in writing to the address on file in the Registrar's Office. Academic probation and suspension will appear on the student's official transcript at the end of each grading period.

Duration of Academic Suspension

The first academic suspension from New Mexico Tech will be for one regular (fall or spring) semester. Second and subsequent academic suspensions will be for one calendar year. A student academically suspended after the fall semester is suspended for the following spring and summer semesters. A student academically suspended after the spring semester is suspended for the following summer and fall semesters. A student academically suspended after the summer semester is suspended for the following fall semester. Credits earned at another institution during the period of academic suspension at New Mexico Tech will not be accepted for transfer at New Mexico Tech. Students will not be readmitted after their third suspension except in very unusual circumstances.

Appeal of Suspension

Undergraduate Appeal of Suspension

A student who, after conferring with his or her advisor, feels that he or she has been unjustifiably placed on suspension may appeal for a change of status by written petition to the Academic Standards and Admission Committee. A student may appeal suspension by petitioning for readmission. Petitions must be submitted to the Office of the Registrar by 5:00pm the Wednesday before classes begin.

Graduate Appeal of Suspension

A student who, after conferring with his or her advisor, feels that he or she has been unjustifiably placed on suspension may appeal for a change of status by written petition to the Dean of Graduate Studies. A student may appeal suspension by petitioning for readmission. Petitions must be submitted to the Center for Graduate Studies by 5:00pm the Wednesday before classes begin.

Other Policies

Academic Load

The academic year at NM Tech consists of two semesters. A class hour is 50 minutes in length; ordinarily, a laboratory period is about three times as long. One class hour or laboratory period a week through a semester gives one credit hour.

The Veterans Administration requires students on the GI Bill to carry a minimum of 12 credit hours (6 credit hours in summer) to qualify for full benefits. Physical Recreation (PHED), Fine Arts (ARTS), and Community Education (designated by the letter "C" in the course number) courses do not count toward the minimum credit hours for veterans. Complete information can be obtained from the Veteran's Administrator.

Undergraduate Academic Load

A full-time undergraduate should carry an academic load of approximately 16 credit hours per semester for the fall and spring semesters. During the summer session, 6 credit hours is a full-time academic load; 3 credit hours is half-time.

Graduate Academic Load

Full-time graduate students must carry a load of at least 9 credits each fall and spring semester. Graduate students on assistantships must carry at least 12 credits in the fall and spring. Graduate students who are in residence during the summer must register for 6 credits. Physical Recreation (PR), Fine Arts (FA), Health and Wellness (HW), Lifestyle Activities (LIFE), and Community Education (CED) courses (designated by the letter "C" in the course number) do not count toward the minimum credit hours for graduate students. Graduate loads normally only count courses numbered 300 and above.

Part-time graduate students must register each fall and spring semester for 1-8 credits. If in residence during the summer, part-time graduate students must register for 1-6 credits.

Directed Study Course

Undergraduate Directed Study Course

To be included as part of student declaration of courses fulfilling degree requirement, directed study courses (courses numbered 491 and 581) require the approval of the department chair in the major department, the chair of the department offering the course, and the student's advisor. Approval must be obtained before the student takes the course.

Graduate Directed Study Courses

Directed study courses (courses numbered 491 and 581) are not typically accepted to meet graduate requirements. To be included as part of a student's declaration of courses fulfilling degree requirements, directed study courses require the approval of the student's graduate committee, the department chair in the major department, and the Graduate Dean unless the use of directed study is explicitly listed as applicable in the graduate student's degree program requirements. Approval must be obtained before the student takes the course and recorded in the student's graduate file in the Center for Graduate Studies.

PRIVACY OF STUDENT RECORDS(FERPA)

STUDENT RECORD REGULATIONS

“Student Record” means all material concerning an individual student maintained in any form by New Mexico Tech or its employees, or Board of Regents, or contracted Third Party, except personal notes maintained by academic or other school personnel solely for their own individual use and not communicated to any other person. If these personal notes are transmitted to any dean, department, chairperson, academic program director, advisor, or administrator, they become student records to be treated in accordance with these rules and regulations. “Student” means any individual currently or previously enrolled in any academic offering of New Mexico Tech.

Transcripts and other documents in a student’s file from other institutions, organizations or individuals submitted to New Mexico Tech for admission, credit transfer or under control of the Registrar’s Office become the property of New Mexico Tech, and cannot be returned to the student or forwarded to other institutions. Under Federal policy, the student has the right to view the documents in their file; New Mexico Tech does not provide copies of these documents.

RETENTION AND SECURITY OF RECORDS

Records managers shall have the overall responsibility for maintaining and preserving the confidentiality and security of student records. The records managers may, however, designate another professional employee of the school to perform the duties of records manager.

- The Director of Human Resources shall be the records manager for records maintained regarding on-campus employment
- The Registrar shall be the records manager for academic records maintained by the central administration of the school
- The Director of Alumni Relations shall be the records manager for the records maintained by the Alumni Office
- The Director of Operations of the Career Management Center shall be the records manager for records maintained by the Career Management Center
- The Controller shall be the records manager for records maintained by the Accounting Office
- The Director of Financial Aid shall be the records manager for the records maintained by the Financial Aid Office
- The Academic Program Chairs shall be records managers for the records maintained by their programs
- The Director of International Students & Scholars Office shall be the records manager for the records maintained by the International Students & Scholars Office.

STUDENT RECORD CONFIDENTIALITY

Notification of Rights Under FERPA

The Family Educational Rights and Privacy Act of 1974 (FERPA) affords eligible students certain rights with respect to their education records. An “eligible student” under FERPA is a student who is 18 years of age or older or who attends a postsecondary institution. These rights include:

- 1. The right to inspect and review the student's education records within 45 days of the date that New Mexico Institute of Mining and Technology (New Mexico Tech) receives a request for access.**
 - Current and former students who wish to make a FERPA-related request to view records should submit an online or written request to the Office of the New Mexico Tech Registrar that identifies the record(s) the student wishes to inspect.
 - Applicants do not have FERPA rights unless and until they are admitted and are in attendance at the New Mexico Tech.
 - Students are advised to **provide complete information** in order to assist the New Mexico Tech in following up on the request. Federal law requires that the New Mexico Tech provide access to requested extant records within 45 days.
 - A Registrar's Office official will make arrangements for access and notify the student of the time and place where the records may be inspected. If the records requested are not under the control of the Registrar's Office, the Registrar's Office will make arrangements for the relevant office to provide the records within the time frame established under the law.
- 2. The right to request the amendment of the student's education records that the student believes are inaccurate, misleading, or otherwise in violation of the student's privacy rights under FERPA.**
 - A student may ask the New Mexico Tech to amend the record that he or she believes is inaccurate or misleading. The student should write the New Mexico Tech official responsible for the record (with a copy to the New Mexico Tech Registrar), clearly identify the part of the records he or she wants changed, and specify why it should be changed.

- If the New Mexico Tech decides not to amend the record as requested by the student, the New Mexico Tech will notify the student in writing of the decision and advise the student of his or her right to a hearing regarding the request for amendment.
 - Additional information regarding the hearing procedures is provided to the student when notified of the right to a hearing.
- 3. The right to consent to disclosures of personally identifiable information contained in the student's education records, except to the extent that FERPA authorizes disclosure without consent.**
1. FERPA contains various exceptions to the general rule that the New Mexico Tech should not disclose education records without seeking the prior written consent of the student. The following circumstances are representative of those in which education records (and information drawn from education records) may be disclosed without the student's prior written consent:
 2. Upon request, the New Mexico Tech may release Directory Information (see the "FERPA Directory Information" section below).
 3. School officials who have a legitimate educational interest in a student's education record may be permitted to review it. A school official has a legitimate educational interest if the official needs to review an education record in order to fulfill his or her responsibility to NMT or to the student.
 - a school official is: a person employed by the New Mexico Tech in an administrative, supervisory, academic or research, or support staff position (including law enforcement unit personnel and health staff);
 - a person or company with whom the New Mexico Tech has contracted (such as an attorney, auditor, or collection agent);
 - a person serving on the Board of Trustees/Board of Regents; or a student or volunteer serving on an official committee (or representing a recognized student group), such as a disciplinary or grievance committee, or assisting another school official in performing his or her tasks.
- 4. FERPA permits disclosure of personally identifiable information (PII) from students' educational records, without consent of the student, if the disclosure meets certain conditions found in FERPA regulations. Some examples are:**
- New Mexico Tech must provide records in response to lawfully issued subpoenas, or as otherwise compelled by legal process.
 - New Mexico Tech discloses education records without consent to officials of another school, in which a student seeks or intends to enroll, upon request of officials at that other school.
 - The New Mexico Tech may choose to disclose education records (and information drawn from education records) to either supporting parent(s) or guardian(s) where the student is claimed as a dependent under the Internal Revenue Code.
 - The New Mexico Tech may inform persons including either parent(s) or guardian(s) when disclosure of the information is necessary to protect the health or safety of the student or other persons.
 - For students under the age of 21, the New Mexico Tech may notify either parent(s) or guardian(s) of a violation of any law or policy relating to the use of alcohol or controlled substances.
- 5. The right to file a complaint with the U.S. Department of Education concerning alleged failures by New Mexico Tech to comply with the requirements of FERPA.**

The name and address of the office that administers FERPA is:

Student Privacy Policy Office
 U.S. Department of Education,
 400 Maryland Avenue, SW,
 Washington, DC 20202-4605.

FERPA Directory Information

- **Student's name**
- **Address** (local and campus box number)
- **Telephone listing**
- **Electronic mail address**
- **Photographs, videos and other similar information**
- **Major field of study**
- **Dates of attendance**
- **Class** (freshman, sophomore, junior, senior)
- **Degrees, honors, and awards received**
- **The most recent educational agency or institution attended**
- **Student ID number, user ID, or other unique personal identifier used to communicate in electronic systems but only if the identifier cannot be used to gain access to education records except when used in conjunction with one or more factors that authenticate the user's identity, such as a PIN, password, or other factor known or possessed only by the authorized user**
- **A student ID number or other unique personal identifier that is displayed on a student ID badge, but only if the identifier cannot be used to gain access to education records except when used in conjunction with one or more factors that authenticate the user's identity, such as a PIN, password, or other factor known or possessed only by the authorized user.**

The student is entitled to request that this information not be made publicly available by a request, in writing, to the Registrar at least one week prior to the beginning of Fall, Spring, or Summer. Requests received after the beginning of the term will be effective for the next term.

NOTE: It is still permissible for the school to release information to lenders, guarantee agencies, or the Department of Education concerning the enrollment status or address of any student or previous student who has obtained a loan under the Federal Perkins Loan, Federal Stafford Student Loan, Federal Graduated PLUS Loan and/or Private Education/Alternative Loan Programs.

STUDENTS OPTING FOR NO RELEASE IN THE CLASSROOM SETTING:

Students cannot choose to be anonymous in the classroom setting. If a student has chosen “no release” for their directory information, that does not mean that an instructor cannot call on the student by name in class or that the student’s email address cannot be displayed on an electronic classroom support tool such as a discussion board, blog, or chat feature. In addition, courses or sections offered through distance learning require a student photograph as identification similar to a student wearing an ID in an in-person class and is not subject to “no release” in a “classroom setting.”

CONSENT TO USE OF PHOTOGRAPHIC IMAGES:

Registration as a student and attendance at or participation in classes and other campus and New Mexico Tech activities constitutes an agreement by the student to the New Mexico Tech's use and distribution (both now and in the future) of the student's image or voice in photographs, video or audio capture, or electronic reproductions of such classes and other campus and New Mexico Tech activities.

If any student in a class where such photographing or recording is to take place does not wish to have his or her image or voice so used, the student should raise the matter in advance with the instructor.

Lecture Capture Videos: FERPA does not prohibit instructors from making a recording of virtual lectures or class sessions available to students controlled in the course. However, sharing the recordings beyond students enrolled in the course would generally require prior written consent.

SOCIAL SECURITY NUMBERS IN STUDENT RECORDS

As required by law, social security numbers are collected from prospective and current students who plan to seek employment on campus or wish to receive financial aid. In addition, the university is mandated by federal tax regulations to provide tuition and fee payment information to the student and the Internal Revenue Service, so that applicable educational tax credits may be computed. The social security number will be necessary to submit this tax reporting. The social security number is a confidential record and is maintained as such by the university in accordance with the Family Educational Rights and Privacy Act.

SHARING INFORMATION WITH PARENTS

Students are encouraged to maintain an ongoing, open dialogue with parents throughout their careers at NMT about academic progress and personal development. Most student difficulties are resolved at NMT without involving parents. Students may sign a release for Parents to discuss specific information with one of NMT student offices. The consent form can be found on the Registrar's Home page under FERPA. The New Mexico Tech does recognize, however, that there are some exceptional situations where parental involvement may be appropriate to assist a student through a difficult circumstance. Under those circumstances, NMT may (but is not required to) choose to disclose information to parents if permitted by law.

Under the Family Educational Rights and Privacy Act (FERPA), NMT is permitted to disclose information drawn from education records to parents if one or more parent claims the student as a dependent for federal tax purposes. Some laws, especially those relating to medical and mental health care, prohibit the disclosure of information without the student's consent, even where the student is a tax dependent.

PROCEDURE FOR INSPECTION OF RECORDS

- Step 1.** Students may request, in writing, the opportunity to inspect personal records. The request should be made to the records manager or designee in the department in which the records are on file.
- Step 2** Such requests must specify records to be inspected. A request to inspect the pertinent records will be granted within a reasonable period of time, but such time is not to exceed forty-five days after the request has been made. Records will be inspected by the student or other authorized individual in the presence of the records manager or designee. Students may take notes but not remove, photo copy or photograph actual documents.
- Step 3.** A notation will be placed in the file each time it is inspected by anyone other than authorized school personnel

PROCEDURES FOR CHALLENGE OF RECORDS

Step 1: In the event that a student objects to any decision of a records manager regarding the retention of any student data, in whole or in part, such student shall make the objection known in writing to the records manager of those records.

Step 2: If the objection is not satisfied by discussion with the records manager, the student shall have the right to appeal to the Vice President of Academic Affairs. The student may challenge the retention of any data in the student record on the basis that it is inaccurate, misleading, or otherwise a violation of the privacy or other rights of the student. Request for appeal shall be in writing and must identify the specific portion(s) of the record to be challenged and state the reason for the challenge. Grades may be challenged under this procedure only on the basis of the accuracy of their transcription.

Step 3: The Vice President of Academic Affairs (VPAA), or designee, shall create a review panel composed of the one Dean and two faculty members. Additional staff members may be involved, but will not be voting members of the committee. The review panel shall decide, upon appeal of the student, whether the challenged student data should be destroyed or amended.

Step 4: The review panel shall, within four weeks after being notified of such appeal, or longer should the appellant request delay, conduct a fair hearing to decide the issues presented by the appellant.

The records manager shall have the burden of proof with regard to the issues presented by the appellant

The appellant and the records manager shall have the right to be represented by an advocate of his or her choosing, cross-examine witnesses, present evidence, make a tape recording of the proceedings, and request a written decision supported by reasons

Potential Outcomes

- If the student appeals according to the provisions set forth above and obtains a favorable ruling, the contested data shall be expunged from the student's record or corrected.
- If the student receives an unfavorable ruling upon appeal, then the objection must be noted in the student's record and the student be given the opportunity to insert a written rebuttal into the record.

The Department of Education has designated the following office to investigate, process and review violations and complaints. Any student who feels, after a hearing, that the school has not acted in accordance with the law may contact this office:

Student Privacy Policy Office
U.S. Department of Education
400 Maryland Avenue, SW
Washington, D.C. 20202-4605

PROCEDURE FOR INSPECTION OF FINANCIAL AID RECORDS

- The general procedure for inspection of records also applies to financial aid records and follows the same procedure for inspection
- The records and conversations between any aid applicant, his/her family, and the staff of the Financial Aid Office are confidential
- As a rule, all currently enrolled and former students have the right to review their financial aid records to determine their content and accuracy with the exception of those records including parental information and confidential references or recommendations for scholarships received from prior institutions attended, other individuals or from faculty and staff of New Mexico Tech
- A student who wishes to obtain access to his/her financial aid records is able to do so in the presence of a Financial Aid Office full-time employee
- Information may be disclosed to other institutional employees, if deemed appropriate, and representatives of Federal and state agencies, auditors and accrediting organizations

Students, faculty, and others with questions regarding student records should contact the Office of the New Mexico Tech Registrar.

Requesting a Transcript

In order for your official transcript to be released, you must have a zero balance or a credit balance at New Mexico Tech. Should you have a balance, contact NMT's Student Accounts by phone at 575.835.5338.

New Mexico Tech has partnered with Parchment Send to fulfill transcript orders. Transcripts are ordered online at <http://www.nmt.edu/registrar/transcripts.php>. The student will initially need to create an account with Parchment using an email and password of choice.

Information Needed to Create a Parchment Account

You must provide the following information:

- Your name, address and phone number.
- The name you had when you attended NM Tech
- Your NM Tech ID and last 4 digits of your Social Security number or your full Social Security number if Tech ID is unknown.
- The approximate years you attended NM Tech

Ordering a Transcript

You can order an official transcript through Parchment to be delivered:

- Electronically or by mail. There is a search feature in Parchment to look up institution information; when using this feature, if the institution name, acronym, location, or email does not match the address you would like to send it to, please use the “Send to Yourself, Another Individual, or Third Party” option.
- For pickup by the student (or authorized individual) in the Office of the Registrar. Note that you must request the transcript through the “Send to Yourself, Another Individual, or Third Party” option for pickup.
- You can request a rush transcript for an additional fee of \$3 per transcript. The transcript order is processed within two working days.
- There is an option to “Hold for Grades” or “Hold for Degree.” When selected, the order will be processed once final grades have been processed or degree has been conferred, respectively.
- There is an option to upload attachments to the transcript if needed.
- With the exception of transcripts ordered for pickup, all transcript orders are processed in the Office of the Registrar and fulfilled through Parchment. Once the order has been processed, the Office of the Registrar cannot track transcripts. Parchment will notify the student once the order has been fulfilled.

Unofficial Transcripts

Unofficial paper transcripts are available for in-person pickup only; the student must provide a valid photo ID. The Office of the Registrar cannot provide electronic unofficial transcripts. Unofficial transcripts can also be obtained by the student through Banweb.

Residency

Changing Your Residency

Requirements to establish New Mexico residency: If you are over 18 years of age, you may become a legal resident of New Mexico for tuition purposes by meeting each of the following requirements as defined by the New Mexico Higher Education Department.

A. Twelve month durational requirement.

A person must physically reside in New Mexico for the twelve consecutive months immediately preceding the term for which the resident classification is requested.

B. Financial independence requirement.

Only persons who are financially independent may establish residency apart from parents or guardians. A student cannot be approved for residency who is financially dependent upon his or her parents or legal guardians who are nonresidents of New Mexico. Dependency is always determined by the status of the student on their parent's or guardians previous year federal income tax form. If the student is shown to be dependent, they will not be considered financially independent or eligible for residency during the current year.

C. Written declaration of intent requirement.

The student or person must sign a written declaration of intent to relinquish residency in any other state and to establish it in New Mexico, this is also known as the Application for In-State Residency.

D. Overt acts requirement.

Overt acts are required as evidence support of the written declaration of intent to establish permanent residency in New Mexico.

The required overt acts are evidence of any two of the following:

- If the applicant is financially dependent, a copy of the parent or guardians' previous year income tax showing the applicant as a dependent and the parent address as New Mexico; or
- A New Mexico high school transcript issued in the past year confirming attendance at a New Mexico public or private high school completing as least 2 semesters (12) months; or
- A transcript from an online high school showing a New Mexico address confirming attendance with the completion of 2 semesters twelve (12) months; or
- A New Mexico driver's license or ID card with an original date of issue or a renewal date issued prior to the application date for admission; or
- Proof of payment of New Mexico state income tax for the previous year; or
- Evidence of employment within the state of New Mexico; or
- New Mexico vehicle registration; or
- Voter registration in New Mexico; or
- A bank account established in New Mexico prior to the application date for admission; or
- Proof of residential property ownership in New Mexico; or
- A rental agreement within New Mexico; or
- Utility bills showing the applicant name and a New Mexico address; or
- Other evidence which would reasonably support the individual's intent to establish and maintain New Mexico residency.

Any act considered inconsistent with being a New Mexico resident will cause the request for resident classification to be denied. As such, other relevant factors may be considered in addition to the items listed in this Section.

The Higher Education Department recognizes that there may be circumstances in which a student would not be able to fulfill the requirements of an overt act as listed in this section, such as: 1) individual is physically disabled and does not have a driver's license, or 2) individual is a convicted felon and therefore cannot vote, etc. In instances such as these, the institution will afford the student an opportunity to provide other documentary evidence or reasonable explanation which demonstrates that permanent residency in New Mexico has been established by the student.

All petitions for New Mexico residency are due on registration day and in no case later than the 21st day of the fall or spring semester. You will not be entitled to any refund of tuition if you become a resident during a semester, summer session, or other term. Detailed information concerning residency requirements is available from the Registrar.

Student Use of New Mexico Tech Facilities

Many Tech facilities are available for student use. In order to be eligible, a club or organization must be officially recognized by the Dean of Students, or designated representative and by the Student Association. Facilities may only be used for legal and otherwise legitimate purposes, and that use must not in any way hinder the academic mission of NM Tech. Further details regarding use of classrooms and other facilities may be found in the *New Mexico Tech Student Handbook*

Withdrawing from the University

Students leaving New Mexico Tech, including those who are graduating or transferring to another institution, must withdraw from the university.

Before withdrawing from the university, you must

1. check in all NM Tech property (laboratory keys, gymnasium equipment, etc.);
2. settle or make arrangements for all financial obligations to the university;
3. complete a Statement of Withdrawal form (Forms are available at the Center for Graduate Studies);
4. complete an exit interview with the Financial Aid Office; and
5. notify the Office of the Registrar if you have preregistered for classes offered the next semester. If you withdraw during the semester, you must complete the above steps and:
6. withdraw from all classes (see page 63).

If you do not complete these steps, your transcript and/or diploma may be withheld.

A student may petition for Withdrawal without Prejudice under extremely unusual circumstances, such as serious illness or a death in the student's immediate family (see page 65 for details).

Academic Issues & Appeal Policy and Procedure

Occasionally, students may have reason to disagree with an academic decision or feel that they have a legitimate concern about an instructor or staff member at Tech. Students should be aware that the Associate Vice President of Academic Affairs (for undergraduate students) and the Dean of Graduate Studies (for graduate students) are available to discuss and advise on any troublesome matter of academic concern and frequently helps to expedite resolution of such matters.

The following procedure applies equally to grades or any other academic issues:

- The student first should discuss the issue, orally or in writing, with the instructor or staff member.
- If the student is not satisfied, he or she should then consult with the instructor's department chair or the staff member's supervisor. Every effort should be made to resolve the issues at this level. If the issue or concern is with the department chair, the student should meet with the Associate Vice President of Academic Affairs or the Dean of Graduate Studies.
- If no satisfactory resolution has yet been reached, the student should then present the issue or concern to the Vice President for Academic Affairs or his/her designated representative.
- Non-academic issues must be brought to the Dean of Students (for undergraduate students) and the Dean of Graduate Studies (for graduate students).
- Sexual harassment issues must be brought to the Title IX Coordinator.

Academic Honesty

New Mexico Tech has an outstanding academic reputation and excels as a teaching and research university specializing in areas of science, engineering, and related fields. This reputation is contingent on an environment of academic honesty and integrity. Indeed, the institute's mission statement recognizes integrity as a core value along with creative excellence, collegiality, service, and leadership. New Mexico Tech must honor integrity as a fundamental value. "Dishonesty, cheating, and plagiarism have no place in a respected institution of higher education. But real integrity goes further than these negatives. Integrity means having the courage to defend the truth, to act fairly and honestly in all our endeavors, and to be responsible citizens of the community" (NMT Institutional Values Statement). Academic dishonesty is therefore unacceptable and will not be tolerated at this Institute.

New Mexico Tech's complete Academic Honesty Policy may be found in the Student Handbook. It includes important information about cheating and plagiarism, consequences of violating the Academic Honesty Policy, and the judicial process if charges are brought. All New Mexico Tech students are strongly encouraged to be familiar with this document.

Additional Policies

Students who enroll at New Mexico Tech should do so with the realization that they are presumed to be serious in purpose, and they are expected to conduct themselves as good citizens of the college community. An effective guardianship of the health, general safety, and welfare of all students must be maintained.

The final responsibility for the accomplishment of these purposes must rest upon the administration and faculty of the institution, who may, therefore, prescribe certain rules and enforcement procedures for guidance toward these ends. Information concerning such rules and additional procedures is contained in the *New Mexico Tech's Academic Honesty Policy and Guide to conduct and Citizenship for Students* section of the *New Mexico Tech Student Handbook* and in supplementary bulletins, which may be published from time to time.

New Mexico Tech is committed to the full support of the constitutional rights of its students, including due process in student disciplinary matters. Detailed procedures designed to safeguard students' rights and to guarantee fair and impartial treatment of any disciplinary cases are published in the *New Mexico Tech Student Handbook*. Methods developed to provide due process in student disciplinary matters are based on the 1967 joint recommendations of the American Association of University Professors, the National Association of Students, and the National Association of Student Personnel Administrators, conforming to Title IX—Educational Amendments of 1972.

Continued enrollment in New Mexico Tech is dependent upon the maintenance of satisfactory grades and conformity to the rules of NM Tech.

Check Your *Student Handbook* for General Campus Rules and Policies on:

| | |
|-------------------|----------------|
| Discipline | Privacy Rights |
| Drugs and Alcohol | Quiet |
| Grievance | Vehicle |

Graduation Requirements

To graduate with an undergraduate degree, a student must fulfill the following:

1. The student must be a regular degree seeking student.
2. The student must declare which catalog he or she is graduating under.
 3. If a student is continuously enrolled (excluding summer sessions), the student may choose the degree requirements to be satisfied from:
 - the catalog in effect when the student first enrolled or
 - any subsequent catalog. Students can move up in catalogs however once moved up they cannot move back to older catalogs. Under special circumstances (such as being called away to active military duty), a student may use the catalog under which he or she was admitted (done on case by case basis).
 2. A readmitted student **must** choose degree requirements to be satisfied from:
 - the catalog in effect when the student was readmitted or
 - any subsequent catalog provided the student is continuously enrolled after readmission, but cannot move back.
1. General Education Core Curriculum Requirements —to qualify for all bachelor’s degrees, the student must complete the General Education Core Curriculum Requirements. These are found on page 81 for the Bachelor of Science degree and page 109 for the Bachelor of General Studies degree (gen. ed. and major requirements can be double dipped to fulfill any requirements across both the gen. ed and major if applicable).
2. The student must also complete the courses specified by the major department. Some programs require that the student pass each required class with a grade of “C” or better. Courses required of the major cannot be double-dipped within the major and each individual major requirement must be fulfilled. The minimum number of credit hours for any bachelor’s degree is 120.
3. New Mexico Tech’s Community Education classes (designated by the letter “C” in the course number) may not be used to fulfill the General Education Core Curriculum for a Bachelor of Science degree (page 78). However, these classes may be used to fulfill elective credit for some majors. Check the specific degree requirements for your major.
4. The student’s cumulative grade point average (see page 10) must equal 2.0 or greater.
5. The student must complete a minimum of the last 30 credit hours at Tech.
6. A candidate for a degree, before registering for the final semester of enrollment, must announce candidacy to the Registrar by filing an “Intent to Graduate” form. Deadlines for submitting an Intent to Graduate are June 1 for those completing their degrees in August, 1 for those completing their degrees in December, and November 1 for those completing their degrees in May.
 - At that time, the Registrar must be furnished with a list of all courses the student wishes to submit in fulfillment of requirements for the degree. It is the responsibility of the candidate, in consultation with the chosen major advisor and final confirmation of the Registrar, to make sure that the courses fulfill all requirements for graduation. The Intent must be signed by the student’s major advisor, who certifies that the courses taken meet the requirements for the degree specified. Any arrangement involving a departure from the regular requirements for graduation requires the approval of the Faculty Senate.
 - It is the responsibility of the student to bring any changes of their Intent to Graduate listed courses that are to be used toward their degree(s) to the Office of the Registrar. If a student drops or changes their registered courses in their final semester after turning in an Intent and evaluation of Intent has been done will need to be bring the changes to the attention of the Registrar’s Office. Failure to do so may result in the degree or any minors being incomplete and not awarded.
9. Intent to walk and Intent to Graduate forms have a hard deadline to be turned in no later than the Friday that is 2 weeks before commencement in Spring and the Friday before Thanksgiving break in Fall. There is not an exception to this date.
10. Any substitution or waiver forms being submitted for a degree must accompany the students Intent if not supplied sooner. No more than 15 credits hours may be substituted in any degree. Single course substitutions cannot fulfill more than one major degree requirement (i.e., Math 335 cannot replace MATH 2532 and Math 332, it can only be substituted for one requirement IF applicable and approved).
11. All fees and financial obligations to NM Tech must be paid before a student will be awarded a degree.
12. Students must complete all degree requirements in order to participate in commencement.

Double Majors

Whenever a student satisfies the requirements for two majors, the student shall be awarded one degree listing a double major, and both majors shall be noted on the diploma.

The degrees of Bachelor of Science in Basic Sciences and the Bachelor of General Studies are excluded from the possibility of a double major listing.

Dual Degrees

Students who wish to be granted two undergraduate degrees not only must fulfill all the requirements specified for each individual degree, but also must earn a minimum of 30 credit hours above the requirements for the higher credited degree (example MENG degree requirements is 135 crs– PHYS degree requirements is 120 cr.– both degree requirements need to be met plus 30 credits above the higher degree. In this example is MENG is the higher credited degree, and the minimum requirements needed to be completed for dual degree's would be 165 cr.) The degree of bachelor of General studies is excluded from the possibility of a dual degree listing, and no more than 2 degrees will be awarded at any one time.

Major

Your major is your primary field of study. The number of credit hours required in your major varies by program. Since your choice of major determines which courses you are required to take, it is advisable to declare your major as soon as possible. You may change majors at any time, but the earlier the better.

You must declare a major and be assigned a major advisor prior to completing the coursework for the major.

Minor

New Mexico Tech awards minors for your secondary field of study. (See page 6 for a list of minors.) The number of credits required for a minor vary from department to department. Students cannot earn a minor with either the Associate of General Studies or Bachelor of General Studies.

You must declare a minor and be assigned a minor advisor prior to completing the coursework for the minor. Minors cannot be added after a degree has been conferred.

Terminal Transfer Credits

Terminal transfer credits, credits earned at another college or university in order to complete the last degree requirements at NM Tech, are not allowed except when specified by a particular degree program, or when unusual circumstances appear to justify it. In no case will more than 12 credit hours of terminal transfer credits be allowed. A student who anticipates the need for requesting terminal transfer credit should do so as soon as practical and in no event later than the time of filing the Intent to Graduate for a degree. The request should be addressed to the Vice President for Academic Affairs. It should contain a statement of the circumstances which, in the student's judgment, justify the request and a specific statement of the program proposed for obtaining the terminal credits. Approval, if granted, will be of a specific program.

Curriculum Changes

The Faculty Senate reserves the right to make curriculum changes. Assurance is given to students that proper measures will be employed to avoid hardships that may result from such changes.

Undergraduate students can request a degree audit from the Registrar's Office.

Degree Conferral Schedule

New Mexico Tech confers degrees on a monthly basis. Degrees are submitted for conferral on the first day of each month and will be conferred by the last day of that month. When the Registrar receives documentation that a degree has been completed in the middle of a month, the 30-day conferral process will start on the first day of the next month.

The exception to this schedule is the month of May. If the Registrar receives documentation that a degree has been completed no less than 2 weeks prior the Friday immediately preceding commencement, then that degree will be conferred by the Board of Regents meeting on the Friday immediately preceding commencement. Degrees that are documented as complete after the last day of the spring semester will begin the 30-day conferral process on June 1.

Students who need proof of degree completion pending the conferral process may request a letter of completion from the Registrar's Office.

Commencement

Commencement ceremonies are held each year in May. New Mexico Tech will accept (participate in the ceremony) up to 2 years after your degree conferral. For example, if you conferred your degree between May 2019 and 2020 you may still participate in the commence ceremony through May 2022. Please refer to the Registrar's commencement page for instructions and fees. Students must complete all degree requirements in order to participate in commencement. The only exception is for the earth science major who needs to complete GEOL 480, Field Methods, during the summer immediately following commencement. See the following pages for a list of honors awarded at commencement ceremonies.

Honors and Awards

Honor Roll

An Honor Roll of all students who successfully completed at least 12 credit hours with a grade-point average of 3.0 or better is released at the end of each semester. At least 6 of those credit hours must have received letter grades.

Tech Scholars

The “Tech Scholar” designation is awarded to students who have demonstrated superior scholastic competence and conduct. Nominations are submitted by the academic advisor or major department chair for approval by the VPAA by September 30 each year. To qualify for this unique designation the student must:

1. Have completed 30 or more letter-graded credit hours in residence at New Mexico Tech;
2. Have achieved a cumulative GPA of 3.500 or better at New Mexico Tech or receive a nomination that outlines contributions to New Mexico Tech and the Community that may include, but is not limited to, extraordinary service, outstanding leadership, excellent performance in research or internships, exemplary conduct; and
3. Have no disciplinary/academic honesty findings or pending review.

The “Tech Scholar” designation will remain in effect until the student graduates, but will be revoked if the student’s cumulative GPA falls below 3.00 or the student is found to have violated community conduct or academic dishonesty standards. In recognition of scholarly competence, the NM Tech Scholar may register early at preregistration. The designation of “Tech Scholar” will also be added to the student’s transcript and they will be recognized at their graduation ceremony unless revoked.

A student may not regain their "Tech Scholar" nomination once the standing is revoked because of disciplinary/academic dishonesty findings.

Commencement Awards

Graduation with Honors

Any undergraduate student who has earned a cumulative GPA of 3.0 or higher at NM Tech graduates with honors. The minimum requirements for graduation with honors are:

- “with highest honors,” GPA of 3.75
- “with high honors,” GPA of 3.50
- “with honors,” GPA of 3.00

A student with fewer than the two final years in residence at NM Tech must have attained the required average overall, as well as at NM Tech, to qualify for graduation with honors.

Brown Award

The Brown Award is named in honor of C. T. Brown, who was for many years a member of the NM Tech Board of Regents. The award is given to that person graduating with a Bachelor of Science degree who is judged by the faculty to be highest in scholarship, conduct, and leadership. In addition to a plaque, the award consists of a \$1,000 prize.

Cramer Award

This award was established to honor Tom Cramer, an engineer and a member of the NM Tech Board of Regents for 26 years. It is awarded to the top two seniors graduating in engineering who rank highest in scholarship. The awards consist of citations and \$400 prizes. The recipients are chosen by the Faculty Senate upon recommendation of the engineering faculty.

Founders’ Award

A Founders’ Award was created to honor the persons responsible for establishing the New Mexico School of Mines in Socorro in 1889, especially J. J. Baca and Ethan Eaton. The award is presented to the recipient of an advanced degree who has made an outstanding contribution to NM Tech through scholarship, research, and involvement in campus affairs. The recipient is chosen by faculty nomination and Faculty Senate election. The award consists of a plaque and a \$800 cash prize.

Langmuir Award

The Langmuir Award for Excellence in Research is given for an outstanding scientific research paper by any student or graduate of New Mexico Tech. The paper must have been submitted to or published by a recognized journal during the preceding year. The recipient is selected by the Faculty Senate’s Honorary Degrees and Awards Committee. The award is named in honor of Irving Langmuir (Nobel Laureate, 1932) who conducted extensive research with NM Tech staff. The award consists of a plaque and a \$400 cash prize.

New Mexico Tech Student Association and Graduate Student Association Service Awards

The New Mexico Tech Student Association and Graduate Student Association present appreciation awards to students, faculty, and staff, who have done the most for the students of NM Tech.

Alumni Association Distinguished Achievement Award

This award is presented to alumni who have achieved distinction in their special fields of endeavor. Awards are presented to alumni of both the New Mexico School of Mines and New Mexico Institute of Mining and Technology. Recipients are selected by the Alumni Association Board from those nominated by other alumni, faculty and staff, or friends of New Mexico Tech.

Alumni Association Distinguished Service Award

The Alumni Association Distinguished Service Award is presented to alumni or friends of New Mexico Tech who have contributed outstanding service. Recipients are selected by the Alumni Association Board from those nominated by other alumni, faculty and staff, or friends of New Mexico Tech.

Distinguished Teaching Award

The Distinguished Teaching Award is presented each year to a faculty member based on recommendations and nominations from students, alumni, and other faculty.

Distinguished Research Award

This award is presented each year to an outstanding researcher on the NM Tech faculty or staff nominated by their colleagues and chosen by a committee of fellow researchers.

Department Awards

| Department | Name of Award | Criteria and Description |
|---------------------------------------|--|---|
| Biology | David K. Shortess Prize | Awarded to the outstanding graduating student in biology |
| Chemistry | Morris F. Stubbs Award | Given in honor of Morris F. Stubbs, professor emeritus |
| Computer Science | Patrick Orr Memorial Award | Given to the outstanding graduate student who demonstrates excellence in scholarship and potential for service in computer science education. The award is given in memory of Patrick Orr, a former member of the Computer Science Department. |
| Earth and Environmental Science | Albuquerque Gem & Mineral Club Scholarship | Given to a junior or senior majoring in earth science who displays academic excellence in the field |
| | Anton and Antia Budding Graduate Research Scholarship | Given to a graduate student in good standing in the earth and environmental science department |
| | Estwing Award | Given to a senior graduating with a degree in earth science. The award consists of a rock hammer and certificate. |
| | New Mexico Geological Society Lucille Plokin Undergraduate Scholarship | Given to a junior or senior earth science student, with preference to students with interests in subsurface, sedimentary, and/or geology. |
| | New Mexico Geological Society Registration Award | Given to a student majoring in earth science. The award pays for registration for the New Mexico Geological Society's Fall Field conference. |
| | New Mexico Geological Society Grant-in-Aid | Given to a student majoring in earth science who is doing research in New Mexico. A cash award of up to \$500. |
| Environmental Engineering | Page Ashman Memorial Prize | Given to a graduating senior who has demonstrated excellence in environmental engineering and is active in the student environmental club. |
| CLASS | Howard Sylvester Prize | Given to the member of the graduating class who has shown high achievement in the Humanities. |
| Information Technology | Addy and Ravi Bhasker Award | Given to the graduating student with the highest G.P.A. in Information Technology. |
| Materials & Metallurgical Engineering | Ashman Award | Given to B.S., M.S., and Ph.D. students who have demonstrated excellence in the field and who are active in the department activities. |
| | Ron Roman Scholarship | Given to a student who has demonstrated excellence in Materials engineering and contributed to Tech's research effort. |
| | Javorsky Scholarship | Given to an undergraduate student showing academic excellence that shows a financial need. |
| | Kari Staudhammer Award | Given by the ASM Los Alamos Chapter to an outstanding undergraduate student as on voted by the department faculty. |
| Petroleum Engineering | John M. Kelly Fellowship | Given to an outstanding graduate student. |
| | Langdon B. Taylor Award | Given to a student who has rendered outstanding service to the student chapter of the society of Petroleum Engineers. |
| Physics | Abraham and Esther Brook Prize | Given to a student who has demonstrated excellence in physics. The \$650 prize is given at the end of the junior year. |
| | Leslie Fallon Award | Given to the graduate student who does the best job of teaching freshman physics labs or recitations. Reviews will be considered, as will the view of previous Fallon winners. Prize of \$650. |
| | Marvin Wilkening Award | Given to the graduating physics student who has demonstrated excellence in experimental physics. The technical tool kit is valued between \$1000-\$1100. |
| | Petscheck Award | Given to a junior, senior, or graduate student who has exhibited outstanding and sustained achievement in the field of physics, preferably theoretical physics. |
| | Wilkening Graduate Fellowship | Awarded annually to a current or incoming graduate student in the physics department and based on outstanding achievement or potential in academics, research, physics education, and service to the broader scientific, NMT, or local communities. |

Course Descriptions and Curricula

Course Descriptions

Course Numbers

Courses are arranged numerically by department or program. In general, courses numbered from 1000 to 1990 are intended primarily for first-year students (freshmen); 2000 to 2990 for second-year students (sophomores); 300 to 399 for third-year students (juniors); 400 to 499 for fourth-year students (seniors); and 500 to 599 for graduate students. Exceptions may be made with the approval of the major advisor and instructor. Graduate students may be allowed credit for courses numbered 300 and above.

New Mexico Common Course Numbering System (NMCCNS): Lower-Division Courses

Effective in fall 2019, New Mexico has revised its “common course numbering system” (CCNS) to assign the same course prefix and number to lower-division courses that are equivalent among New Mexico public institutions, regardless of where taken. This system will assist students in understanding how their credits will apply at all state institutions and is in the process of implementation at all NM institutions. hed.state.nm.us. The NMCCNS utilizes a 4-letter prefix (e.g., ENGL) and a 4-digit course number (e.g., 1110). As the HED is still in the process of creating common numbers for some lower-division disciplines—and as NMT is still in the process of updating upper-division courses—students may still find courses with the original prefixes and three-digit course numbers in the meantime. Students can find NMT equivalents to courses that they took at another New Mexico school using the NMHED Course Crosswalk: <https://ccns.hed.state.nm.us/>

Graduate Course Restrictions

Graduate students may be allowed credit for courses numbered 300 and above; see program requirements for additional restrictions.

Credit Hours

Following the course title, you will find the number of credit hours (cr) you will receive for completing the course. Credit hours for all courses, including synchronous and asynchronous distance delivery courses, are measured in class hours (cl hrs), lab hours (lab hrs), and recitation/discussion hours (recitation hr). “1 cl hr” and “1 recitation hr” correspond roughly to one hour spent in class each week during a standard 16-week semester and is equivalent to one (1) credit hour. “3 lab hrs” equals about three hours per week in the laboratory during a standard 16-week semester and is also equivalent to one (1) credit hour.

In addition to class and lab time, students can expect to spend two to three hours of study and preparation for each credit hour of class. Most one-semester classes average three credit hours. Summer courses and other compressed-format courses are required to meet the requirements stated above regardless of their shortened term.

Prerequisites and Corequisites

Some courses have prerequisites or courses you must successfully complete before enrolling in that course. Exceptions can be made with the instructor’s approval. If you enroll in a course in which you do not have the prerequisites without the instructor’s permission, you may be disenrolled. Corequisites are courses taken during the same semester. Prerequisites and corequisites are not determined by the student’s individual catalog, but rather by the catalog in effect at the time that the course is taken.

Semester Offered

Not all courses are offered every semester. The first semester of a two-semester-sequence course (such as ACCT 2110/(2120), ES 110/111, and GEOL (1110)/(2120)) is usually offered in the fall semester. The second semester is usually offered in the spring semester. Courses that are offered only one semester (“Offered fall semesters”) or alternate years (“Offered Spring Semesters and alternate years”) are so noted. “Offered on demand” implies that the course is offered only when a sufficient number of students want to enroll in the course.

Description

The course description contains a short list of topics to be covered during the semester. This list is not meant to be exhaustive.

Cross-listing

Sometimes courses fulfill the requirements for two different degrees and are listed under both programs. In such cases, the course description will end with the cross-listing

Electives

Electives are courses taken in addition to the specific courses required by your major. Electives bring your credit hours up to the required number for graduation. Some majors allow students to choose many electives; others, few.

Undergraduate Electives

New Mexico Tech's community education classes (designated by the letter "C" in the course number) may not be used to fulfill the General Education Core Curriculum Requirements for a Bachelor of Science degree (listed on page 78). However, these classes may be used to fulfill elective credit for some programs.

Graduate Electives

All graduate electives must be 300-level or above, but may be required to be 500-level by program requirements.

Degree Requirements

Undergraduate Degree Requirements

In order to graduate, every student enrolled in a Bachelor of Science program must complete NM Tech's General Education Core Curriculum Requirements, which are listed on (page 78). This core set of requirements contains courses in humanities, mathematics, and basic science or engineering. In addition, each program has its own set of course requirements as well as the minimum number of credit hours needed to graduate.

Graduate Degree Requirements

Graduate students must also complete a set of general requirements. In addition, each program has its own set of courses you must complete to earn the degree, as well as the minimum number of credit hours needed to graduate. In order to graduate, every student must complete the General Degree Requirements (page 77).

Sample Curricula

Most programs provide sample curricula to help you set your schedule. While you will graduate at the end of four years if you follow the sample curriculum faithfully, *these curricula are meant to be guides only. Talk with your advisor to chart your individual curriculum and select electives to round out your degree program.*

New Mexico General Education Requirements

The following 31 credits are required to fulfill the New Mexico General Education Curriculum as described on the New Mexico Higher Education Department Website: https://hed.state.nm.us/resources-for-schools/public_schools/general-education. Students transferring to New Mexico Tech having completed courses in the New Mexico General Education Curriculum at other New Mexico universities schools will receive credit for completing these General Education requirements. However, students will still be required to complete New Mexico Tech Institute Requirements (next section) if they did not complete these courses as part of fulfilling their general education requirement.

- Area 1– Communications (6 credit hours)
- Area 2 - Mathematics (3 credit hours)
- Area 3 - Basic Laboratory Sciences (4 credit hours)
- Area 4 - Social Sciences (3 credit hours)
- Area 5 - Humanities (3 credit hours)
- Area 6 – Creative and Fine Arts (3 credit hours)
- Area 7 (Flexible 9) - Additional Social Sciences or Humanities (9 credit hours)
- To include at least 3 credit hours from each of Area 4 and Area 5, and three additional hours from either Area 4 or 5

Transfer students are expected to meet these general requirements in principle but are not required to present the exact duplicated of these courses. Their transcripts will be evaluated by the Office of the Registrar. Students readmitted will meet with and be reviewed by the Office of the Registrar and faculty advisor to determine requirements to complete their General Education requirements.

Students transferring to New Mexico Tech having completed course sin the New Mexico General Education Curriculum at other New Mexico universities schools will receive credit for completing these General Education requirements. However, students completing a Bachelor of Science or Bachelor of Arts will still be required to complete New Mexico Tech Institute requirement or may need to complete other prerequisites courses for their major.

Changes in the educational program are made from time to time by action of the Faculty Senate. Students in continuous residence area assured that care will be taken to avoid unnecessary hardship caused by such changes.

New Mexico Tech Institute Requirements

In addition to the required New Mexico General Education Curriculum, New Mexico Tech students completing a bachelor's degree at New Mexico Tech (Bachelor of Science, Bachelor of Arts, and Bachelor of General Studies) will have Institute Requirements to fulfill. Institute Requirements may be either specific classes NMT students must take to receive a degree (e.g., students completing a BS degree must take MATH 1510 and 1520) or additional credits required in certain content areas.

For students originating at New Mexico Tech, these Institute Requirements should be taken to satisfy the New Mexico General Education Curriculum. Students transferring to NMT who satisfied their New Mexico General Education requirement using other classes will receive credit for completing the General Education but will still need to complete the Institute Requirements for their degree.

The following table shows the courses needed to complete the General Education and Institute Requirements for each bachelor's degree.

| NM Gen Ed + NMT Institute Requirements for NMT Bachelor's Degree Programs | | | |
|---|--|--|--|
| | Bachelor of Science | Bachelor of Arts | Bachelor of General Studies |
| Area 1: Communications | 9 credits ENGL 1110 (3)* ENGL 1120 (3)* ENGL 341/MENG 341 (3)* | 9 credits ENGL 1110 (3)* ENGL 1120 (3)* ENGL 341/MENG 341 / TCOM 411 (3)* | 9 credits ENGL 1110 (3)* ENGL 1120 (3)* COMM 242 or ENGL 341 (3)* |
| Area 2: Mathematics and Quantitative Reasoning | 8 credits MATH 1510 (4)* MATH 1520 (4)* | 6-8 credits total taken from CSE 107 (4) CSE XXXX (3) MATH 1430 (3) MATH 2350 (3) MATH 1510 (4) MATH 1520 (4) <i>(At least 3 credits must be MATH)</i> | 3 credits from any MATH |
| Area 3: Science | 18 credits PHYS 1310 & 1310L (5)* PHYS 1320 & 1320L (5)* CHEM 1215 & 1215L (4)* CHEM 1225 & 1225L (4)* | 14-16 credits <i>(One semester in each field, with lab.)</i> Biology (Biology 2110 +L) Chemistry (CHEM 1120, Chem 1215+L) Earth Sciences (ERTH 1110+L) Physics (PHYS 109, PHYS 1310+L) | 8 credits from any Science or Engineering (with associated labs) |
| Area 4: Social and Behavioral Science | 6 credits taken from ECON, POLS, PSYC, ANTH, SOSC, GNDR | 9 credits <u>Area 4a: Policy and Technology (3)</u> At least one of "policy and technology" classes (PS/ POLS; SOSC) <u>Area 4b: Other Social Sciences (6)</u> ECON, POLS, PSYC, ANTH, SOSC, GNDR | 6 credits taken from ECON, POLS, PSYC, ANTH, SOSC, GNDR |
| Area 5: Humanities | 6 credits taken from ENGL (except 103, 1110, 1120, 341), COMM, HIST, PHIL, HUMA, TCOM (except 321, 420, 422), foreign languages | 9 credits <u>Area 5a: Ethics and Technology (3 cr)</u> At least one of "ethics and technology" classes <u>Area 5b: Other Humanities (6 cr)</u> ENGL (except 103, 1110, 1120, 341), COMM, HIST, PHIL, HUMA, TCOM (except 321, 420, 422), foreign languages | 6 credits taken from ENGL (except 103, 1110, 1120, 341), COMM, HIST, PHIL, HUMA, TCOM (except 321, 420, 422), foreign languages |
| Area 6: Creative and Fine Arts | 3 credits taken from ARTH, DANC, MUSC (except ensembles), THEA | 3 credits taken from ARTH, DANC, MUSC (except ensembles), THEA | 3 credits taken from ARTH, DANC, MUSC (except ensembles), THEA |
| Area 7: Additional Courses | 3 credits taken from Areas 4 or 5 | N/A | 3 credits taken from Areas 4 or 5 |
| Total credits | 53 | 50-54 | 38 |
| * Denotes a class that is an Institute Requirement for one of the degree types. NOTE: Specific Bachelor of Arts (BA) degree programs may require specific classes to complete certain content areas. Please refer to your degree program description and talk to your advisor about program-specific requirements. | | | |

Completing the New Mexico General Education and New Mexico Institute Requirements

It is recommended for students originating at New Mexico Tech and for students who are considering a transfer to New Mexico Tech to use the courses in the Institute Requirements toward the New Mexico General Education Requirements. Taken together, these courses comprise 53 total credits, as shown below.

Area 1—Communications

ENGL 1110 (3 credits)

ENGL 1120 (3 credits) -Must meet prerequisites to enroll.

ENGL 341/MENG 341 (3 credits) -Must meet prerequisites to enroll.

Area 2—Mathematics

MATH 1510 (4) – Must meet prerequisites to enroll.

MATH 1520 (4) – Must meet prerequisites to enroll.

Area 3—Basic Laboratory Sciences

PHYS 1310 & 1310L (5) -Must meet prerequisites to enroll.

PHYS 1320 & 1320L (5) -Must meet prerequisites to enroll.

CHEM 1215 & 1215L (4) -Must meet prerequisites to enroll.

CHEM 1225 & 1225L (4) -Must meet prerequisites to enroll.

Area 4 - Social Sciences (6 credit hours)

Economics (ECON); Political Science (POLS); Psychology (PSYC); Anthropology (ANTH); Women's and Gender Studies (GNDR); Social Science (SOSC)

Area 5 - Humanities (6 credit hours)

English (ENGL) except 103, 1110, 1120, 341; Communication (COMM); History (HIST); Philosophy (PHIL); Humanities (HUMA); Technical Communication (TCOM) except 321, 420, 422; Foreign Languages

Area 6 – Creative and Fine Arts (3 credit hours)

Art History (ARTH); Dance (DANC), Music (MUSC); Theater (THEA)

Area 7 - Additional Social Sciences or Humanities (3 credit hours)

from Areas 4 or 5

The Graduate Program

(www.nmt.edu/gradstudies)

The graduate program provides opportunities for advanced study and research in the basic sciences, computer science and mathematics, the earth sciences, and several engineering fields at both the Masters and Doctoral level. Our Master of Science for Teachers program provides a growing number of New Mexico secondary school teachers with science and mathematics tools to challenge students in their classrooms. The Master of Engineering and Professional Masters programs provides a unique opportunity for working engineers and scientists to obtain the skills needed for expanding responsibilities in the technology fields. Students are provided the opportunity to learn the spirit as well as the methods of productive scholarship.

Research Opportunities

Outstanding opportunities for a wide range of field investigations in the sciences and engineering disciplines are made possible by New Mexico Tech's location in the Southwest. Langmuir Laboratory, at an elevation of 3,240 m (10,630 ft) in the nearby Magdalena Mountains, is a unique facility for the study of thunderstorms and other atmospheric phenomena.

The Very Large Array (VLA) radio telescope on the plains to the west of Socorro and the Magdalena Ridge Observatory located on the mountain near the Langmuir Laboratory, provide extraordinary opportunities for astronomical research. Headquarters for the VLA and Very Long Baseline Array (VLBA) radio telescopes are located on campus (the VLA and VLBA are facilities of the National Radio Astronomy Observatory, distinct from New Mexico Tech). Graduate students in the earth sciences are afforded expanded research and funding opportunities through the National Science Foundation research consortium, the Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL), located on campus and tasked with exploring the Earth's interior through the collection, distribution, and analysis of seismic data.

Present on campus are the New Mexico Bureau of Geology and Mineral Resources and the Petroleum Recovery Research Center, making New Mexico Tech especially attractive for graduate study in the Earth, mineral science and engineering fields.

The Energetic Materials Research and Testing Center provides opportunities for graduate work in Materials and mineral engineering, mechanical engineering, chemistry, physics, geophysics, computer science, and applied mathematics. The Playas Training and Research Center provides a unique setting research related to urban combat, drug interdiction and border security training programs, complete with state-of-the-art surveillance and monitoring equipment.

The Institute for Complex Additive Systems Analysis (ICASA) is dedicated to studying the behavior, vulnerabilities, and predictability of complex systems. ICASA's unique, interdisciplinary, strategic approach harnesses information-age relevant research, application of that research to real-world problems, development of key enabling technologies, and training and education of our nation's next generation of critical systems thinkers.

The Computer Science and Engineering Department in collaboration with ICASA has been designated as a National Center of Excellence in Information Assurance Education and Research by the National Security Agency and the Department of Homeland Security. The associated Scholarship for Service program provides funding for student education and training in cyber security to prepare them for government service in the broad transdisciplinary field of cybersecurity.

Faculty and facilities from all divisions of Tech provide advanced courses and research opportunities for graduate students.

Applying for Graduate Admission

Regular Admission

Interested persons who have completed or will complete a bachelor's degree prior to admission and have a record that indicates good potential for advanced study (undergraduate GPA of 3.0 is used as a general guideline) and research in Tech's programs are encouraged to apply for admission to graduate study. All applications for degree seeking admission must be submitted via an only Centralized Application System (either GradCAS or EngineeringCAS). Links to the appropriate CAS can be found at www.nmt.edu/gradstudies under Graduate Programs. Each CAS has integrated help and instructions for application submission. Questions about NMT's graduate school can be directed by e-mail to graduate@nmt.edu or by mail to:

Center for Graduate Studies
New Mexico Tech
801 Leroy Place
Socorro, New Mexico 87801

For full consideration for assistantships and fellowships, completed applications must be received by:

- February 15 for the fall semester
- August 15 for the spring semester
- May 1 for the summer semester.

Individual departments may have earlier dates for consideration of assistantships. To be assured of consideration for admission, completed *domestic* applications must be received no later than August 1 for the fall semester, January 2 for the spring semester, and May 1 for the summer semester. To allow enough time for the admission decision and the acquisition of passports and visas, international students are advised to make sure their application, supporting documents, and application fee are in the Center for Graduate Studies by March 15 (for summer and fall semesters) or by September 15 (for spring semester).

Admission to graduate study at New Mexico Tech and the award of financial aid are made to qualified individuals without regard to race, color, creed, sex, or national origin.

Professional Masters, Master of Engineering, Master of Science, and Doctor of Philosophy Degrees

In addition to completed application forms, applicants for all masters and doctoral programs must provide:

- 1) Transcripts:
 - Unofficial transcripts may be uploaded in the CAS for application consideration, but official transcripts are required before matriculation.
 - Official transcripts from universities in the United States are to be submitted directly to the CAS.
 - Sealed, official transcripts of all international college work must be mailed directly to the Center for Graduate Studies at the address above.
- 2) References from three professors and/or employers familiar with the applicant's academic, professional, and/or research performance
- 3) The required application fee is specified for each program in its CAS
- 4) Official Graduate Record Examination (GRE) scores. GRE General Exam scores are required for many other Master of Science, professional Masters programs, Master of Engineering Management, and Doctor of Philosophy programs. Please refer to the listings at http://www.nmt.edu/grad_studies/programs.php for the GRE General Examination requirements for each program. If your GRE scores are required by the program to which you are applying, but they are no longer available because you took the examination too long ago, you must retake the GRE examination. (Unofficial copies may be used for application, but official copies are required before matriculation.) A few departments may also require a subject test score. Information related to departmental requirements for the subject GRE may be on the programs page listed above. The subject test must be in the same field in which the applicant intends to major.
- 5) Domestic applicants seeking financial aid of any kind are strongly encouraged to submit a completed Free Application for Federal Student Aid (FAFSA) form. The FAFSA form is available online from <http://www.fafsa.ed.gov/>.

Master of Engineering Management (MEM)

NMT's MEM program offers a terminal degree to individuals with undergraduate backgrounds in calculus-based engineering or applied science and work experience in an engineering and/or applied science discipline. Individuals with undergraduate backgrounds in other areas who have at least two years of work experience in a technical environment will also be considered for admission to the program. Preference among all applicants will be given to individuals with at least two years of relevant work or military experience.

In addition to completed application forms, applicants for the Master of Engineering Management program must provide:

- 1) Transcripts:
 - Unofficial transcripts may be uploaded in the CAS for application consideration, but official transcripts are required before matriculation.
 - Official transcripts from universities in the United States are to be submitted directly to the CAS.
 - Sealed, official transcripts of all international college work must be mailed directly to the Center for Graduate Studies at the address above.
- 2) References from three individuals familiar with the applicant's academic and professional capabilities. We prefer that at least one reference form/letter be submitted by a past or current supervisor. If the applicant is an entrepreneur with no supervisor, a reference form/letter from a business associate is acceptable;
- 3) The required application fee is specified for each program in its CAS
- 4) Official general Graduate Record Examination (GRE) scores. If your GRE scores are no longer available because you took the examination too long ago, you must retake the GRE examination.
- 5) A current resume that includes information about the applicant's work history, especially in engineering or applied science;
- 6) Applicants with three or more years of work experience with an undergraduate GPA of less than 3.0 must provide detailed

information about recent work experience and references from at least two recent supervisors who are able to evaluate the applicant's potential for success in the NMT MEM program;

- 7) A statement of the applicant's goals. This short (two pages or less) statement should summarize the applicant's career goals and briefly describe how the NMT MEM program will aid in achievement of those goals.

Master of Science for Teachers (MST)

Applicants to the Master of Science for Teachers program must provide the following in addition to the completed Master of Science for Teachers' application Materials:

- 1). Transcripts:
 - Unofficial transcripts may be uploaded in the CAS for application consideration, but official transcripts are required before matriculation.
 - Official transcripts from universities in the United States are to be submitted directly to the CAS.
 - Sealed, official transcripts of all international college work must be mailed directly to the Center for Graduate Studies at the address above.
- 2). A letter of reference, preferably from your department chair or principal, indicating your interest and abilities related to the pursuit of your MST degree; and
- 3). The required application fee is specified for each program in its CAS

Certificate Programs

Post-baccalaureate certificates are available in Cybersecurity, Electrical Engineering, Hydrology, Scientific and Professional Communication, and Technical Leadership. Certificates provide an opportunity for students and working professionals to expand and update their knowledge in these fields at the graduate level without committing to a graduate degree.

Cost of Attendance

For the 2021—2022 academic year graduate students paying out-of-state tuition at New Mexico Tech may expect to spend \$42,000 (including tuition, fees, room and board, and reasonable personal expenses) for one calendar year of study. Visit the web page at <http://www.nmt.edu/tuition-and-fees> for up to date information on costs. In-state tuition rates, which reduce the total by about \$14,000, are available to non-resident and international students *only* if they:

- have been granted assistantships,
- have been selected for qualified fellowships that cover the entire period of the semester, or
- they request participation in the Western Regional Graduate Program with their acceptance of admission and are documented residents of a state in the Western Interstate Commission for Higher Education: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming, the Commonwealth of Northern Mariana Islands, or Guam.

International Students

New Mexico Tech is authorized under federal law to enroll nonimmigrant alien students. International applicants whose native language is not English are required to take the Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS) examination in addition to the GRE. An internet-based TOEFL (iBT) score of 76, computer-administered score of 207 or paper-administered score of 540 or IELTS score of 6 is used as a minimum for admission. Information about these examinations is available from the Educational Testing Service, Princeton, New Jersey 08540.

Financial statements need to be uploaded in the CAS system as part of the acceptance of admission process. Applications from international students, complete with supporting documents, and application fee must be submitted in the CAS by March 15 (for summer and fall semester) or by September 15 (for spring semester) to allow enough time for the admission decision and the acquisition of passports and visas. To be assured of consideration for assistantships and fellowships, completed applications must be received by February 15 for the summer and fall semesters and by August 15 for the spring semester. Individual departments may have earlier dates for consideration of assistantships. Tuition and fees are payable upon registration. Deferred payment plans are available for those holding assistantships.

Provisional Admission

Applicants for regular admission may be granted provisional admission if their previous work is deficient in either quality or quantity. Subject to the major department's approval, students admitted provisionally may be advanced to regular graduate student status after one or more semesters of satisfactory academic performance and completion of the designated deficiencies. Credits earned for designated deficiencies may not be used towards a graduate degree. Students admitted or placed on provisional status must advance to regular status before a degree can be conferred. Students admitted or placed on provisional status are not eligible for financial support including assistantships and cannot work on campus.

Special Admission

Those who have baccalaureate degrees and who wish to earn graduate credits as their qualifications warrant may be admitted as special graduate students. Special graduate students are not degree or graduate certificate candidates and are not eligible for most

forms of financial aid including assistantships, fellowships, and student employment. Special graduate status does not qualify international students for student visas. Application for special graduate status must be made using an application for Admission as a Special Graduate Student available from the Center for Graduate Studies (see contact information under Regular Admission). Request for transfer to regular status must be made using the application for regular admission. No more than 12 credit hours earned as a special graduate student may be applied toward a graduate program.

Dual Registration

Simultaneous registration as a graduate student and undergraduate student may be approved subject to the following conditions:

- 1) Admission to an Accelerated Masters Program:
 - a) The student must have a minimum grade-point average of 3.0 admission.
 - b) The student must apply to one of the approved accelerated masters programs and be admitted to the graduate program.
 - c) Once admitted to the graduate program, the Accelerated Masters Program student will spend his or her senior year as dual registered student.
 - d) After completion of the undergraduate program and earning the B.S degree the student transitions to graduate student standing and will be eligible for graduate assistantships.
- 2) The student may apply for Accelerated Masters Program in his or her last semester before graduation under the following criteria:
 - a) the student has applied for admission and been accepted to the graduate program;
 - b) the student is within nine credit hours of the undergraduate degree
 - c) the required undergraduate credits must be completed in the first semester;
 - d) the student has a minimum grade-point average of 3.0; and
 - e) where more than one department is involved, the approval of the undergraduate's major department must be obtained.

Students holding dual registration are charged undergraduate tuition and are not eligible for assistantships and fellowship appointments, but may have work authorizations.

Financial Assistance for Graduate Students

The majority of regular graduate students at New Mexico Tech receive financial aid in the form of assistantships, fellowships, study grants, or part-time employment. Requests for financial support should be made on the application form or in writing to the department if the student is already registered. To qualify for these aids, the student must first be admitted as a *regular full-time student*. Continuation of the award is contingent upon the student maintaining the minimum level of registration (at least 12 credits each fall and spring semester and 3 credits during the summer semester; 300-500 level courses) and satisfactory academic progress as described below. A student failing to complete the length or terms of his or her contract forfeits the right to obtain a new or replacement contract during the interval covered by the original contract. A student failing to maintain registration requirements while on contract forfeits the right to obtain a contract during the *next registered semester*. A student failing to satisfactory academic progress forfeits the right to all funding support and may or may not be funded subject to determination of the sponsor. Fellowships are grants-in-aid for full-time study and research leading to an advanced degree. Assistantships normally require half-time service in teaching or research. Quarter-time appointments may be made in some cases. Students holding assistantship appointments qualify for resident tuition.

Assistantships and fellowships are awarded to qualified U.S. citizens and international students to support them in their educational objectives. The advisor, the department chair, and the Dean of Graduate Studies must approve any additional employment or remuneration.

Teaching Assistantships

Teaching assistants are typically appointed for nine months at competitive stipend levels. Additional teaching duties or research opportunities during the summer available. Teaching assistants will have from six to ten contact hours per week plus preparation and grading of assigned recitation, laboratory, or tutorial duties. The maximum teaching load for regular instructional duties is six credit hours.

Research Assistantships

Many graduate students are supported on grants, contracts, or division research funds under the supervision of a faculty member. Research done under the assistantship may or may not be applicable to thesis or dissertation requirements. Research assistants commonly receive summer appointments as well as nine-month academic year appointments.

Fellowships

Fellowships for the support of graduate students are available from the Institute, professional and industrial organizations, and certain federal agencies. Amounts range from those covering tuition and fees to full support including monthly stipends. Fellows must devote full time to studies and research.

Financial Aid for Graduate Students

Graduate students who are U.S. citizens or resident aliens are eligible to apply for Direct Stafford Unsubsidized Student Loans and Direct Graduate PLUS Loans. Regular graduate students must be registered for at least six hours per semester to be eligible for federal aid.

Satisfactory Academic Progress for Financial Aid

Financial Aid offices are required to have a policy regarding Satisfactory Academic Progress. The purpose of this policy is to measure a student's academic progress in both a quantitative and qualitative way. This is done by measuring both credit hours earned and cumulative grade point average. To continue receiving Federal Financial Aid students must meet the minimum requirements set in New Mexico Tech's Satisfactory Academic Progress Policy. Be aware that these standards are not the same as New Mexico Tech's standards for academic probation and suspension.

At New Mexico Tech, satisfactory academic progress is reviewed at the end of each payment period (semester). The Satisfactory Academic Progress Policy applies to graduate students that participate in the Federal Work Study, Federal Direct Loan, or Federal Direct Grad PLUS Loan programs.

To be in good standing for Financial Aid purposes a graduate student must earn at least 67% of the hours they attempt with a cumulative GPA of at least 3.0. If a graduate student falls below this standard, the student will be placed on financial aid warning for the following semester. During this semester, the graduate student will still be eligible to receive aid. To get back in good standing, the graduate student will need to meet the policy requirements by the end of the working semester. If the graduate student does not meet the policy requirements by the end of the warning semester, the graduate student will be placed on financial aid suspension. Once a student is on financial aid suspension, he/she is not eligible for any Federal Financial Aid until the standards of the Satisfactory Academic Progress Policy have been met or an appeal is approved.

Students have the opportunity to appeal the determination that they are not making satisfactory academic progress. To appeal the student will need to complete an Appeal Form. On that form the student will need to explain why he/she failed to meet our Satisfactory Academic Progress standards and what has changed that will allow him/her to meet the standards by the end of the next semester. If an appeal is approved the student's Satisfactory Academic Progress status will change to either Probation (1 semester of eligibility) or Probation with a plan (Continued eligibility as long as conditions of individual plan are met).

There is also a maximum financial aid timeframe that a student has to complete a graduate degree. The maximum is 1.5 times as many credit hours as the minimum required for the specific degree. This includes all hours attempted at that level.

Employment

Part-time, on-campus employment is sometimes available to regular, full-time graduate students for up to 20 hours per week. Hourly campus employment requires a minimum registration of six credits in the fall and spring semesters, while assistantships require a minimum registration of 12 credits. Students who are not progressing towards their degree over the summer may have campus employment if they are preregistered full-time for the fall semester.

Annual Leave

Graduate students on twelve-month assistantship or fellowship contracts are allowed two weeks of annual leave. Scheduling of the vacation period will be worked out with the advisor. Teaching assistants follow the regular academic calendar, with some variation in programs that hold special summer sessions.

Academic Freedom and Tenure

Graduate student teaching and research assistants are included in New Mexico Tech's academic freedom and tenure policy.

Graduate Program Policies

See the *Graduate Student Handbook* at www.nmt.edu/student-handbook for more information.

Graduate Student Status

Regular

A regular graduate student is a degree-seeking student admitted to a graduate degree program at New Mexico Tech.

A regular full-time graduate student is one enrolled for nine to thirteen credit hours per fall or spring semester (three credit hours in the summer semester). In the fall and spring semesters, graduate students may register for a 13th credit of Community College or Physical Recreation courses at the 100-200 levels. Such registrations carry no additional tuition charge. Courses numbered 300 level or above to be counted for the graduate degree, non-credit Community College classes and 100/200-level classes required as deficiency courses do not qualify for the tuition free 13th credit. Graduate students on assistantships must register for 12 qualifying credits in fall and spring and 3 credits in summer (300-500 level).

A regular part-time graduate student is one enrolled for eight or fewer credit hours per semester and is *not eligible* for financial support. To be admitted as a part-time graduate student, an applicant must meet the same standards for admission as a regular full-time graduate student. Changes in full-time/part-time status are only granted in extraordinary circumstances for students who are in

good standing, with the exception of students who have completed all degree course and credit requirements, who may request becoming part-time with the approval of their advisor. See the student handbook for details on changing status.

A regular distance graduate student is one admitted to one of the graduate degree programs that incorporate distance delivery as a major component of its instructional offerings. Currently graduate degrees that may be obtained solely by distance delivery include only the Master of Engineering in Chemical Engineering, Master of Science and Master of Engineering in Mechanical Engineering, the Professional Master of Hydrology, Professional Master of Transdisciplinary Cybersecurity and the Master of Engineering Management. In addition, graduate certificates in Cybersecurity and Hydrology are available. Distance graduate students are typically place bound or employed full-time. To be admitted as a regular distance graduate student, an applicant must meet the same standards for admission as a regular full-time or part-time graduate student. Distance students register for as many credits as are necessary, but typically not for more than 13 credits. Each distance student must register for at least one semester in each academic year to be regarded as a continuing student. Failure to do so will require that the student reapply for admission to the graduate program and if readmitted, the student will be required to meet the requirements of the current catalog.

Provisional Graduate Status

Provisional (full-time, part-time, or distance) graduate status may be granted to students whose previous work is deficient in either quality or quantity. Subject to the major department's approval, students admitted provisionally may be advanced to regular graduate student status after one or more semesters of satisfactory academic performance and completion of the designated deficiencies. Credits earned for designated deficiencies cannot be used towards a graduate degree. Students admitted or placed on provisional status must advance to regular status before a degree can be conferred. Provisional students are not eligible for financial support and cannot work on campus.

Special Graduate Status

Special graduate status provides an opportunity for those who have baccalaureate degrees to earn up to nine graduate credits hours per semester. Special graduate students are not degree candidates and are not eligible for assistantships, fellowships, and student employment. The Graduate Dean will either serve as the advisor for special graduate students or designate a faculty member as advisor. Request for transfer to regular status must be made using the application for regular admission. No more than 12 credit hours earned as a special graduate student may be applied toward a graduate program.

Advisor and Advisory Committee

Each regular and provisional graduate student will be assigned a temporary advisor by the department from the student's major field of study at the time of first registration. The student's academic advisor must be a **regular faculty member** (tenured, tenure-track or emeritus) of the department in which the student is pursuing his or her degree.

The full time student in a research-based program will formalize a thesis, dissertation, or independent-study advisor and an advisory committee by the end of the student's second semester of residency. Part-time and distance education students must formalize their committees by the time they complete 18 credits. The student's academic advisor must be a **regular faculty member** (tenured, tenure-track or emeritus) of the department in which the student is pursuing his or her degree. The academic advisor will typically serve as the student's research advisor, however, in some cases a separate research advisor may be designated. The research advisor is responsible for guiding the student to the completion of their research project and for supervision of the preparation of the research report (thesis, dissertation or independent study paper). A research advisor need not be a regular departmental faculty member. Regular faculty members from the department or interdisciplinary program may not be in the minority on a committee. The department chair and the Graduate Dean must approve the advisor and members of the advisory committee. Committee forms are available in banweb under the Student and Financial Aid tab after login.

At the Master's level, the advisory committee consists of at least the academic advisor and two other members. At the doctoral level, the advisory committee consists of at least the advisor and three other members. One of these members must be from outside the department and must be assigned or approved by the Dean of Graduate Studies. Some departments require five members on the doctoral advisory committee. The academic advisor serves as chair of the advisory committee. The student should meet with his or her advisory committee at least once a year.

All graduate committees must be approved by the Department Chair and the Dean of Graduate Studies. Students enrolled in graduate certificate or professional Master's programs are only required to have an academic advisor and do not have graduate committees

Course Program

Courses to be used towards each of the graduate degrees at New Mexico Tech must meet the requirements of the degree being pursued and must have prior approval of the student's advisory committee. These courses constitute the student's Course Program. The approved Course Program must be on file in the Center for Graduate Studies no later than the middle of the semester before the semester of graduation for Masters students and by the fifth semester for Doctoral students (prior to candidacy). Part-time and distance education students must formalize their committees by the time they complete 18 credits. The course program is reported on a form, available online and from the Center for Graduate Studies. Graduate course programs must be approved by the Dean of Graduate Studies.

Course Load

Regular and provisional full-time and part-time graduate students are required to continue registration each semester until certified for the degree. Regular distance students must register for a minimum of one semester each academic year (summer, fall, and spring) and their registrations must conform to the plan of study developed with their advisory committee and on file in the Center for Graduate Studies. Students whose registration lapses will be required to meet the requirements of the current catalog if they are readmitted to a graduate program. The minimum course load for a full-time graduate student is nine credit hours (12 credit hours if on support) per fall or spring semester; three credit hours during the summer semester if they are progressing towards the degree. Part-time graduate students normally register for eight or fewer credits per semester, but may register for more as offerings and time permits. Credits taken to satisfy minimum registration requirements must be numbered 300 or above and must be applicable to the graduate program as determined by the advisory committee. Written permission from the advisor, the department head, and the Dean of Graduate Studies is required for exceptions to the described course load. Regular and provisional graduate students registered for other classes may audit at most one class and associated lab if applicable. Audit credits apply to the semester credit requirements, but do not earn credits toward a degree, and are limited to three credits or four if the audited course has an associated laboratory. All course credits counted toward credit hour requirements in graduate programs must be earned with letter grades (A-F), except for independent study, thesis, and dissertation (e.g., 30 credits for Masters degree). Some programs require seminar courses, which may be graded S/U, but do not count toward program credits hours.

For resident students, part-time status may be granted after a student has completed all required courses and credits while completing the final research requirements leading to their degree, but only with the approval of their advisor. A full-time graduate student in good standing who has two or more years of residence, has completed all course work, has filed an Intent to Graduate, and who has no assistantship or fellowship support, may request reduced registration for *only* one semester. The request is accomplished via a reduced registration request form, available in the Center for Graduate Studies and online, which must be approved by the advisor (acknowledging that it is expected that the student will finish in that semester) and the Dean of Graduate Studies. While in this category, the student must enroll for at least three credit hours of thesis, independent study, or dissertation.

After successful defense of the thesis or dissertation, with advisor approval, and the dean of Graduate Studies a full-time student may register for one credit for one semester only to complete corrections to the thesis or dissertation. Students with an approved reduces registration are allowed a one—time work authorization. See the Center for Graduate Studies web page for all graduate deadlines (<http://www.nmt.edu/gradstudies>).

Grades

At the time of graduation, the cumulative GPA must be 3.0 or higher for all courses numbered 300 or above. Only 300-500 level courses with a grade of “C” or higher may count towards the graduate degree. Independent study (590), thesis (591), or dissertation (595) courses will be graded with either PR (progress) or U (unsatisfactory). A student will be placed on probation for earning a “U” in independent study, thesis, or dissertation. A second “U” in independent study, thesis, or dissertation may result in dismissal from graduate school. Only those credits graded PR (progress) accumulate toward the minimum required number of credits for research.

Directed research (500) and courses taken on a S/U basis may not be used to fulfill graduate degree requirements, with the exception of the required research course for research-based degrees (independent study (590), thesis (591), or dissertation (595)).

Graduate Co-op Experience

Graduate students may choose to gain research experience as part of their graduate program by performing sponsored work away from campus. To be involved in co-op experiences students must:

- 1) submit a letter of application to the Dean of Graduate Studies with supporting letters from the student’s advisor or graduate committee;
- 2) be a regular full-time student in the semester of application;
- 3) enroll in a Directed Research course (500) in their department during the co-op period, maximum of 12 months;
- 4) provide a final report and any other requirements placed on the student to their graduate committee on completion of the co-op experience.

The student is responsible for arranging the co-op experience with both their advisor and with the work sponsor.

Graduate Degrees for Faculty and Staff

Instructors in the College Division and staff members of the Bureau of Geology and Mineral Resources, Petroleum Recovery Research Center, Institute for Complex Additive Systems Analysis, and Research and Economic Development Office who are not on tenure may pursue programs leading to Master’s or Ph.D. degrees. NMT policy does not permit administrative officers and members of the faculty with the rank of assistant professor or above to take advanced degrees.

Employees who wish to pursue a degree program should apply for admission to the department desired by using standard applications available online. Time limits for degree programs apply.

Leave of Absence

In certain circumstances, a candidate may interrupt progress toward the degree by petition to the Dean of Graduate Studies for leave of absence for one or more semesters. Such letters must carry the endorsement of the student's advisor and the department chair. While on leave, the student does not have access to the facilities and staff of the Institute.

Satisfactory Academic Progress

To demonstrate satisfactory academic progress, each regular graduate student must:

- earn a grade-point average of 3.0 or better each semester;
 - earn no grade less than C for those courses in which a standard letter grade is received;
 - earn a PR or S for research courses (independent study, thesis, dissertation);
 - formalize their advisory committee:
 1. full-time students must formalize their advisory committee and establish their Course Program no later than the middle of semester before graduation for Masters students and by the end of the fifth semester for Doctoral students;
 2. part-time and distance education students must formalize their advisory committee and establish their Course program before the completion of 18 credits;
 - satisfactorily complete sufficient credits
 1. full-time students must satisfactorily complete a minimum of nine credit hours (12 credit hours if on an assistantship) each fall or spring semester; three credit hours must be completed during the summer semester if in residence (as described under Academic Load, page 68);
 2. part-time students typically register for eight or fewer credits each semester; distance students must register according to the plan on file with the Center for Graduate Studies;
 3. each semester, all graduate students may audit at most one course that is up to three or four credits (requiring an "S" for satisfactory progress); and
 - perform satisfactorily on their research as guided by their research advisor.

Assistantships or fellowships are subject to immediate termination if satisfactory academic progress is not achieved. Any student who is struggling with academic performance is encouraged to discuss the situation with their instructor(s), advisor(s), and the Dean of Graduate Studies. Any student who fails to maintain satisfactory progress for two consecutive semesters will be dropped from regular graduate student status. Such students (citizens and permanent residents) may apply for special (non-degree) status without financial support. After completion of nine credit hours (four for part-time students) within a single semester in courses approved for the degree program with a grade-point average of 3.0 or better and no grade less than C, the student may petition the department for return to regular graduate status.

Thesis, Independent Study, and Dissertation Requirements

The thesis or dissertation is to be written with the intention of publication. The thesis or dissertation must include a preliminary, roman-numbered section containing the title page, acknowledgments, abstract, table of contents, list of figures, and list of tables. The acceptance sheet, signed by the members of the committee, is included at the end of the preliminary section of the thesis or dissertation. Arabic page numbering should begin with page 2 of the body of the thesis. Appendices may be included. The last appendix, entitled Permissions, must contain permissions for any substantial copyrighted material used in the publication (figures, tables, etc.). The bibliography should include only references cited in the text. Templates and detailed instructions for completion of the thesis manuscript are available online at: <http://www.nmt.edu/gradstudies/grad-survival-guide.php>. Master's theses and Ph.D. dissertations must be publicly presented and defended. After a successful defense and completion of all changes required by the student's committee, a thesis or dissertation must be submitted to the Center for Graduate Studies for publication online, in the Joseph R. Skeen Library, and be submitted for publication elsewhere. The thesis or dissertation submitted to the Center for Graduate Studies must be the version approved by the graduate committee. No changes can be made to theses or dissertations after submission to the graduate school for degree completion. As a result, no changes can be made to any thesis or dissertation that has been delivered for public dissemination. Note that students have not officially met all requirements until designated as complete by the Center for Graduate Studies (including iThenticate check and final formatting approval of the submission to ProQuest).

As is the case throughout the United States, New Mexico Tech is increasingly involved in contract research for corporations and governmental entities, and many times portions of these research projects cannot be published because of commercial or national security concerns. While a research assistant may complete conditions of employment by working on such projects, there must be a prior understanding between the student, advisory committee and funding source regarding precisely what will be available for the student's thesis or dissertation, and what will not be available. Documentation of such understanding is to be signed by all parties (student, supervisor, and funding agency/agent) and filed with the Center for Graduate Studies prior to the beginning of graduate student involvement in the research project. Students who fail to file such documentation, may be required to restart research on a different topic if there is a disagreement with the corporation or agency.

Thesis and Dissertation Completion

Completed digital and printed theses or dissertations and digital copies of independent study abstracts must be submitted to and

approved by the Center for Graduate Studies no later than two weeks prior to the end of the semester in which the requirements for the degree are to be completed. Although students may complete their degree at any time, students must allow two weeks processing time before a letter of completion can be guaranteed. Further, degree conferral takes approximately two months from the date of final submission of all Materials to the Center for Graduate Studies. During the winter holiday, degree conferral typically takes three months.

Academic dishonesty in a thesis or dissertation has severe consequences. See the Academic Honesty and Research Integrity Policy in the Graduate Student Handbook for full details.

Digital Thesis and Dissertations

Students writing theses or dissertations must deposit complete digital copies of their manuscripts with the Institute's online digital thesis and dissertation database. Theses and manuscripts or portions thereof that are published must be uploaded and circulated locally pending receipt of approval from the publisher for global circulation. If the publisher denies permission, only those portions affected will be limited to local circulation. Please visit the Graduate Studies web pages or the Center for Graduate Studies for information on submission of digital manuscripts. Digital manuscripts must be submitted and approved by the Center for Graduate Studies two weeks prior to the end of the semester in which the requirements for the degree are to be completed. A copyright form must be completed and signed at time of submission of the digital manuscript.

Manuscript Preparation

Complete guidelines and templates for manuscript preparation are available online at <http://www.nmt.edu/gradstudies/grad-survival-guide.php>. Students are strongly encouraged to use the provided LaTeX template and may use ShareLatex as a free online resource.

Independent Study Requirements

Formats for the preparation of Independent Study papers should conform to the requirements of the advisor, advisory committee and department where the student is enrolled, but may follow the guidelines for theses and dissertations (above). A digital version of the independent study abstract must be submitted to the Center for Graduate Studies no later than two weeks before the end of the semester. If for any reason, an Independent Study report is published through the New Mexico Tech Library, it must also be checked using iThenticate and submitted to the New Mexico Tech online digital thesis and dissertation database.

Time Limits

All work presented to fulfill the requirements for a master's degree must be completed within three calendar years from the date of first registration. The corresponding limit for the doctoral degree program is a total of five years past the master's degree or a maximum of eight years if the student enters the program after completing only a bachelor's degree.

Extensions of these limits may be made in special cases, but only upon recommendation by the department and with the approval of the Dean of Graduate Studies. Time limitations for part-time students will be considered on an individual basis.

Funding offers for graduate students holding fellowship or assistantship appointments are typically two years for a master's level degree or four years for the doctoral degree. Funding is limited to three years for a master's level degree or three years beyond the masters for the doctoral degree. Consideration for extension beyond these limits can be given through petition to the Dean of Graduate Studies.

Transfer Credits

A maximum of 12 credit hours of course work with grade B or better earned at another accredited institution may be approved by the student's advisory committee and major department for transfer credit into the Master's program. The student's advisory committee considers transfer credit in doctoral programs on an individual basis. To be approved, such credits must not have been used to satisfy the requirements for a previous degree.

For details of the transfer credit policy applicable to the Master of Science for Teachers program, see page 206.

Tuition and Fees

Please refer to pages 49 for information on the costs of tuition, housing, medical insurance and other fees affecting graduate students.

Completion of Degree Requirements

- During the final semester of residence, the student must have on file a Declaration of Intent to Graduate with the Registrar's Office. Deadlines are July 1 for those completing their degrees in December and December 1 for those completing their degrees in May and August. The Declaration communicates the candidate's intent to fulfill the degree requirements. When completing this form, the student is recommended to verify with their advisor and the Center for Graduate Studies that they will have met all degree requirements prior to completion of their next semester.
- Generally, at least eight weeks prior to the end of the candidate's planned defense, preliminary copies of the candidate's thesis, independent study, or dissertation must be in the hands of the advisor.
- Two weeks prior to the defense, the complete defense draft (with all sections, figures, bibliography, and appendices) must be in the hands of the committee.

- The student must be registered for the semester during which the thesis or dissertation is defended or the independent study is approved. Students may pay a fee to defend/present between semesters, but they must have been registered the semester before and they must have permission of their full committee. The student must also be registered in the semester that they complete all corrections, including formatting. Between semester defense and all requirements must be completed two weeks before the first day of class for the subsequent semester or the student must enroll and pay for registration. Post defense, with the permission of the advisor, the student may register for just one credit as a full time student after their successful defense to complete corrections that do not require significant experiments.
- The chair of each graduate advisory committee will submit a written report to the student with copies to the chair of the department and Dean of Graduate Studies within five days of the defense of a thesis or dissertation. In this report, the chair shall state that the thesis or dissertation is accepted as submitted and defended or explain at a high level what needs to be done in order for the thesis or dissertation to be accepted. The report will be initialed by the members of the advisory committee or they must be cc'ed if the report is submitted via email (email to graduate@nmt.edu).
- Two weeks prior to the end of the semester the completed report of the advisory committee, iThenticate report from academic advisor, and ProQuest submission of the final thesis/dissertation must be submitted to the Center for Graduate Studies or one final copy of an accepted independent study paper must be submitted to the student's advisor and advisory committee. Student degrees are not complete until final Materials have been approved by the Center for Graduate Studies and the student receives final acceptance via email from the ProQuest system.

Appeal

Requirements for graduate degrees may be appealed to the Dean of Graduate Studies or to the Graduate Council through the appropriate department.

Graduate Degree Requirements

Graduate Minors

A graduate minor at the master's level requires at least 12 hours in the minor area with at least 6 of them at the 500 level. Courses used for a bachelor degree or bachelor minor may not be used for a graduate minor. Specific requirements for minor must be approved by the Graduate Council and faculty senate.

Graduate Certificates

The following are the general requirement for a graduate certificate. Additional requirements for specific curricula are listed under the appropriate department.

1. A minimum of 12 credit with at least 9 credits, excluding research credits, at the 500 level.
2. More than half of the credits must be at the 500-level excluding research credits.

Master of Science Degree

General requirements common to all Masters of Science degree curricula in the sciences and engineering fields are listed below. Additional requirements for specific curricula are listed under the appropriate department.

General Requirements

1. it is required that a student preparing to complete the M.S. degree:
2. have a minimum of six credit hours of approved out of program upper-division or graduate course work,
3. declare a major with at least 12 credit hours of course work above the 500-level, exclusive of research credits, and
4. complete a research project culminating in a thesis or independent study paper and
5. theses must be checked with iThenticate by the academic advisor before they will accepted.

Note: Students pursuing an M.S. degree in a different discipline than their B.S. degree may request a waiver for the out of program requirement. Waivers must be approved by the student's advisor, committee, department chair, and the Dean of Graduate Studies.

These general requirements do not apply to students in the Master of Science for Teachers (MST) program.

Approvals

- The appropriate department grants admission to its graduate program.

- The appropriate department and the Dean of Graduate Studies must approve the composition of each graduate student's advisory committee.
- The graduate student's advisory committee must approve the student's thesis or independent study research project. The MS degree will not be awarded until the thesis or independent study paper has been approved by the advisory committee.
- Coursework to be applied toward the degree must meet the associated degree requirements and be approved by the graduate student's advisory committee and the Dean of Graduate Studies.

Research Options

There are two research options, M.S. with Independent Study and M.S. with Thesis. Each option requires a minimum of 30 credit hours. Some departments do not recognize the Independent Study option.

M.S. with Independent Study requires:

- Completion of at least 27 credit hours of approved course work, with at least 15 credit hours of 500-level courses, exclusive of research credits;
- Completion of at least three credit hours of independent study; and
- Submission of a formal paper describing the results of the research to the candidate's advisor and advisory committee.
- Submission of a digital abstract of the independent study to the Center for Graduate Studies.

M.S. with Thesis requires:

- Completion of at least 24 credit hours of approved course work, with at least 12 credit hours of 500-level courses, exclusive of research credits;
- Completion of at least six credit hours of thesis work;
- Satisfactory oral defense of the thesis research; and
- Submission of the digital thesis to the Center for Graduate Studies via ProQuest.

Professional Master's Degree

General requirements are common to all Professional Masters degree curricula in the science and engineering fields. Specific requirements are listed under appropriate departments. Professional Masters degrees include Professional Master of Hydrology, Professional Master of Transdisciplinary Cybersecurity, Master's of Engineering in Chemical Engineering and Master of Engineering in Mechanical Engineering.

General Requirements

It is required that a student preparing to complete a professional masters degree:

1. Have a minimum of six credit hours of approved out of program upper-division or graduate course work
2. Declare a major with at least 18 credit hours of course work at the 500-level.

Approvals

1. The appropriate department grants admission to its graduate program.
2. Coursework to be applied toward the degree must meet the associated degree requirements and be approved by the graduate student's advisor, chair, and the Dean of Graduate Studies.

Master of Engineering Management

New Mexico Tech's Master of Engineering Management graduate program is a Master's degree program designed for students interested in developing their management and leadership skills as practitioners in their respective fields. The MEM is a entirely course-based degree program consisting of 30 credit hours of 500-level courses taken from the Business and Technology Management Department. The curriculum is designed to be innovative and can be delivered both on campus and via distance education. Specific requirements related to the Master of Engineering Management degree curricula are listed on page 255.

General Requirements

Approvals

The Management Department grants admission to its graduate program.

Coursework must be approved by the graduate student's advisor, chair, and the Dean of Graduate Studies.

Master of Science for Teachers

The graduate program in science for teachers provides graduate-level classroom and laboratory instruction for secondary school teachers of science and mathematics and leads to the Master of Science for Teachers (MST) degree. Courses for science teachers are offered on the campus during the summer session and through distance education during the academic year. Specific requirements for the Master of Science for Teachers degree curricula are listed on page 206

All MST research products (independent study or thesis) must be checked with iThenticate before being accepted.

General Requirements

Approvals

- The Master of Science for Teachers program grants admission to its graduate program.
- The Master of Science for Teachers program and the Dean of Graduate Studies must approve the composition of each graduate student's advisory committee.
- The graduate student's advisory committee must approve the student's thesis or independent study research project. The MST degree will not be awarded until the thesis or independent study paper has been approved by the advisory committee.
- Coursework to be applied toward the degree must be approved by the graduate student's advisory committee.

Research Options

There are two research options, MST with Independent Study and MST with Thesis. Each option requires a minimum of 30 credit hours.

M.S. with Independent Study requires:

- Completion of at least 27 credit hours of approved course work, with at least 15 credit hours of 500-level courses;
- Completion of at least three credit hours of independent study; and
- Submission of a formal paper describing the results of the research to the candidate's advisor and advisory committee.
- Independent study must be checked with iThenticate.
- Submission of a digital abstract of the independent study to the Center for Graduate Studies.

M.S. with Thesis requires:

- Completion of at least 24 credit hours of approved course work, with at least 12 credit hours of 500-level courses;
- Completion of at least six credit hours of thesis work;
- Satisfactory oral defense of the thesis research; and
- Thesis must be checked with iThenticate.
- Submission of digital thesis to the Center for Graduate Studies via ProQuest.

Accelerated Master Option

Well prepared advanced students with a GPA of 3.0 or higher, or with a recommendation from the department chair, may apply for an accelerated Masters degree. The Accelerated Master's option allows accepted students to fulfill the requirements for both Bachelor's and Master's degrees, potentially within 5 years. Students who are enrolled in the Accelerated Masters program may count at most 12 credits of 500-level courses total towards both their undergraduate and graduate degrees (individual departments may impose lower limit); no undergraduate courses may be counted toward both degrees. In partial fulfillment of the Master's degree, students must have an approved course plan by the student's graduate committee; therefore, qualified students are highly encouraged to apply when they reach junior standing within their major to ensure all requirements are being timely met. If admitted, graduate status will be granted upon fulfillment of the requirements for the Bachelor's degree. Please refer to participating departments' corresponding section for additional requirements and restrictions.

Second Master of Science Degree at Tech

Students who wish to earn a second Master degree at NMT must fulfill the requirements for both degrees. Twelve credits may be applied to both degrees. Independent study, directed study or thesis credits may not be counted twice. Second degrees may not be available from some departments.

Doctor of Philosophy Degree

The degree of Doctor of Philosophy requires a high level of competence in a recognized field of learning, and only those students showing unusual promise are accepted. A dissertation that contributes to the general field of knowledge must be written and defended before a committee of the faculty. No doctoral degree will be awarded without full committee approval of the doctoral dissertation and its defense.

The doctoral student can expect to spend at least five or more years of study and research beyond the bachelor's degree in order to complete the program. In addition to dissertation credits, course requirements for each specialty are listed under the programs and courses of instruction for each department.

Doctoral degree programs are available in chemistry, computer science, the earth science fields, electrical engineering, Materials, mathematics, mechanical engineering, petroleum engineering, and physics. Faculty, courses, research fields, and specific requirements for these programs are given under the appropriate department listing.

Preliminary Examination

Each department may require a preliminary or qualifying examination for the students admitted to its doctoral degree program.

Students contemplating doctoral studies at the university should contact the respective department regarding the administration of these examinations.

Candidacy Examination

The purpose of the candidacy examination is to evaluate the student's ability to complete dissertation research. The exam is taken before enrollment in or accumulation of dissertation credits, typically after completion of the majority of graduate course work. The candidacy exam is the responsibility of the individual department; the graduate student should consult their department about candidacy exams. Passing the candidacy exam is one of several steps that must be completed prior to Admission to Candidacy. Graduate committees can and should require additional coursework and/or other remediation for deficiencies discovered during the candidacy exam. Any such remediation is to be added to the students graduate file in the Center for Graduate Studies.

Admission to Candidacy

A doctoral student may apply for candidacy upon completion of a minimum of one year of graduate study at NMT. A student qualifies for admission to candidacy by:

- 1) averaging B or better in coursework taken;
- 2) passing the preliminary or qualifying examination at an approved level;
- 3) passing the candidacy examination; and
- 4) showing preliminary work under way on a dissertation subject; typically this is done through the defense of a dissertation proposal.

Candidacy must be achieved at least one year prior to the time the degree is conferred.

Dissertation

The doctoral dissertation demonstrates the candidate's capacity for independent research. The student may register for dissertation hours only after successfully advancing to candidacy. A minimum of 24 credit hours of dissertation distributed over one or more years must be devoted to the dissertation after candidacy has been achieved. No dissertation credits taken before approval of candidacy will count toward a doctoral degree. The student is encouraged to explore the various current research projects in his or her field of interest before choosing a dissertation subject. The dissertation must be defended before the NMT faculty under the supervision of the student's advisory committee. Manuscript requirements are on page 50. An external examiner will be included on the defense committee. The candidate must be registered during the semester in which the completed dissertation is defended and submitted to the Center for Graduate Studies. Students may pay a fee to defend between semesters, but they must have been registered the semester before and they must have permission of their full committee. Between semester defense and all requirements including final formatting and inclusion of required permissions must be completed two weeks before the first day of class for the subsequent semester or the student must enroll and pay for registration. Doctoral candidates are required to present at least one departmental or general seminar on the dissertation during their tenure as a graduate student. Before the degree is approved and granted, at least one paper on the subject matter of the dissertation must be submitted to a recognized journal acceptable to the doctoral committee of the student. Generally, significantly more research publication is expected.

Departmental Certification

The appropriate department must certify to the Center for Graduate Studies that the general requirements are being satisfied and that the candidate is making required progress. The method of evaluation varies with the department. Certification is transmitted to the Center for Graduate Studies on forms provided by the Center for Graduate Studies. These forms are:

The Advisory Committee Form, and

The Report of the Advisory Committee, which records the actions of the student's advisory committee.

Completion of Requirements

A record of all steps completed in a particular student's program is kept in the Center for Graduate Studies. When all the requirements are completed, the record of the program is sent to the Registrar for the student's permanent file. If the graduation and other fees have been paid and a Declaration of Intent has been filed and approved by the Registrar, the candidate's name will be presented to the Faculty Senate for recommendation of conferral of degree to the Regents.

Postdoctoral and Visiting Scholars

Postdoctoral fellows, research associates, and visiting scholars are accommodated as appropriate in research programs within departments. The faculty host and department negotiate arrangements, with an official appointment made by the NMT administration. International guests may visit classes on an informal basis by arrangement with the instructor. If credit or audit privileges are desired, application must be made through the Center for Graduate Studies.

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Arts & Sciences

Air Force ROTC (AFROTC)

AFROTC Detachment 510
(Aerospace Studies Building 159)
MSC02 1650 / 1901 Las Lomas NE
1 University of New Mexico
Albuquerque, NM 87131-0001
(505)277-4502
www.afrotc.com <http://afrotc.unm.edu/>

The mission of the Air Force ROTC is to provide instruction and experience to all cadets in a diversified college or university environment, so they can graduate with the knowledge, character, and motivation essential to becoming leaders in the United States Air Force. The Air Force ROTC approach to education encourage inquiry, analysis, critical thinking, imagination, judgment, and individual participation on the part of each student.

Program Requirements

The General Military Course: The General Military Course (GMC) is an introduction to U.S. military forces and to the development of air and space power. The course of study is designed to prepare cadets for entry into the studies normally offered to freshman and sophomores. The GMC totals approximately 180 course hours, consisting of 60 course hours of academics and 120 course hours of leadership laboratory over two years. Four courses are required to complete the GMC: First year; AFAS 120 (Fall semester), AFAS 121 (Spring semester), Second year; AFAS 250 (Fall semester), AFAS 251 (Spring semester). Sophomores may dually enroll in AFAS 120/121 and

AFAS 250/251 to accomplish these requirements in two semesters instead of four.

The Professional Officer Course: The Professional Officer Course (POC) subject matter includes theoretical and applied leadership, management, communication skills and national security and defense policy. The POC prepares cadets for active duty as commissioned officers. It is normally for juniors and seniors. The POC totals approximately 300 hours, with 180 hours of academics and 120 hours of leadership laboratory over two years.

Field Training: Field training is a two-week encampment at Maxwell AFB in Montgomery, AL, which is designed to evaluate the student while challenging them both mentally and physically. Upon successful completion of Field Training, the student is allowed to enter the POC.

NOTE: Leadership Laboratory is a corequisite each semester throughout the four-year program. Leadership laboratory provides a variety of practical leadership experiences by rotating cadet corps positions and responsibilities among students enrolled in the GMC and POC. Cadets may receive credit for the Physical Fitness by taking a portion of Leadership Laboratory AFAS 329 per UNM policy.

Air Force ROTC Commissioning Program

The Air Force ROTC commissioning program is open to qualified students in all academic majors that will allow for the necessary AFROTC attendance and participation requirements. The program is divided into a general military course (GMC) and a professional officer course (POC). The latter is the final commissioning phase for those students who qualify and desire a commission in the United States Air Force or United States Space Force. Both the GMC and POC programs require students to enroll in an Aerospace Science Leadership Laboratory each semester.

This department is administered by personnel of the United States Air Force and/or United States Space Force under rules promulgated by the Department of the Air Force and the University of New Mexico.

Students may enter Air Force ROTC from any high school, college, or university. Transfer students with a ROTC background can receive credit for previous ROTC experience.

Following successful completion of the Air Force ROTC program, each individual is commissioned as a second lieutenant in the United States Air Force or United States Space Force. Full pay and benefits begin upon initial assignment to active duty.

Requirements

Qualified students may enroll in aerospace studies classes following normal college registration procedures. The student enrolls in the General Military Course (GMC) for the first two years. Prior to enrolling in the last two years of the program, the Professional Officer Course (POC), the student must meet Air Force ROTC qualification standards and requirements. In addition, all Air Force ROTC participants must complete a four-week summer field training course prior to entering the POC, normally between the sophomore and junior years. It is possible to compress the two GMC years to one through dual enrollment into the academic courses. The POC portion must last two years.

General Military Courses

AFAS 120, Heritage and Values, 1 cr

Survey course designed to introduce students to the U.S. Air Force and U.S. Space Force and provides an overview of the basic characteristics, missions, and organization of the Air Force and Space Force.

AFAS 120L, Leadership Laboratory, 1 cr

Corequisite: AFAS 120

Dynamic and integrated grouping of leadership developmental activities designed to meet the needs and expectations of prospective Air and Space Force second

lieutenants and complement the AFROTC academic program.

AFAS 121 Heritage and Values II, 1 cr

Survey course designed to introduce students to the U.S. Air Force and U.S. Space Force and provides an overview of the basic characteristics, missions, and organization of the Air Force and Space Force.

AFAS 121L, Leadership Laboratory

Corequisite: AFAS 121

Continuation of AFAS 120L. Graded S/U.

AFAS 250, Team and Leadership Fundamentals I, 1 cr

Provides a fundamental understanding of both leadership and team building. The lessons and course flow are designed to prepare cadets for field training and leadership positions in the detachment.

AFAS 250L, Leadership Laboratory

Corequisite: AFAS 250

Dynamic and integrated grouping of leadership developmental activities designed to meet the needs and expectations of prospective Air and Space Force second lieutenants and complement the Air Force ROTC academic program. Graded S/U.

AFAS 251, Team and Leadership Fundamentals II, 1-2 credits

Provides a fundamental understanding of both leadership and team building. The lessons and course flow are designed to prepare cadets for field training and leadership positions in the detachment.

AFAS 251L, Leadership Laboratory, 1cr

Corequisite: AFAS 251

Continuation of AFAS 250L. Graded S/U.

AFAS 300, Leading People and Effective Communication I, 3 cr

Utilizes cadets field training experience to take a more in-depth look at leadership. Special emphasis is placed on enhancing communication skills, and why that is important as a leader.

AFAS 300L, Air Force Leadership Laboratory, 1 cr

Corequisite: AFAS 300

Dynamic and integrated grouping of leadership developmental activities designed to meet the needs and expectations of prospective Air and Space Force second lieutenants and complement the Air Force ROTC academic program. Graded S/U.

AFAS 301, Leading People and Effective Communication II, 3 cr

Utilizes cadets field training experience to take a more in-depth look at leadership. Special emphasis is placed on enhancing communication skills, and why that is important as a leader.

AFAS 301L, Air Force Leadership Laboratory, 1 cr

Corequisite: AFAS 301

Continuation of AFAS 300L. Graded S/U.

AFAS 400, National Security, Leadership Responsibilities and Commissioning Preparation I, 3cr

Overview of the complex social and political issues facing the military profession and gives the foundation to understand the role of military officers and how they are directly tied to our National Security Strategy.

AFAS 400L, Air Force Leadership Laboratory, 1cr

Corequisite: AFAS 400

Dynamic and integrated grouping of leadership developmental activities designed to meet the needs and expectations of prospective Air and Space Force second lieutenants and complement the Air Force ROTC academic program.

AFAS 401, National Security, Leadership Responsibilities and Commissioning Preparation II, 3cr

Overview of the complex social and political issues facing the military profession and gives the foundation to understand the role of military officers and how they are directly tied to our National Security Strategy.

AFAS 401L, Air Force Leadership Laboratory, 1 cr

Corequisite: AFAS 401 Continuation of AFAS 400L.

Graded S/U

These courses are taught through a special cross-enrollment agreement with the University of New Mexico and its Department of Aerospace Studies on the main campus of UNM in Albuquerque.

It is also recommended to visit afrotc.unm.edu for additional information.

Atmospheric Sciences

Interdepartmental Graduate Program

A number of departments at NM Tech offer coursework and research opportunities in the atmospheric sciences. This program was developed to:

- 1) make it easier for students to discern what is available at NM Tech in the atmospheric sciences and
- 2) facilitate cross-departmental course and research work by students.

The actual degrees awarded are those offered by each department; there is no separate degree in the atmospheric sciences. The student must satisfy all the requirements in his or her department to earn a degree. Each student shall have an academic advisor from the student's home department. However, the student's research advisor can be a faculty member from any of the participating departments.

Current Specialties

Atmospheric and environmental chemistry: *Kyle, Wingenter*
 Cloud physics, cloud dynamics, and atmospheric electricity:

Eack, Krehbiel, Raymond, Rison, Winn

Hydroclimatology: *Hendrickx*

Upper-atmosphere physics: *Minschwaner, Thomas*

Applicable Courses

Chemistry

CHEM 422, Environmental Geochemistry
 CHEM 531, Chemistry of Aquatic Systems
 CHEM 532, Atmospheric Chemistry

Earth and Environmental Science

GEOL 422, Environmental Geochemistry
 GEOC 507, Hydrogeochemistry
 HYD 503, Groundwater Hydrology
 HYD 507, Hydrogeochemistry
 HYD 512, Surface Water Hydrology
 HYD 513, Hydroclimatology
 HYD 517, Vadose Zone Hydrology

Environmental Engineering

ENVE 413, Fundamentals of Air Pollution Engineering
 ENVE 416, Design of Air Pollution Engineering Systems
 ENVE 535, Transport and Fate of Air Pollutants

Physics

PHYS 331, Physics of Weather and Climate I
 PHYS 332, Physics of Weather and Climate II
 PHYS 432, Atmospheric Remote Sensing
 PHYS 443, Atomic and Nuclear Physics
 PHYS 526, Fluid Dynamics
 PHYS 533, Advanced Topics in Atmospheric Physics

Participating Departments and Faculty

Chemistry

Wingenter—Atmospheric Chemistry

Earth and Environmental Science

Hendrickx—Vadose Zone Hydrology

Kyle—Igneous Geochemistry, Antarctic Geology, Volcanology

Electrical Engineering

Rison—Atmospheric Electricity, Instrumentation

Thomas—Upper Atmospheric Physics, Instrumentation

Materials and Metallurgical Engineering

G. Bond—Carbon Dioxide Remediation

Physics

Eack—Atmospheric Physics, Atmospheric Electricity

Krehbiel—Lightning Studies, Radar Meteorology, Thunderstorm Electrification

Minschwaner—Radiative Transfer and Climate, Physics of the Upper Atmosphere

Raymond—Geophysical Fluid Dynamics, Cloud Physics, Clouds and Climate

Winn—Atmospheric Physics, Electrical Discharges in Gases, Instrumentation

Basic Sciences Program

(Interdepartmental)

Administrative Committee for Basic Sciences:

Jeff Altig, Chemistry

Mark Samuels, Psychology

David Westpfahl, Physics

Ex Officio: Dean of Arts & Sciences (Chair)

Degrees Offered: B.S. in Basic Sciences

The degree Bachelor of Science in Basic Sciences is intended for the student who desires a Bachelor of Science degree but wishes more latitude in the selection of courses than is available otherwise. It is well adapted to the needs of a student who may wish to complete preparation for secondary school teaching in science or mathematics. For this purpose, however, proper selection of courses is necessary, and the advice of the Department of Education should be sought.

To qualify for the degree Bachelor of Science in Basic Sciences, a student must satisfy the general education core curriculum requirements for the Bachelor of Science degree (page 81).

- Of the minimum 120 credit hours required for this degree, at least 65 must be in science and mathematics. These can include biology, chemistry, computer science, earth and environmental science, mathematics, engineering courses (numbered above 200), physics, and psychology.
- At least 30 of these credit hours must be in courses numbered 201 or above. In order that a reasonable depth of study is attained in at least two fields, the 30 credit hours must include at least nine credit hours in each of two fields.
- Of the total credit hours required, at least 42 must be in courses numbered 300 or above.

Biology

Professors: DeVeaux (Chair of the Department), Kieft, Rogelj
Associate Professor: Duval

Assistant Professor: Sharbrough

Instructor: Goncz

Adjunct Faculty: Beers, Bell, Buelow, Chain,
 Elliott, Markwell, Pias, Piyasena, Tartis,
 Thompson, Vuyisich, P. Wilkinson

Emeritus Faculty: Reiss, Smoake

Faculty teaching BMS specific classes:

ChoGlueck (CLASS), Thompson (CLASS),
 DeVeaux (Biology), Goncz (Biology), Rogelj (Biology)
 Hassanalian (Mechanical Engineering), Makhnin (Math),
Advisors: ChoGlueck (CNS), Elliott (CNS), Thompson
 (CNS), DeVeaux (Biology), Goncz (Biology), Rogelj
 (Biology), Pias (Chemistry).

Degrees Offered: *B.S. in Biology, B.S. in Biology with Environmental Science Option; B.S. in Biomedical Sciences with options in Biology, Chemistry, and Cognitive Neuroscience(CNS); M.S. in Biology; and M.S. in Biology with Specialization in Biochemistry*

Program Offered: *Accelerated MS Program*

The mission of the Biology Department is to provide students with a relevant education for biomedical and biotechnological careers, to lead in molecular biological and environmental life science research, and to serve the university and the scientific community. The Biology program prepares undergraduate students for graduate education in the medically allied professions and in the specialized fields of the biological sciences. **(Students who are interested in pre-medical, pre-dental, and pre-veterinary science programs should see page 187)**

A wide variety of career opportunities is currently available for those individuals possessing advanced knowledge and skills, particularly in the areas of biochemistry, molecular biology, microbiology, ecology, genetics, endocrinology, and immunology. Market demand in these areas will likely remain strong for the foreseeable future.

Undergraduate majors typically have diverse career goals and objectives. To accommodate these differences, the undergraduate program is very flexible; only a minimal number of technical core courses is required. Through the selection of appropriate technical electives, each student customizes their education based on personal academic needs and career objectives.

The main approach in the classroom is to stress the highly quantitative and analytical nature of modern biological inquiry, which utilizes sophisticated biochemical and biophys-

cal techniques to answer fundamental questions about living organisms. Undergraduates are encouraged to undertake research through various directed study and special topics offerings and are often employed as technicians in the research laboratories of the faculty.

Program Educational Objectives:

Our graduates will be able to use basic principles of science to analyze, to explain, and to apply biological information and concepts.

Our graduates will be able to design and implement biological research and report findings orally and in writing.

Undergraduate Program

Bachelor of Science in Biology

Minimum credit hours required—120

In addition to the General Education and Institute Core Curriculum Requirements (page 78), the following courses are required:

- BIOL 1131 (1), BIOL 2110 (3) & 2110L (1), 2610 (3) & 2610L (1), 311 (3) & 311L (1), 331 (3), 341 (3) & 341L (1), and BIOL 471 (1)
- At least 6 additional credit hours from:
 BIOL 351 (3) & 351L (1), 352 (3) & 352L (1), 431 (3), 437 (3), 443 (3) & 443L (1)
- At least 6 additional credit hours from:
 BIOL 343 (3) & 343L (1), 344 (3) & 344L (1), 345 (3), 402 (3), 455 (3)
- Additional Biology courses 2000-level and above (12).
 CHEM 441 and 442 (Biochemistry I and II) may be applied to biology electives.
- CHEM 333 (3); plus 6 additional hours from the following:
 CHEM 311 (3), 311L (1), 331 (3), 333L (1), 334 (3), 334L (1), 441 (3) & 441 (1).
- Computer Science or Mathematics: CSE 107 (4) or MATH 2350 (3)
- Electives to complete 120 hours

Biology laboratory classes are required for biology lecture courses that offer an associated laboratory if credit for the lecture course is used to meet the required number of biology credits for a degree in biology. Students pursuing a B.S. in Biology must take Biology and Chemistry courses for a letter grade, except for BIOL 1131 and BIOL 1141. Prerequisites for a particular course may be waived only with the written permission of the course instructor and chair of the department.

Sample Curriculum for the Bachelor of Science in Biology

Semester 1

- 1 BIOL 1131 (Intro to Biology & BMS)
- 4 BIOL 2110 & 2110L (intro)
- 4 CHEM 1215 & 1215L (general)
- 3 ENGL 1110 (college English)

4 MATH 1510 (calculus I)
16 Total Credit Hours

Semester 2

4 BIOL 2610 & 2610L (intro)
4 CHEM 1225 & 1225L (general)
3 ENGL 1120 (college English)
4 MATH 1520 (calculus II)

15 Total Credit hours

Semester 3

3 BIOL 331 (cell)
3 Social Science
5 PHYS 1310 & 1310L (general)
3 CHEM 333 (organic)
1 Physical Recreation

15 Total credit hours

Semester 4

4 BIOL 311 & 311L (genetics)
3 Humanities
5 PHYS 1320 & 1320L (general)
3 Chemistry Elective

15 Total credit hours

Semester 5

4 BIOL 341 & 341L
3 Biology Environmental Elective
3 Chemistry Elective
3 Social Science
3 ENGL 341 (technical writing)

16 Total credit hours

Semester 6

3 Biology Elective
3 Biology Environmental Elective
3-4 CSE 107 (computer science) or
MATH 2350 (statistics)
3 Humanities
3 Social Science

15-16 Total credit hours

Semester 7

4 Biology Medical/ Molecular Elective
3 Biology Elective
8 Electives

15 Total credit hours

Semester 8

1 Biology 471 (seminar)
4 Biology Medical/Molecular Elective
3 Biology Elective
3 Humanities/Social Science/Fine & Creative Arts
4 Electives
15 Total credit hours

Bachelor of Science in Biology with Environmental Science Option

Minimum credit hours required—120

In addition to the General Degree Requirements (page 78), the following courses are required:

- BIOL 2110 (3), 2110L (1), 2610 (3), 2610L (1), 311 (3), 311L (1), 331 (3), 341 (3) & 341L (1), and BIOL 471 (1)
- At least 12 additional credit hours from: BIOL 343 (3), 343L (1), 344 (3), 344L (1), 345 (3), 402 (3), 455(3), 493 (4); CHEM 422 (3), 422L (1), EARTH 340 (3), 390 (3), 422 (3), 440 (3)
- Additional Biology (12) CHEM 441 and 442 (Biochemistry I and II) may be applied to biology electives.
- CHEM 333 (3); plus 6 additional hours from the following: CHEM 311 (3-4), 331 (3-4), 333L (1), 334 (3), 334L (1), 422 (3-4), 441 (3-4)
- Computer Science or Mathematics: CSE 107 (4) or MATH 2350 (3)
- Electives to complete 120 hours

Biology laboratory classes are required for biology lecture courses that offer an associated laboratory if credit for the lecture course is used to meet the required number of biology credits for a degree in biology. Students pursuing a B.S. in Biology must take Biology and Chemistry courses for a letter grade, except for BIOL 1131 and BIOL 1141. Prerequisites for a particular course may be waived only with the written permission of the course instructor and chair of the department.

Minor in Biology

Minimum credit hours required—18

The following courses are required:

- BIOL 2110 & 2110L (4)
- BIOL 2610 & 2610L (4)
- BIOL 331 (3)
- BIOL 344 & 344L (4)
- Additional biology course numbered 300 or above (3)

Biology classes required for a minor in biology may not be taken on an S/U basis.

Minor in Geobiology

Minimum credit hours required — 18

The following courses are required:

- GEOL 1110 (3), GEOL 1130L, GEOL 2150 & 2150L (4)
- BIOL 2110 & 2110L (4)
- Two classes from the following list: EARTH 450 (3), EARTH 390 (3), BIOL 341 (3), BIOL 344 (3), EARTH 449/BIOL 449 (3)

Bachelor of Science in BMS (all options)

The Bachelor of Science in Biomedical Sciences is a broadly interdisciplinary degree, drawing on knowledge from both science and engineering. Students take a common set of core courses from several disciplines. For more in-depth study, they select an option in Biology, Chemistry, or Psychology along with a concentration in one of four engineering fields: Biochemical Engineering, Bioinformatics, BioMaterials, or Biomechanics.

Minimum credit hours required—120

In addition to the General Education and Institute Core Curriculum Requirements (page 78), the following core program is required of all BMS students. Note that courses marked

with an asterisk (*) may also be used to satisfy General Education requirements:

- BIOL 1131 (1), BMS 300 (1), BMS 301 (2), BMS 495 (2) & BMS 496 (2)
- BIOL 2110 & 2110L (4), BIOL 2610 & 2610L (4),
- BIOL 331 (3), BIOL 341 (3)
- CHEM 333 & 333L (4), CHEM 334 & 334L (4),
- CHEM 441 & 441L (4)
- CSE 107 & 107L (4) or CSE 113 & 113L (4) or ES 111 & 111L (3)
- MATH 2532 (4), MATH 335 (3), MATH 383 (3)
- PHIL 342 (3)*
- PSYC 1110 (3)*, PSYC 2285 & 2285L (4)*

One of the **Science Options** described below AND
One of the **Engineering Concentrations** described below.

Science Options

Every BMS student must complete the requirements of one of the science options described below.

Bachelor of Science in BMS with Biology Option

In addition to the General Education and Institute Core Curriculum Requirements (page 78), and the core BMS Requirements, the following courses are required:

- BIOL 351 & 351L (4)
- BIOL 352 & 352L (4) OR BIOL 443 & 443L (4)**
- BIOL 435 (3)** OR BIOL 437 (3)

**Note: prerequisites must be met

Bachelor of Science in BMS with Chemistry Option

In addition to the General Education and Institute Core Curriculum Requirements (page 78), and the core BMS Requirements, the following courses are required:

- CHEM 311 & 311L (4)
- CHEM 331 & 331L (4)
- CHEM 442 & 442L (4)

Bachelor of Science in BMS with Cognitive Neuroscience Option

In addition to the General Education and Institute Core Curriculum Requirements (page 78), and the core Biomedical Sciences Requirement, the following courses are required:

- PSY 2310 (3)*

PSY 309 & 309L (3)*

PSY 314 (3)*

PSY 409 (3)*

PSY 410 (3)*

Engineering Concentrations

Every BMS student must complete the requirements of one of the four engineering concentrations described below.

Biochemical Engineering

The following courses are required:

- ChE 326 (3)
- Two of: ChE 468 (3), ChE 476 (3), ChE 477 (3),
- ChE 489 Nanostructures & Nanomaterials (3)

Bioinformatics

The following courses are required:

- BIOL 311 & 311L (4)
- BIOL 443 & 443L (4) and BIOL 435 (3) (part of Biology Option)
- CSE 122 (3), CSE 373 (3)

BioMaterials

The following courses are required:

- MTLs 202 & 202L (4), MTLs 310 (3), MTLs 420 (3)

Biomechanics

The following courses are required:

- ES 201 (3), ES 216 (3), ES 303 (3)
- MENG 460 (3)

Graduate Program

Master of Science in Biology

The master's candidate must demonstrate competence in mathematics, chemistry, and physics comparable to New Mexico Tech's Bachelor of Science in Biology. Additional requirements are the following:

Thesis option:

- Completion of at least six credit hours of 500-level biology coursework other than thesis, directed study, independent study, or seminar.
- Completion of at least six credit hours of 500-level coursework other than thesis, directed study, independent study, or seminar in one or more disciplines outside of biology.
- Completion of two credit hours of BIOL 501, Graduate Seminar.

Independent Study option:

- Completion of at least 18 credit hours of 500-level Biology coursework other than thesis, directed study, independent study, or seminar.

- Completion of at least 6 hours of 500-level coursework other than thesis, directed study, independent study, or seminar, in one or more disciplines outside of biology.
- Completion of three credit hours of BIOL 501, Graduate seminar in Biology.
- Completion of three credit hours of BIOL 590, Independent study.

Master of Science in Biology with Specialization in Biochemistry

The master's candidate must demonstrate competence in mathematics, chemistry, and physics comparable to New Mexico Tech's Bachelor of Science in Biology. Additional requirements are the following:

- Completion of at least six credit hours of 500-level biology coursework other than thesis, directed study, independent study, or seminar.
- Completion of at least six credit hours of CHEM 561 (Advanced Topics in Biochemistry, 3cr) and CHEM 547 (Medicinal Chemistry, 3cr), or committee-approved substitute 500-level chemistry course (s).
- Completion of two credit hours of BIOL 501 (Graduate Seminar) and two credit hours of CHEM 529 (Chemistry Graduate Seminar).
- Thesis overlaps the fields of Biology and Chemistry and is supervised by faculty from both Biology and Chemistry Departments.

Accelerated Master's program:

Exceptionally qualified and motivated students may earn both BS (in Biology or BMS) and MS (in Biology) degrees in as little as five years. Accepted students may apply up to six credits of 500-level or above coursework to both degrees.

Students should apply for the accelerated Master's program no later than the semester prior to their final undergraduate year. During their final year of undergraduate study, students must select a graduate advisory committee and formalize their graduate research or independent study topic and program of study. Thesis students must also enroll in BIOL 581 (Directed study) for one credit with their research advisor during their final semester of undergraduate study, and pass with a B or better, to remain in the accelerated program.

Both thesis and independent study students must receive a B or better in dual counted classes to remain in the accelerated program. Independent study students must also enroll in one semester of BIOL 501 (graduate seminar) during their final undergraduate year.

Biology Courses:

BIOL 1131, Introduction to Biology & Biomedical Sciences, 1 cr, 1 cl hr

Graded S/U

A discussion-focused course exploring current topics in biomedical research and innovation. The course promotes a broad view of the biomedical sciences and related challenges, with class discussions stimulated largely by TED talks and other internet videos.

BIOL 1141, A Survey of Anatomy and Physiology for Allied Health Course 2cr, 2 cl hrs

Graded S/U

Anatomy and Physiology for Allied Health integrates diseases and disorders within each body system to maximize learning. Easy-to-understand language and numerous illustrations make the course ideal for learners in an introductory anatomy and physiology course with little or no science background or learners continuing their education in Allied Health. This course will also assist the student in developing a better understanding and interest in the medical field.

BIOL 2110, 2110L, Principles of Biology: Cell and Molecular Biology, 3-4 cr, 3 cl hrs, 3 lab hrs

Corequisite: CHEM 1120 or CHEM 1215

This course introduces students to major topics in general biology. This course focuses on the principles of structure and function of living things at the molecular, cellular and organismic levels of organization. Major topics included are introduction to the scientific process, chemistry of cells, organization of cells, cellular respiration, photosynthesis, cell division, DNA replication, transcription, and translation. [NMCCNS BIOL 1214: General Education Area III]

BIOL 2610, 2610L, Principles of Biology: Biodiversity, Ecology and Evolution, 3-4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: BIOL 2110

This course is an introduction to the dynamic processes of living things. Major topics include the mechanisms of evolution, biological diversity, population genetics, and ecology. The laboratory course is an introduction to the dynamic processes of living things. [NMCCNS BIOL 1224: General Education Area III]

BIOL 301, Genetic Engineering: At the Bench, 2 cr, 1 cl hr, 3 lab hrs

Prerequisites: BIOL 2110 and BIOL 2110L

This course introduces basic biology lab techniques through experiments involving genetic engineering. Students will learn the fundamentals of genetic engineering through the direct manipulation of genetic sequences studied in easily grown model organisms, such as bacteria.

BIOL 311, 311L, Genetics, 3-4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: BIOL 2610 & 2610L; CHEM 1215

An overview of the storage, transmission and expression of biological information. The lab emphasizes Mendelian analysis in model organisms and molecular analysis of DNA.

BIOL 331, Cell Biology, 3 cr, 3 cl hrs

Prerequisites: BIOL 2110; CHEM 1215

Studies of life at the cellular level. The structure and functions of eukaryotic cells and their organelles. The molecular basis for energy transfers, growth and development, and their regulation.

BIOL 341, 341L, Introductory Microbiology, 3-4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: CHEM 1225

Prerequisite or Corequisite: BIOL 331

A comparative study of reproduction, growth, and metabolism of bacteria, rickettsia, and viruses, with emphasis on the bacteria and their relation to man and their environment.

BIOL 343, 343L, Environmental Microbiology, 3–4 cr, 3 cl hrs, 3 lab hrs*Prerequisite: BIOL 2110**Prerequisite or Corequisite for Biology majors: BIOL 331; BIOL 331 recommended for other majors*

A study of the relationship between microorganisms and water and soil environments with emphasis on biogeochemical cycles.

BIOL 344, 344L, Introductory Ecology, 3–4 cr, 3 cl hrs, 3 lab hrs*Prerequisites: BIOL 2610; GEOL 206*

A study of the principles governing interactions between organisms and the environment, and biological organization at the population, community and ecosystem level.

BIOL 345, Evolutionary Biology, 3 cr, 3 cl hrs*Prerequisites: BIOL 2610; GEOL 206*

The mechanisms and implications of biological evolution. Topics include early Earth evolution, population genetics, adaptation and natural selection, geologic evidence, molecular evidence and human evolutionary origins.

BIOL 350, Psychobiology of Sex, 3 cr, 3 cl hrs*Prerequisite: PSYC 1110 or consent of instructor and advisor*

Sexual reproduction in a broad evolutionary context. Topics include sexual and asexual reproduction, sexual selection, the endocrinology of mammalian reproduction, development of the reproductive system and sexually differentiated behaviors, sex differences in the brain, and human behavioral sex differences.

(Same as PSY 350)**BIOL 351, Anatomy and Physiology I, 3 cr, 3 cl hrs***Prerequisite: BIOL 2610, BIOL 331*

An in-depth study of the form, function, and evolution of the following human systems: skeletal, muscular, nervous, cardiovascular, and respiratory. Gross and microanatomy and detailed physiological concepts covered. **This is the first course in a two-semester sequence**

BIOL 351L, Anatomy and Physiology Lab I, 1 cr, 3 lab hrs*Corequisite: BIOL 351*

Laboratory to accompany BIOL 351. Focus on gross and microanatomy through dissection and physiology through inquiry-driven exercises.

BIOL 352, Anatomy and Physiology II, 3 cr, 3 cl hrs*Prerequisite: BIOL 351 & BIOL 351L*

A continuation of the in-depth study of the form, function, and evolution of the following human systems: endocrine, digestive, immune, lymphatic, integumentary, urinary, and reproductive. Gross and microanatomy and detailed physiological concepts covered. Focus on mod-

ern research in physiology. **This is the second course in a two-semester sequence**

BIOL 352L, Anatomy and Physiology Lab II, 1 cr, 3 lab hrs*Prerequisite: BIOL 351, BIOL 351L**Corequisite: BIOL 352*

Laboratory to accompany BIOL 351. Focus on gross and microanatomy through dissection and physiology through inquiry-driven exercises.

BIOL 362, Animal Behavior, 3 cr, 3 cl hrs*Prerequisites: PSYC 1110; BIOL 2610; or consent of instructor and advisor*

An overview of the study of animal behavior, focusing on presentation, adaptive advantage and mechanisms of specific behaviors. **(Same as PSY 362)**

BIOL 402, Ecosystem Biology, 3 cr, 3 cl hrs*Prerequisite: BIOL 344*

An approach to ecology that treats organisms and the physical environment as an integrated system. Focus on abiotic feedbacks between plant and microbial function including decomposition, greenhouse gas flux, and major biogeochemical cycles. Potentially strenuous field work is a component of the course. Laboratory analysis of field samples are part of projects that develop quantitative skills using student-collected data. Shares lecture with BIOL 502 with additional expectations for graduate credit.

BIOL 409, Cell and Molecular Neuroscience, 3 cr, 3 cl hrs*Prerequisite: PSY 1110 or BIOL 2110*

A study of the molecular and cellular basis of the nervous system, covering fundamentals of cell biology, principles of neuronal signaling and neuronal circuits, and cell and molecular approaches to the investigation, diagnosis and treatment of diseases of the nervous system. Shares lecture with BIOL 509 and BIOT 509, with additional expectations for graduate credit. **(Same as PSY 409.)**

BIOL 411, Advanced Genetics, 3 cr, 3 cl hrs*Prerequisites: BIOL 311 and either BIOL 443 or BIOL 341, or consent of instructor and advisor*

A study of current topics in genetics, including the molecular basis of gene structure and action in eukaryotes and/or prokaryotes.

BIOL 431, Virology, 3 cr, 3 cl hrs*Prerequisite: BIOL 311, BIOL 331*

An intensive course focusing on mammalian, plant and bacterial viruses as obligate cellular parasites. This program will examine strategies for sustaining an efficient infectious cycle through discussions around current research, including social implications of study in the field. Shares lecture with BIOL 531 with additional expectations for graduate credit.

BIOL 435, Bioinformatics, 3 cr, 3 cl hrs*Prerequisite: BIOL 311 or consent of instructor and advisor*

Computer analysis of biological sequence data used to perform in silico experiments. Students will design and

perform experiments using public domain software and databases. Shares lecture with BIOL 535 and BIOT 535 with additional expectations for graduate credit.

BIOL 437, Infection and Immunity, 3 cr, 3 cl hrs

Prerequisite: BIOL 341

Study of human infectious disease and the immune system. Pathogenic microorganisms and mechanisms of pathogenicity. Innate and acquired immune responses. Disease ecology and evolution in infectious disease systems.

BIOL 443, 443L, Molecular Biology, 4 cr, 3 cl hr, 3 lab hrs

Prerequisites: BIOL 331 and BIOL 311 & 311L; CHEM 1215

Principles of modern molecular biology. Laboratory emphasizes enzyme purification and recombinant DNA techniques, organized as a gene cloning project. BIOL 443 and BIOL 443L must be taken concurrently.

BIOL 445, Evolutionary Biomechanics, 3 cr, 3 cl hrs

Prerequisites: BIOL 345 and MATH 1520, or consent of instructor and advisor

Study of techniques to assess the evolution of functional systems. Independent contrasts and phylogenetic generalized least squares models applied to morphological and functional performance hypotheses. Interdisciplinary, research-based course.

BIOL 449 Astrobiology, 3 cr, 3 cl hours

Prerequisites: CHEM 1215, 1225, PHYSICS 1310, 1320 plus one other science course and consent of instructor. Offered on demand.

An in-depth and interdisciplinary study of astrobiology, including interactions between living and non-living systems at multiple scales: stellar, planetary, meso, and microscopic. Addresses fundamental questions regarding the origin of life, and the possible extent and distribution of life in the universe. Combines principles of astrophysics, geosciences, planetary science, chemistry, and biology. Innovative interactive exercises and projects working in interdisciplinary groups and individually. Shares lecture with BIOL 549, with additional expectations for graduate credit. **(Same as GEOL 449.)**

BIOL 455, Molecular Ecology, 3 cr, 3 cl hrs

Prerequisites: BIOL 311 and 344, or consent of instructor and advisor

Application of molecular biological techniques to ecological and environmental problems. Current research projects at Tech are emphasized.

BIOL 470, Biology CURE, 2 cr, 1 cl hr, 3 lab hrs

Prerequisites: BIOL 331 and one of the following: BIOL 311L, BIOL 331L, BIOL 341L, BIOL 343L or BIOL 301

In this Course-based Undergraduate Research Experience (CURE) students will plan and conduct independent research projects under the supervision of the instructor. The topic of research will change each year, and be related to the faculty member's research interests. Students will learn the background of the project, design and per-

form experiments, read literature, and present their results, all with minimal oversight. Distribution of time between lecture and lab each week may vary considerably during semester.

BIOL 471, Life Sciences Seminar, 1 cr, 1 cl hr

Prerequisite: Senior standing in biology or consent of instructor and advisor

Review, discussion, and student presentations of the current literature on a single topic in biology. Topics are chosen with the aim of integrating multiple levels of biological organization and research approaches.

BIOL 481, FreeStyle BioSciences, 1 cr, 2 cl hr

Prerequisite: Senior or Graduate Standing

Exploratory, interdisciplinary seminar-style class utilizing web resources focused on recent developments in Biology and Biology-related areas.

BIOL 489, Special Topics in Biology, cr and hrs to be arranged

Prerequisites: Two semesters of advanced courses and consent of instructor

Special readings or course in biology.

BIOL 491, Special Problems, cr and hrs to be arranged

Prerequisites: Two semesters of advanced courses and consent of instructor

An introduction to methods of research. Problems are chosen from the fields of biology and may be small independent investigations or part of a research program being directed by the advisor.

BIOL 493, Directed Study in Environmental Biology, cr and hrs to be arranged

Prerequisites: Senior student majoring in Biology—Environmental Science Option, and consent of instructor

A student-designed study of local problems and processes occurring during interaction between biological systems and their physico-chemical environment including literature review, field and laboratory research, and result presentation by written report and seminar.

BIOL 500, Directed Research, cr to be arranged

This course may not be used to fulfill graduate degree requirements. Research under the guidance of a faculty member.

BIOL 501, Graduate Seminar, 1 cr, 1 cl hr

Prerequisite: Graduate-level standing in Biology or Biotechnology, or consent of instructor and advisor

Special topics in biology. Readings, student presentations, and discussions will focus on a single topic within biology, with a different topic to be selected by the Biology faculty each semester.

BIOL 502, Ecosystem Biology, 3 cr, 3 cl hrs

Prerequisite: Graduate-level standing in Biology or Biotechnology, or consent of instructor and advisor

An approach to ecology that treats organisms and the physical environment as an integrated system. Focus on abiotic feedbacks between plant and microbial function

including decomposition, greenhouse gas flux, and major biogeochemical cycles. Potentially strenuous field work is a component of the course. Laboratory analysis of field samples are part of projects that develop quantitative skills using student-collected data. Shares lecture with Ecosystem Biology BIOL 402 with additional expectations for graduate credit that include: organizing data collection and group work sessions for undergraduates (400-level students) and leading manuscript preparation for final group assignments.

BIOL 509, Cell and Molecular Neuroscience, 3 cr, 3 cl hrs

Prerequisite: Graduate-level standing in Biology or Biotechnology, or consent of instructor and advisor

A study of the molecular and cellular basis of the nervous system, covering fundamentals of cell biology, principles of neuronal signaling and neuronal circuits, and cell and molecular approaches to the investigation, diagnosis and treatment of diseases of the nervous system. Shares lecture with BIOL 409, with additional expectations for graduate credit. (Same as BIOT 509.)

BIOL 511, Advanced Genetics, 3 cr, 3 cl hrs

Prerequisites: Graduate-level standing in Biology or Biotechnology, or consent of instructor and advisor

A study of current topics in genetics, including the molecular basis of gene structure and action in eukaryotes and prokaryotes. Shares lecture with BIOL 411, with additional expectations for graduate credit.

BIOL 531, Virology, 3 cr, 3 cl hrs

Prerequisite: Graduate-level standing in Biology or Biotechnology, or consent of instructor and advisor

An intensive course focusing on mammalian, plant and bacterial viruses as obligate cellular parasites. This program will examine strategies for sustaining an efficient infectious cycle through discussions around current research, including social implications of study in the field. Shares lecture with Virology BIOL 431, with additional expectations for graduate credit.

BIOL 535, Bioinformatics, 3 cr, 3 cl hrs

Prerequisite: Graduate-level standing in Biology or Biotechnology, or consent of instructor and advisor

Computer analysis of biological sequence data used to perform in silico experiments. Students will design and perform experiments using public domain software and databases. Shares lecture with BIOL 435 with additional expectations for graduate credit. (Same as BIOT 535.)

BIOL 537, Infection and Immunity, 3 cr, 3 cl hrs

Prerequisite: Graduate-level standing in Biology or Biotechnology, or consent of instructor and advisor

Study of human infectious disease and the immune system. Pathogenic microorganisms and mechanisms of pathogenicity. Innate and acquired immune responses. Immunochimistry, cellular immunity, and immunopathology. Shares lecture with BIOL 437, with additional expectations for graduate credit.

BIOL 542, Advanced Microbiology, 3 cr, 3 cl hrs

Prerequisite: Graduate-level standing in Biology or Biotechnology, or consent of instructor and advisor

A study of the current topics in structure, function, genetics, and biochemistry of microorganisms, with emphasis on recent scientific literature. Medical and environmental topics will be covered.

BIOL 543, 543L, Molecular Biology, 4 cr, 3 cl hr, 3 lab hrs

Prerequisites: Graduate-level standing in Biology or Biotechnology, or consent of instructor and advisor

Principles of modern molecular biology. Laboratory emphasizes enzyme purification and recombinant DNA techniques, organized as a gene cloning project. BIOL 543 and BIOL 543L must be taken concurrently. Shares lecture and laboratory with BIOL 443 & 443L, with additional expectations for graduate credit.

BIOL 549 Astrobiology, 3 cr, 3 cl hours

Prerequisites: Graduate status or consent of instructor and advisor. Offered on demand.

An in-depth and interdisciplinary study of astrobiology, including interactions between living and non-living systems at multiple scales: stellar, planetary, meso, and microscopic. Addresses fundamental questions regarding the origin of life, and the possible extent and distribution of life in the universe. Combines principles of astrophysics, geosciences, planetary science, chemistry, and biology. Innovative interactive exercises and projects working in interdisciplinary groups and individually. Shares lecture with BIOL 449, with additional expectations for graduate credit. (Same as GEOL 549.)

BIOL 564, Molecular Ecology, 3 cr, 3 cl hrs

Prerequisite: Graduate-level standing in Biology or Biotechnology, or consent of instructor and advisor

Molecular ecology is the application of molecular genetics to ecological and environmental issues. The current literature in the field is reviewed. Participants choose a topic to research and develop a research proposal as the final project. Graduate students present a public seminar.

BIOL 581, Directed Study, cr to be arranged

Study under the guidance of a member of the biology staff. In general, subject matter will supplement that available in other graduate offerings in biology.

BIOL 582, FreeStyle BioSciences, 1 cr, 2 cl hr

Prerequisite: Senior or Graduate Standing

Exploratory, interdisciplinary seminar-style class utilizing web resources focused on recent developments in Biology and Biology-related areas. Shares class-time with BIOL 481, with additional expectations for graduate credit.

BIOL 590, Independent Study, cr to be arranged

Organized independent student research coordinated with a faculty member and documented in a final written report.

BIOL 591, Thesis (master's program), cr to be arranged

Biomedical Sciences Courses:

BMS 101, Topics in Biomedical/Biological Sciences, 1 cr, 1 cl hr

Graded S/U

A discussion-focused course exploring current topics in biomedical research and innovation. The course promotes a broad view of the biomedical sciences and related challenges, with class discussions stimulated largely by TED talks and other internet videos. **Cross-listed with BIOL 101.**

BMS 300 Biomedical Sciences Seminar, 1 cr, 1 cl hr

An overview of research in biomedicine, bioinformatics, bioprocesses, and biorobotics. Attention also given to moral and ethical issues. Student participation is integral to the course objectives.

BMS 301, Genetic Engineering: At the Bench, 2 cr, 1 cl hr, 3 lab hrs

Prerequisites or corequisites: BIOL 2110 and BIOL 2110L

This course introduces basic biology lab techniques through experiments involving genetic engineering. Students will learn the fundamentals of genetic engineering through the direct manipulation of genetic sequences studied in easily grown model organisms, such as bacteria. **Cross-listed with BIOL 301.**

BMS 495, Biomedical Research & Design: Science, 2 cr, 1 cl hr, 3 lab hrs.

Prerequisite: BMS 300 and BMS 301

Students participate in novel, topical research and design projects that are related to ongoing research interests of the faculty. Students will collaborate as a team to solve authentic problems that are inherently interdisciplinary with Biomedical Science implications. This is part of a 2 semester course. In this course, students participate in an original science investigation. Students will be mentored but are expected to manage the project, write papers, present and communicate their results to the professional community. Project topics will vary each semester depending on the Instructor. Shares lecture with BMS 593, with additional expectations for graduate credit.

BMS 496, Biomedical Research & Design: Engineering, 2 cr, 1 cl hrs, 3 lab hr

Prerequisite: BMS 300 and BMS 301

Students participate in novel, topical research and design projects that are related to ongoing research interests of the faculty. Students will collaborate as a team to solve authentic problems that are inherently interdisciplinary with Biomedical Science implications. This is part of a 2 semester course. In this course students focus on an engineering design project. Students will be mentored but are expected to manage the project, write papers, present and communicate their results to the professional community. Project topics will vary each semester depending on the Instructor. Shares lecture with BMS 594, with additional expectations for graduate credit.

BMS 593, Biomedical Research & Design: Science, 3 cr, 3 cl hrs

Students participate in novel, topical research and design projects that are related to ongoing research interests of the faculty. Students will collaborate as a team to solve authentic problems that are inherently interdisciplinary with Biomedical Science implications. This is part of a 2 semester course; for one semester students participate in an original science investigation, in the other they focus on an engineering design project. Students will be mentored but are expected to manage the project, write papers, present and communicate their results to the professional community. Project topics will vary each semester depending on the Instructor. Shares lecture with BMS 495, with additional expectations for graduate credit.

BMS 594, Biomedical Research & Design: Engineering, 3 cr, 3 cl hrs

Students participate in novel, topical research and design projects that are related to ongoing research interests of the faculty. Students will collaborate as a team to solve authentic problems that are inherently interdisciplinary with Biomedical Science implications. This is part of a 2 semester course; for one semester students participate in an original science investigation, in the other they focus on an engineering design project. Students will be mentored but are expected to manage the project, write papers, present and communicate their results to the professional community. Project topics will vary each semester depending on the Instructor. Shares lecture with BMS 496, with additional expectations for graduate credit.

Faculty Professional and Research Interests

Beers—Dentistry

Bell --- Transcriptomics, Complex Interactions between Plants and Soil Bacteria (NCGR)

Boston—Geomicrobiology (NASA Astrobiology Institute)

Buelow ---high-resolution spectroscopy, ultra-fast dynamical processes, CEO ([NM Consortium](#))

Chain— Bioinformatics, Metagenomics, Molecular Genetics (LANL)

DeVeaux — Radiation Microbiology and Extremophilic Adaptations, Pathogenicity Gene Transfer (NMT)

Duval — Biogeochemistry, Plant Ecology & Soil Science (NMT)

Elliott — Neuroscience, Animal Communications, and Psycholinguistics (NMT)

Goncz — Education, Education of Educators, Curriculum Development (NMT)

Kieft — Microbiology, Environmental Biology (NMT)

Markwell — Medical Professions (Retired MD)

Pias — Biochemistry & Computer Simulations of Biological Phenomena (NMT)

Piyasena — Analytical Tools for Environmental, Biological, and Chemical Analysis (NMT)

Reiss —Molecular Genetics, Evolution (NMT Emerita)

Rogelj —Anti-Cancer and Anti-Infectives, Drug Discovery, Anti-Microbial Materials (NMT)

Smoake — Animal Physiology, Endocrinology (NMT Emeritus)

Tartis — Chemical Engineering of Drug Delivery Systems (NMT)

Thompson —Cell and Molecular Neuroscience of Vision (NMT)

Vuyisich— Genome Science & Technology Applications (Viome)

Dean Wilkinson—Veterinary Professions (NMT & Animal Haven Veterinary Clinic)

Pepita Wilkinson—Veterinary Professions (Animal Haven Veterinary Clinic)

Biotechnology

(Transdisciplinary)

Faculty:

*Biology - DeVeaux, Duval, Kieft, Rogelj,
Chemical Engineering - Calvert, Choudhury,
Chowdhury, Lecerlc, Tartis
Chemistry - Frolova, Pias, Piyasena, Tello-Aburto
Computer Science & Engineering - Mazumdar
Earth & Environmental Science - Cadol
Environmental Engineering - Huang
Management- Anselmo
Materials Engineering - Kalugin
Mathematics - Makhnin, Stone
Mechanical Engineering - Mousavi, Ryu
Psychology - Elliott, Thompson*

Degree Offered: Doctor of Philosophy in Biotechnology

Graduate Program

Doctor of Philosophy in Biotechnology

Students of exceptional ability, as demonstrated in previous courses or in a master's degree program, may pursue a program leading to the doctoral degree.

The Prospective doctoral candidate in Biotechnology should develop a good background in biology, chemistry, and mathematics plus at least one of the following: computer science, mechanical engineering, chemical engineering, or Materials engineering. Additionally, students should achieve a high level of competence in the field of specialization defined by their dissertation research. Additional information is found in the Graduate Program section of the catalog.

Research fields appropriate for the biotechnology candidate include bioengineering, molecular biology, microbiology, tissue engineering, pathogen detection, drug discovery, drug delivery, medical instrument development, neuroscience, and biochemistry. Interdisciplinary projects are strongly encouraged.

Degree Requirements

- Up to 30 credit hours from an appropriate master's degree, excluding thesis and S/U courses, may be included.
- Students are normally expected to take BIOL 501 each semester that they are in residence on the New Mexico Tech campus.
- 48 hours of coursework approved by the student's advisory committee, to include:
 1. Core Biotechnology courses:
 - BIOT 502 Molecular Biotechnology
 - BIOT 503 Biochemical Technology
 - BIOT 504 Biophysical Technology
 - BIOT 505 Biomechanical Technology
 2. 12 hours of upper-division or graduate-level coursework outside the Biology Department.
- Dissertation (24 credit hours): BIOT 595

Qualifying Examination

Core competency in two or more academic disciplines relevant to biotechnology must be demonstrated. The

qualifying exam will also assess a student's ability to rationally approach novel problems and apply engineering and analytical tools. The student will take written exams in two topic areas as selected by the student with approval of the academic advisor. Exam Topic Areas:

- Molecular Biology
- Bioinformatics
- Microbiology
- Biochemistry
- Biophysics
- Biomechanical engineering
- BioMaterials
- Biomathematical modeling
- A topic from one other academic area related to the interdisciplinary Biotechnology Program can be selected with approval from the Biotechnology Advisory Panel.

The exam questions will be written and graded by faculty members with expertise in each of these disciplines. Results of these exams will be used to evaluate the student's knowledge of core topics at the undergraduate level and their ability to a) apply advanced knowledge of mathematics, science, and engineering, b) identify, formulate, and solve problems.

The exam will be just before the start of each semester. The exam must be first taken before the beginning of the 3rd semester and is subject to the following:

- Students must take exams from two selected topics at the first exam attempt.
- A student who does not pass a topic exam may retake that topic exam (or another topic exam with advisor approval) at the next offering, i.e., before the beginning of the next semester; they do not need to retake exams that they have passed.
- A student who has not passed exams in two topics by the completion of their second exam attempt (beginning of the 4th semester) does not advance, and will leave the program. The student may be able to pursue a M.S. in an appropriate NMT program subject to those degree requirements.

Admission Requirements

Completion of a bachelor's degree in a relevant field (e.g. biology, biotechnology, chemistry, biochemistry, bioengineering, biophysics, computer science with a biology minor, etc.) or the expectation of completing such a degree before the beginning of the first semester of graduate study. Students are expected to have competencies in math, chemistry, and physics equivalent to those required for completion of a B.S. degree at New Mexico Tech. Students who are deficient in one or more of these areas will be required by their advisory committee to complete undergraduate coursework in the area(s) of deficiency. Students should have an academic record that indicates a good potential for success in a doctoral program. An undergraduate GPA of 3.0 or higher is used as a general guideline in New Mexico Tech's Graduate School.

Biotechnology Courses:

BIOT 502, Molecular Biotechnology, 3 cr, 3 cl hrs

A lecture-supported, laboratory-based course on molecular biotechnology of microbial and mammalian systems. Used in prokaryotic and mammalian molecular biotechnology. Recombinant DNA methodologies (DNA/RNA isolation and manipulation, restriction mapping, cloning, PCR, site-directed mutagenesis, DNA sequencing, Crispr/CAS editing combined with classical biochemical protein (SDS-PAGE protein gels, ELISA, Western blotting, enzyme assay) techniques. Textbook: *Molecular Biotechnology* by Glick & Pasternak.

BIOT 503, Biochemical Technology, 3 cr, 3 cl hrs

After an introduction to basic biochemistry and cell biology this course covers biotechnology routes to foods, drugs, polymers and fuels. Fermentation reactions with immobilized enzymes, bacteria, fungi, plants and animal cells are covered; also separation and purification. Offered mostly online with occasional in person classes.

BIOT 504, Biophysical Technology, 3 cr, 3 cl hrs

Covers biomedical Materials and devices including properties of hard and soft tissue, orthopedic implants, cardiovascular devices, skin, cartilage and tendon, eye and ear implants, neural prosthetics, cyto- and biocompatibility. Offered as an online course with occasional meetings.

BIOT 505, Biomechanical Technology, 3 cr, 3 cl hrs

The mechanical functionality of the human body. Covers mechanics of cells, fluid mechanics of blood, respiration and lymph, muscle, bone, and joints, gait analysis, exercise, injury and orthopedic fixtures, eyes and ears.

BIOT 509, Cell and Molecular Neuroscience, 3 cr, 3 cl hrs

A study of the molecular and cellular basis of the nervous system, covering fundamentals of cell biology, principles of neuronal signaling and neuronal courses, and cell and molecular approaches to the investigation, diagnosis and treatment of the disease of the nervous system. Application of emerging technologies. Shares lecture with BIOL 409 & PSY 409 with additional expectations for graduate credit. (Same as BIOL 509.)

BIOT 510, Behavioral Neuroscience, 3 cr, 3 cl hrs

Study of the neural bases of behavior, including functional neuroanatomy of sensory and motor system, and clinical correlates of neurological abnormalities. Behavioral neuroscience plus directed review and discussion of current research in application of biotechnology in the neurosciences.

BIOT 531, Experimental Cell Biology, 3 cr, 3 cl hrs

Prerequisite: BIOL 331, BIOL 333, BIOL 333L

This advanced course explores in detail the methodological tools of experimental cell biology. These include prokaryotic and eukaryotic cell culture,

cloning and gene transfections, biochemical studies of signaling pathways, membrane behavior and analysis of change in gene expression; (SEM, TEM, fluorescence, confocal) microscopy, electrophoresis, fractionation, microbiological assays (MIC/MBC) transgenic animals, preclinical studies for drug development as well as finding and interpreting methodologies available in the literature and other resources.

BIOT 531L, Experimental Cell Biology Lab, 1 cr, 3 lab hrs

Lab component of BIOT 351 lecture.

BIOT 535, Bioinformatics, 3 cr, 3 cl hrs

Prerequisite: BIOL 311 or consent of instructor and advisor

Computer analysis of biological sequence data used to perform in silico experiments. Students will design and perform experiments using public domain software and databases. Shares lecture with BIOL 435 with additional expectations for graduate credit. (Same as BIOL 535.)

BIOT 541, Applied Microbiology, 3 cr, 3 cl hrs

Prerequisite: BIOL 341 or BIOL 343, graduate standing or consent of instructor and advisor

Principles of applied and industrial microbiology and microbial technology. Application of microbes in various products and processes, biofermentors and scale-up of microbial culturing, molecular engineering of microbes, bioenergy.

BIOT 576, Drug Delivery, 3 cr, 3 cl hrs

Focus is on current development in drug delivery techniques, with only a brief discussion of common clinical techniques. The first portion of the class focuses on various delivery mechanisms and the tools needed to validate successful targeted drug delivery (both in vitro, in vivo and diagnostic tools). The second part of the course focuses on current developments in drug delivery based on published research articles. Students will read, digest, and critically analyze scientific work from leading research laboratories. Students will also gain valuable communication tools, as each student will present an article of interest to the class. Finally, the third part of the course focuses on important Materials characterization methods such as biological sample prep, SEM, TEM, DSC, flow Cytometry, Fluorescence Microscopy, ELISA Assays. Same as MTL5 576. Shares lecture with ChE 476 with additional expectations for graduate credit.

BIOT 578, Principles of Drug Design, 3 cr, 3 cl hrs

Principles in Drug Design course provides an overview of the multilayered and multidisciplinary processes involved in starting from a druggable-problem and ending with a novel clinically-used drug. This includes molecular or phenotypic target identification, compound design (including computational, combinatorial chemistry and structure-based drug design methods), drug synthesis, development of model

model assays, discovery of a lead, optimization of the lead, identification of mode of action, kinetics of molecular targeting, prodrug design and drug development from this in vitro analysis via preclinical studies to clinical studies and introduction of new drugs into clinical practice. Regulations pertaining to each of these steps will be discussed.

BIOT 580, Entrepreneurial Biotechnology, 3 cr, 3 cl hrs

Rules and regulations governing product development and post-approval marketing from medical devices and pharmaceuticals. From cGMP compliance to federal regulations. Introduction of students to the creation of a company; from pitching a concept and securing funding as a venture capital investment. Current research and industrial trends in the evolution of a biotechnological idea to a biotech venture. Strategic and tactical approaches for marketing of biotechnological products and services.

BIOT 595, Dissertation, cr to be arranged

Prerequisites: Successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.

Chemistry

Associate Professors Altig, Pias (Chair), Piyasena,
Rubasinghe, Patidar

Assistant Professors Gao, Ranasinghe

Emeritus Professors Brandvold, Popp

Adjunct Professors Elliott, Heagy, Khandehwal

Degrees Offered: B.S. in Chemistry, B.S. in Chemistry with Environmental Science Option, and B.S. in Chemistry with Biochemistry Option, B.A in Chemistry; M.S. in Chemistry and M.S. in Chemistry with Specialization in Biochemistry; Ph.D. in Chemistry

The fundamental mission of the Department of Chemistry is to provide students with: (1) the skills necessary for critical and analytical thinking; (2) an understanding of the basic concepts of chemistry; (3) an appreciation of chemistry and its central place among the sciences; (4) a feeling for the joys and frustrations of original research; and (5) the ability to communicate observations and discoveries.

The Department of Chemistry offers a balance between pure and applied chemistry and presents science as part of a liberal education. The faculty is qualified in the major divisions of chemistry—inorganic, organic, analytical, physical, and biochemical. The undergraduate program emphasizes development of a strong foundation in the fundamental areas of chemistry in order to prepare students for the diverse career opportunities available to chemists. Laboratory facilities support research in all major areas of chemistry, with a focus on environmental and biomedical topics. Interdisciplinary work is encouraged.

The department maintains a full complement of modern analytical instrumentation. Most undergraduate students participate in departmental research. Career possibilities range from industrial process control through scientific research in academic and government laboratories. More than 60 percent of Tech chemistry graduates continue their education in graduate school.

Many have become teachers, medical doctors, or research scientists. The student has freedom to select courses to meet individual interests and objectives, such as preparation for graduate school or industry, or simply a superior education. B.S graduates receive a degree accredited by the American Chemical Society, and the chemistry B.S curriculum is approved by the Committee on Professional Training of the American Chemical Society.

Undergraduate Program

Bachelor of Science in Chemistry

Minimum credit hours required—120

In addition to the General Education and Institute Core Curriculum Requirements (page 78), the following courses are required:

- MATH 2532(4), CSE 107 (4) or CSE 113 (4) or ES 111 (3)
- CHEM 301 (1), 311 (3), 311L (1), 331 (3), 331L (1), 332 (3), 332L (1), 333 (3), 333L (1), 334 (3), 334L (1), 343 (3), 343L (1), 411 (3), 411L (1), 441 (3), 441L (1), 443 (3), 443L (1), 446 (3), 493 (1), 494 (2);
- Advanced Chemistry courses: Six (6) credit hours from 400 or 500 level Chemistry courses not required above (excluding CHEM 300, 400, 481, 489, 495, 496).

The above curriculum leaves a minimum of 10 credit hours of general electives. The Chemistry Department encourage a diverse set of electives for a well-founded education and especially recommend the following courses for students majoring in Chemistry.

Recommended Electives

- CHEM 442 (3), CHEM 442L (1)
- CHEM 343 (3)
- One or more of MATH 2420 (3), 2350 (3) or 382 (3), 335 (3)
- One or more of MGT 330 (3), 462 (3), 476 (3)
- BIOL 2110 (3), 2110L (1)

The probable sequence of electives should be discussed with the student's advisor during the freshman year. Students interested in admission to medical school (or other professional schools) should see *Pre-professional Programs* on page 187 for advice on choosing electives.

Sample Curriculum for the Bachelor of Science in Chemistry

This curriculum assumes a reasonably strong high school background. Where possible, CHEM 311, 333, and 334 should be completed by the end of the sophomore year. This is only a sample curriculum. Students should consult their advisor to design programs that fit their individual backgrounds, math placement, and interests.

Semester 1

- 4 CHEM 1515 & 1515L (general)
- 1 CHEM 130 (seminar)
- 3 ENGL 1110 (college English)
- 4 MATH 1510(calculus)
- 4 BIOL 2110 & 2110L (general)
- 16 Total credit hours

Semester 2

- 4 CHEM 1525 & 1525L (general)
- 1 CHEM 130 (seminar)
- 3 ENGL 1120 (college English)
- 4 MATH 1520(calculus)
- 5 PHYS 1310 & 1310L (general)
- 17 Total credit hours

Semester 3

- 4 CHEM 311 & 311L (quantitative analysis)
 - 4 CHEM 333 & 333L (organic)
 - 1 CHEM 130 (seminar)
 - 4 MATH 2532 (calculus)
 - 5 PHYS 1320 & 1320L
- 18 Total credit hours

Semester 4

- 4 CHEM 334 & 334L (organic)
 - 1 CHEM 130 (seminar)
 - 4 CSE 107 & 107L (programming)
 - 3 Humanities
 - 3 Social Science
 - 3 CHEM 343 (inorganic)
- 18 Total credit hours

Semester 5

- 4 CHEM 331 & 331L (physical)
 - 1 CHEM 430 (seminar)
 - 3 Humanities
 - 3 Social Science
 - 4 CHEM 441 & 441L (biochemistry)
 - 3 Math Recommended
- 18 Total credit hours

Semester 6

- 4 CHEM 332 & 332L (physical)
 - 1 CHEM 430 (seminar)
 - 3 ENGL 341 (technical writing)
 - 3 Humanities/Social Science/Fine & Creative Arts
 - 4 CHEM 442 & 442L (biochemistry)
 - 1 CHEM 301 (toolbox)
- 16 Total credit hours

Semester 7

- 4 CHEM 411 & 411L (instrumental)
 - 3 CHEM 400 (directed research)
 - 3 CHEM 446 (polymer)
 - 1 CHEM 493 (senior thesis)
 - 1 CHEM 430 (seminar)
 - 3 Humanities/Social Science
- 15 Total credit hours *

Semester 8

- 4 CHEM 443 & 443L (inorganic)
 - 4 CHEM 400/500 (directed research)
 - 2 CHEM 494 (senior thesis)
 - 1 CHEM 130 (seminar)
 - 3 MGT 300 or 462 (management elective)
- 14 Total credit hours *

- In order to earn or retain the NM Lottery Scholarship, student must earn 15 credits each semester. Please see your advisor for more information.

Bachelor of Science in Chemistry with Environmental Science Option

Minimum credit hours required—124

In addition to the General Education and Institute Core Curriculum Requirements (page 78), requirements include the courses listed for the Bachelor of Science in Chemistry (only 6

credit hours of electives required) and the following courses:

- CHEM 422 and CHEM 422L plus
- Eight (8) credit hours from the following: CHEM 431, 432, or 433; BIOL 343, 344, 446, and 455; GEOL 1170, 130L, 140, 140L, 200, 201, 202, 340, 390, and 405
- In addition to the above requirements, strongly recommended courses include: CHEM 343; one or more of MATH 2420, 283, 335; and one or more of MGT 330, 462, 476

Bachelor of Science in Chemistry with Biochemistry Option

Minimum credit hours required—122

In addition to the General Education and Institute Core Curriculum Requirements (page 78), requirements include the courses listed for the Bachelor of Science in Chemistry (only 6 credit hours of electives required) and the following courses:

- CHEM 442 (3), 442L (1)
- Six (6) credit hours from the following: CHEM 447; BIOL 311, 331, 333, 341, 343, 351, 352, 411, 431, 435, 437, 471, 486, 487, and 488; ChE 476; and any associated laboratory courses
- In addition to the above requirements, strongly recommended courses include: CHEM 343; one or more of MATH 2420, 383, 335; and one or more of MGT 330, 462, 476

Minor in Chemistry

Minimum credit hours required—19

The following courses are required:

- Chemistry 311 (3) & 311L (1)
- Three of the following courses with the associated labs:
 - Chemistry 331 (3) & 331L (1)
 - Chemistry 332 (3) & 332L (1)
 - Chemistry 333 (3) & 333L (1)
 - Chemistry 334 (3) & 334L (1)
- One chemistry course numbered 400 or above (3-4)

Bachelor of Arts in Chemistry

This degree program is designed to give students a solid foundation in chemistry and biochemistry, while also exploring the “liberal arts” (natural sciences, social sciences, arts, and humanities). Students are able to pursue individualized programs of study that accommodate their interests and enable them to prepare for a variety of future endeavors. This program may be a good option for students planning careers that apply scientific knowledge within a broader professional context, such as medicine, education, law, or government.

Minimum credit hours required—120

In addition to the Institute Requirements for the Bachelor of Arts Degree, the following courses are required. Courses marked with an asterisk () may also be used to satisfy Institute Requirements:*

- CHEM 1215 /1515 (3)*, 1215L (1), 1225/1525 (3), 1225L (1), 130 (1), 301 (1), 311 (3), 311L (1), 331 (3), 333 (3), 333L (1), 334 (3), 334L (1), 343 (3), 343L (1), 430 (1), 441 (3), 441L (1), 493 (1), 494 (2)
- MATH 1510 (4)*, 1520 (4)*

- CSE 107 (4)*
- PHYS 1310 (4)*, 1310L (1)*, 1320 (4), 1320L (1)
- PSYC 1110 (3)* and one additional three-credit course in Psychology (3)
- One three-credit course in philosophy, beyond the Area 5 B.A. Institute Requirements (3)
- MGT 330 (3)
- Two semesters of foreign language (6)*

The above curriculum leaves a minimum of 17 credit hours of general electives. The Chemistry faculty encourage a diverse set of electives for a well-founded education and especially recommend the following courses for students majoring in Chemistry:

Recommended Electives

- Additional Biology, especially BIOL 331 (3)
- CHEM 411 (3), CHEM 411L (1) – valuable for students seeking employment in industry
- Ethics: PHIL 121 (3), 321 (3), or 342 (3)
- Statistics: MATH 2350 (3), 382 (3), or 383 (3)
- Economics: ECON 2110 (3) or 2120 (3)

The probable sequence of electives should be discussed with the student's advisor during the first year. Students interested in admission to medical school (or other professional schools) should see *Pre-professional Programs* on page 205 for advice on choosing electives.

Sample Curriculum for the Bachelor of Arts in Chemistry

The curriculum below assumes a reasonably strong high school background. Where possible, CHEM 311, 333, and 334 should be completed by the end of the sophomore year. This is only an example. Students should consult their advisor to design programs that fit their individual backgrounds, math placement, and interests.

Semester 1

- 4 CHEM 1515 & 1215L (general)
- 1 CHEM 130 (seminar)
- 3 ENGL 1110 (college English)
- 4 MATH 1510 (calculus)
- 4 BIOL 2110 & 2110L (general)
- 16 Total credit hours

Semester 2

- 4 CHEM 1525 & 1225L (general)
- 1 CHEM 130 (seminar)
- 3 ENGL 1120 (college English)
- 4 MATH 1520 (calculus)
- 5 PHYS 1310 & 1310L (general physics)
- 17 Total credit hours

Semester 3

- 4 CHEM 311 & 311L (quantitative analysis)
- 4 CHEM 333 & 333L (organic)
- 3 GEOL 1110 & 1110L
- 5 PHYS 1320 & 1320L
- 16 Total credit hours

Semester 4

- 4 CHEM 334 & 334L (organic)
- 4 CSE 107 & 107L (programming)
- 3 Ethics/Technology (Inst. Requ. Area 5a)
- 3 Creative and Fine Arts
- 3 PSYC 1110 (intro psychology)
- 17 Total credit hours

Semester 5

- 3 CHEM 331 (physical)
- 3 ENGL 341 (technical writing)
- 3 Foreign language I
- 3 Psychology
- 3 Elective: Consider BIOL 331 (cell)
- 15 Total credit hours

Semester 6

- 1 CHEM 430 (seminar)
- 1 CHEM 301 (toolbox)
- 3 CHEM 343 & 343L (inorganic)
- 3 Philosophy
- 3 Foreign language II
- 3 Elective: Statistics recommended
- 1 General elective (art/music/recreation)
- 15 Total credit hours

Semester 7

- 1 CHEM 493 (senior thesis)
- 1 CHEM 430 (seminar)
- 4 CHEM 441 & 441L (biochemistry)
- 3 MGT 330 (management)
- 3 Policy/Technology (Inst. Requ. Area 4a)
- 4 Elective: Consider CHEM 411 & 411L (instrumental)
- 16 Total credit hours

Semester 8

- 2 CHEM 494 (senior thesis)
- 1 CHEM 430 (seminar)
- 3 Elective: Creative/Fine arts recommended
- 3 Elective: Economics recommended
- 3 Elective: Humanities recommended
- 3 Elective: Social science recommended
- 15 Total credit hours

Graduate Program

Students entering any chemistry graduate program must take placement examinations within a week after their first registration. If deficiencies are determined, appropriate remedial undergraduate coursework will be required. Students are encouraged to consult the chemistry graduate handbook for details. Remedial coursework does not count toward degree requirements. The individualized course of study must be approved by the student's graduate advisory committee and must fulfill the general degree requirements for their respective advanced degree.

Master of Science in Chemistry

M.S. students must meet the general degree requirements for the Master of Science degree at New Mexico Tech. In addition, a minimum of 12 credit hours of 500-level chemistry courses is required. CHEM 529 and 530 do not count toward

this requirement. Additionally students must take six (6) credit hours at the 300, 400, or 500-level and above from other departments. Student should consult with their graduate advisory committee and advisor when developing a course plan.

All M.S students must registrar for Gaduate seminar (Chem 529/530) every fall and spring semester that they are enrolled full-time in the graduate program.

Master of Science in Chemistry with Specialization in Biochemistry

Students earning a Master of Science degree in chemistry can receive a specialization in Biochemistry. The requirements for the specialization in biochemistry are the same as those for a Master of Science in Chemistry, except that:

- Six (6) credit hours of the 12 credit hours minimum of 500-level chemistry classes must be from CHEM 561 and 547.
- A maximum of three (3) credit hours of CHEM 581 or BIOL 581 (directed study) may be used toward the degree.
- A minimum of six (6) credit hours of courses in biology, selected from the following, must be completed: BIOL 331, 333, 351, 352, 356, 488, 501, 552, 588.

Accelerated Master's Program

Qualified undergraduate students may apply for admission to the Accelerated Master's Program in Chemistry. In fulfillment of the requirements for both B.S and M.S. degrees, as outlined in their respective sections, accepted students may apply nine (9) credits of 500-level courses to both degrees.

The M.S. degree requires completion of a master's thesis. A portion of the master's project may be presented to fulfill the undergraduate senior thesis requirement. However, the master's thesis must go substantially beyond the senior thesis work. The suitability of the proposed master's level research will be evaluated by the student's graduate advisory committee.

Doctor of Philosophy in Chemistry

Students of exceptional ability may pursue a program leading to the doctoral degree. The prospective doctoral candidate will develop a broad background in chemistry and related fields and prove his or her ability to do independent research. An early assessment of the student's ability is achieved in the candidacy examination to be completed by the end of the third year. Research within the Chemistry department generally emphasizes environmental and human health related topics. Interdisciplinary research with other departments, such as Physics, Biology, Chemical Engineering, or Earth and Environmental Science can be

pursued. Ph.D. students must meet the general degree requirements for the Doctor of Philosophy degree at New Mexico Tech as well as the requirements listed below.

All Ph.d student must register for Graduate Seminar (Chem 529/530) every fall and spring semester that they are enrolled full-time in the graduate program

No Prior Master's Degree In Chemistry

A minimum of 52 credit hours is required. These hours are distributed as follows:

- 500-level chemistry courses 21 cr hrs minimum
- CHEM 529, 530 (Seminar) 2 cr hrs
- COMM 575 and CHEM 555 (Proposal Writing) 5 cr hrs
- CHEM 595 (Dissertation) 24 cr hrs

Students may substitute up to six 6 credit hours of courses at the 300-level and above from other departments. Additional 500-level courses from other departments may be used in place of 500- level chemistry courses, upon approval of student's advisory committee.

Prior Master's Degree in Chemistry

A minimum of 40 credit hours is required. These hours are distributed as follows:

- 500-level chemistry courses 9 cr hrs minimum
- CHEM 529, 530 (Seminar) 2 cr hrs
- COMM 575 and CHEM 555 (Proposal Writing) 5 cr hrs
- CHEM 595 (Dissertation) 24 cr hrs

Students may substitute up to three 3 credit hours of courses at the 300-level and above from other departments. Additional 500-level courses from other departments maybe used in place of 500-level chemistry courses, upon approval of student's advisory committee.

Chemistry Courses:

CHEM 1120, Introduction to Chemistry, 3 cr, 2 cl hrs, 4 lab hrs

Corequisite: MATH 1220

Offered Fall Semesters

An overview of the fundamental concepts in chemistry. Topics will include a discussion of the classification of matter, the fundamental laws of chemical combination, the atomic theory and chemical bonding. The stoichiometry of chemical reactions will be presented. Several types of chemical reactions will be discussed, including precipitation reactions, oxidation-reduction reactions and acid-base reactions. Topics in organic and biochemistry will also be considered. Lectures will include numerous examples and demonstrations of chemical principles. Extensive laboratory exercises will further illustrate concepts discussed during the lecture hours.

CHEM 1215, General Chemistry I, for STEM Majors, 3 cr, 3 cl hrs

Prerequisite: MATH 1220 (passed with grade C- or better) or CHEM 1120 (passed with grade C- or better)

Corequisite: CHEM 1215L

Offered fall and spring semesters

This course is intended to serve as an introduction to General Chemistry for students enrolled in science, engineering, and certain preprofessional programs. Students will be introduced to several fundamental concepts, including mole, concentration, heat, atomic and molecular structure, periodicity, bonding, physical states, stoichiometry, and reactions

CHEM 1215L, General Chemistry Laboratory I, for STEM Majors 1 cr, 3 lab hrs

Corequisite: CHEM 1215; a lab usage fee is charged

Offered fall and spring semesters

Laboratory for Science Majors is the first semester laboratory course designed to complement the theory and concepts presented in General Chemistry I lecture. The laboratory component will introduce students to techniques for obtaining and analyzing experimental observations pertaining to chemistry using diverse methods and equipment.

CHEM 1225, General Chemistry II, for STEM Majors, 3 cr, 3 cl hrs

Prerequisites: CHEM 1215 and 1215L and MATH 1220 (passed with grade C- or better)

Corequisites: CHEM 1225L

Offered fall and spring semesters

This course is intended to serve as a continuation of general chemistry principles for students enrolled in science, engineering, and certain preprofessional programs. The course includes, but is not limited to a theoretical and quantitative coverage of solutions and their properties, kinetics, chemical equilibrium, acids and bases, entropy and free energy, electrochemistry, and nuclear chemistry. Additional topics may include (as time permits) organic, polymer, atmospheric, and biochemistry.

CHEM 1225L, General Chemistry Laboratory II for STEM Majors 1 cr, 3 lab hrs

Corequisite: CHEM 1225; a lab usage fee is charged

Offered fall and spring semesters

General Chemistry II Laboratory for STEM Majors is the second of a two-semester sequence of laboratory courses designed to complement the theory and concepts presented in General Chemistry II lecture. The laboratory component will introduce students to techniques for obtaining and analyzing experimental observations pertaining to chemistry using diverse methods and equipment.

CHEM 130, Issues in Chemistry and Biochemistry, 1 cr, 1 cl hr

Offered fall and spring semesters Graded S/U

A seminar course introducing topics in modern chemistry and biochemistry via video, current literature, guest speakers, and active learning discussion. *May be repeated for credit.*

CHEM 1515, Advanced General Chemistry I, 3 cr, 3 cl hrs, 1.5 recitation hours

Offered fall semesters

Corequisites: CHEM 1215L and MATH 1510 (or equivalent); or consent of instructor

Honors-style course covering topics parallel to CHEM 1215. Emphasis on critical thinking and active, collaborative learning. Small class size, limited enrollment. Prior knowledge of chemistry at the advanced high-school level is assumed. Recommended for Chemistry and Chemical Engineering majors; other majors are welcome. (The CHEM 151/152 sequence is equivalent to CHEM 1215/1225.)

CHEM 1525, Advanced General Chemistry II, 3 cr, 3 cl hrs, 1.5 recitation hours

Offered spring semesters

Prerequisites: CHEM 1515 (or CHEM 1215) and 1215L; or consent of instructor

Corequisites: CHEM 1225L

Continuation of CHEM 1515. Honors-style course covering topics parallel CHEM 1225. Emphasis on critical thinking and active, collaborative learning. Small class size, limited enrollment. Recommended for Chemistry and Chemical Engineering majors; other majors are welcome. (The CHEM 1515/1525 sequence is equivalent to CHEM 1215/1225.)

CHEM 300, Directed Research, cr to be arranged

Research under the guidance of a faculty member.

CHEM 301, The Chemistry Toolbox, 1 cr, 1 cl hrs

Prerequisite: CHEM 1225 passed with grade C- or better
Offered spring semester; offered fall semester if sufficient demand

Topics to include lab safety, literature searches, citation management, data management, and ethics.

CHEM 311, Quantitative Analysis, 3 cr, 3 cl hrs

Prerequisite: CHEM 1225 passed with grade C- or better
Offered fall semester; offered spring semester if sufficient demand

Fundamental theory and techniques in traditional chemical analysis. Emphasizes sampling and separation methods, measurement, statistics, volumetric and gravimetric analysis, equilibrium and pH studies, basic electrochemical techniques, and introduction to instrumentation.

CHEM 311L, Quantitative Analysis Laboratory, 1 cr, 3 lab hrs

Corequisite: CHEM 311; a lab usage fee is charged.

Offered fall semester; offered spring semester if sufficient demand

Laboratory experiments and techniques emphasizing the principles from CHEM 311.

CHEM 331, Physical Chemistry I, 3 cr, 3 cl hrs

Prerequisites: CHEM 1225 passed with grade C- or better; MATH 1520; PHYS 1320

Offered fall semester; offered spring semester if sufficient demand

Study of the fundamental principles of thermodynamics applied to equilibria, physical states, electromotive force, solution phenomena, and reaction kinetics. Study of physical state properties.

CHEM 331L, Physical Chemistry Laboratory I, 1 cr, 3 lab hrs

Corequisite: CHEM 331; a lab usage fee is charged
Offered fall semester; offered spring semester if sufficient demand

Laboratory experiments and techniques emphasizing principles from CHEM 331.

CHEM 332, Physical Chemistry II, 3 cr, 3 cl hrs

Prerequisite: CHEM 331

Offered spring semester

Atomic and molecular quantum theory, group theory, spectroscopy, and statistical mechanics.

CHEM 332L, Physical Chemistry Laboratory II, 1 cr, 3 lab hrs

Corequisite: CHEM 332; a lab usage fee is charged

Offered spring semester

Laboratory experiments and techniques emphasizing principles from CHEM 332.

CHEM 333, Organic Chemistry I, 3 cr, 3 cl hrs

Prerequisite: CHEM 1225 passed with grade C- or better

Offered fall semester; offered spring semester if sufficient demand

Nomenclature, properties, structure, reactions, and synthesis of carbon compounds.

CHEM 333L, Organic Chemistry Laboratory I, 1 cr, 3 lab hrs

Corequisite: CHEM 333; a lab usage fee is charged

Offered fall semester; offered spring semester if sufficient demand

CHEM 334, Organic Chemistry II, 3 cr, 3 cl hrs

Prerequisite: CHEM 333

Offered spring semester

Continuation of CHEM 333.

CHEM 334L, Organic Chemistry Laboratory II, 1 cr, 3 lab hrs

Prerequisite: CHEM 333L

Corequisite: CHEM 334; a lab usage fee is charged

Offered spring semester

CHEM 341, Survey of Biochemistry, 3 cr

Offered spring semesters

Prerequisites: CHEM 333 or consent of instructor

Foundational course in biochemistry. Topics include the chemical basis of life; organizational complexity of biological systems; structure, nomenclature, and reactions of biomolecules (carbohydrates, lipids, proteins, nucleic acids, and enzymes); and an overview of metabolic pathways, regulatory mechanisms, and driving forces.

CHEM 343, Inorganic Chemistry, 3 cr, 3 cl hrs

Prerequisites: CHEM 1225 passed with a grade of C- or better. Offered spring semester; offered fall semester if sufficient demand

Basic chemistry of the main group elements. Topics include analytical, theoretical, industrial, organometallic, bio-inorganic and other areas of inorganic chemistry. Includes significant coverage of Materials based on main-group compounds such as borates, silicates, nanotubes, fullerenes and two-dimensional growth Materials.

CHEM 343L, Descriptive Inorganic Chemistry Laboratory, 1 cr, 3 lab hrs

Corequisite: CHEM 343; a lab usage fee is charged

Offered spring semester; offered fall semester if sufficient demand

CHEM 400, Directed Research, cr to be arranged

Research under the guidance of a faculty member.

CHEM 411, Advanced Instrumental Methods, 3 cr, 3 cl hrs

Prerequisites: CHEM 311 and 332 or consent of instructor and advisor

Corequisite: CHEM 411L

Offered fall semester

Advanced techniques of chemical analysis. Emphasizes gas and liquid chromatography; electrochemistry; atomic spectrometry; ultraviolet, visible, and infrared spectroscopy; nuclear magnetic resonance spectroscopy; mass spectroscopy, etc.

CHEM 411L, Advanced Instrumental Laboratory, 1 cr, 3 lab hrs

Corequisite: CHEM 411; a lab usage fee is charged

Offered fall semester

Laboratory experiments and instrumental techniques emphasizing principles from CHEM 411.

CHEM 412, Advanced Topics in Analytical Chemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 311, 411, or consent of instructor and advisor

Offered on sufficient demand

Study of special topics not otherwise treated in analytical chemistry. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 512, with additional expectations for graduate credit.

CHEM 413, Separation Science, 3 cr, 3 cl hrs

Prerequisite: CHEM 331, 411, or consent of instructor and advisor

Offered on sufficient demand

Theory and practice of separation science. Topics include selective mass transport, extraction, chromatography, and electrophoresis. The graduate and

undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 513, with additional expectations for graduate credit.

CHEM 422, Environmental Chemistry, 3 cr, 3 cl hrs

Prerequisites: Any two of the following: CHEM 311, 331, or 333 (or consent of instructor and advisor)

Offered Spring semester, even years

Application of chemical principles to the study of the environment. Includes natural processes and pollution problems related to water, air, and soil. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 522, with additional expectations for graduate credit.

CHEM 422L, Environmental Chemistry Laboratory, 1 cr, 3 lab hrs

Corequisite: CHEM 422/522; a lab usage fee is charged

Offered Spring semester, even years

Laboratory experiments related to the principles in CHEM 422/522. The graduate and undergraduate versions of the course will differ in the assignments and exams. Shares lab with CHEM 522L, with additional expectations for graduate credit.

CHEM 423, Applied Spectroscopy, 3 cr, 3 cl hrs

Prerequisite: CHEM 332 or consent of instructor and advisor

Offered on sufficient demand

Discussions of mass spectrometry, fluorescence, Nuclear Magnetic Resonance (NMR), X-ray (XPS, X-ray diffraction, solid state spectroscopy), Infrared (IR), Ultraviolet/Visible spectroscopic methods and techniques, as applied to chemical and biological problems, including structure elucidation, medical diagnostics, molecular sensors. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 523, with additional expectations for graduate credit.

CHEM 425, Molecular Quantum Mechanics, 3 cr, 3 cl hrs

Prerequisite: CHEM 332 or consent of instructor and advisor

Offered on sufficient demand

Molecular structure; theories of the chemical bond; perturbation and variation methods; electronic and magnetic properties of molecules. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 525, with additional expectations for graduate credit.

CHEM 426, Chemical Spectroscopy, 3 cr, 3 cl hrs

Prerequisite: CHEM 332 or consent of instructor and advisor

Offered on sufficient demand

Principles and applications of electronic, molecular, and spin spectroscopies, laser spectroscopy; transitions; elements of group theory; quantitative correlations and

analytical chemistry. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 523, with additional expectations for graduate credit.

CHEM 427, Molecular Reaction Dynamics, 3 cr, 3 cl hrs

Prerequisite: CHEM 332 or consent of instructor and advisor

Offered on sufficient demand

Techniques in studies of chemical reaction rates. Topics commonly include: rate laws, collision theory, mechanistic studies, transition state theory, fast reactions, chemical oscillations, transport theory, and transport coefficients. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 527, with additional expectations for graduate credit.

CHEM 428, Advanced Topics in Physical Chemistry

Prerequisite: CHEM 332 or consent of instructor and advisor

Offered on sufficient demand

Study of special topics not otherwise covered in physical chemistry. Shares lecture with CHEM 528, with additional expectations for graduate credit.

CHEM 430, Chemistry and Biochemistry Seminar, 1 cr, 1 cl hr

Offered fall and spring semesters Graded S/U

Current topics in chemistry and biochemistry. *May be repeated for credit.*

CHEM 431, Chemistry of Aquatic Systems, 3 cr, 3 cl hrs

Prerequisite: CHEM 311 or consent of instructor and advisor

Offered on sufficient demand

The thermodynamics and aqueous chemistry of natural waters, with emphasis on groundwater. Chemical equilibrium concepts, surface chemistry, redox reactions, and biochemistry. The interaction of water with the atmosphere and geologic Materials. Basic concepts applied to problems of groundwater quality evolution, water use, and groundwater contamination. Shares lecture with CHEM 531, HYD 507 and GEOC 507 with additional expectations for graduate credit.

(Same as GEOL 407.)

CHEM 432, Atmospheric Chemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 331, or consent of instructor and advisor

Chemistry of the atmosphere. Important chemical reactions and their effects on air, soil, and surface waters. Effects of anthropogenic inputs on the atmosphere, climate change. Distribution of chemical species in the atmosphere, etc. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 532, with additional expectations for graduate credit.

CHEM 433, Global Biogeochemical Cycles, 3 cr, 3 cl hrs

Prerequisite: CHEM 311 or 331, or consent of instructor and advisor

Offered on sufficient demand

Human activity is increasing the rate of addition of Materials to the environment, resulting in changes to the earth's climate. The transformation and movement of natural and anthropogenic sources of chemical substances between reservoirs in a global context. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 533, with additional expectations for graduate credit.

CHEM 441, Biochemistry I, 3 cr, 3 cl hrs

Prerequisite: CHEM 334 or consent of instructor and advisor

Offered fall semester

Overview of basic biochemistry. Emphasizes structure, nomenclature, and reactions of biologically active compounds such as carbohydrates, lipids, proteins, nucleic acids, and enzymes. Introduction to metabolic pathways.

CHEM 441L, Biochemistry Laboratory I, 1 cr, 3 lab hrs

Corequisite: CHEM 441; a lab usage fee is charged

Offered fall semester

Experiments related to CHEM 441.

CHEM 442, Biochemistry II, 3 cr, 3 cl hrs

Prerequisite: CHEM 441

Offered spring semester

Continuation of CHEM 441. Emphasizes vertebrate biochemistry and the study of vitamins, hormones, biochemical genetics, and nutrition. Introduction to photosynthesis.

CHEM 442L, Biochemistry Laboratory II, 1 cr, 3 lab hrs

Corequisite: CHEM 442; a lab usage fee is charged

Offered spring semester

Topics related to CHEM 442.

CHEM 443, Intermediate Inorganic Chemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 332, CHEM 343

Offered spring semester

Advanced bonding theories as applied to inorganic compounds; elements of group theory; acid/base and donor/acceptor chemistry; chemistry in nonaqueous solvents; coordination chemistry; ligand field theory; organometallic chemistry.

CHEM 443L, Intermediate Inorganic Chemistry Laboratory, 1 cr, 3 lab hrs

Corequisite: CHEM 443; a lab usage fee is charged

Offered spring semester

CHEM 444, Advanced Topics in Organic Chemistry

Prerequisite: CHEM 333, 334, or consent of instructor and advisor

Offered on sufficient demand

Study of special topics not otherwise covered in organic chemistry. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 544, with additional expectations for graduate credit.

CHEM 445, Intermediate Organic Chemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 334

Corequisite: CHEM 445L

Offered on sufficient demand

The determination of the structure of organic compounds by chemical and physical means.

CHEM 445L, Intermediate Organic Chemistry Laboratory, 2 cr, 6 lab hrs

Corequisite: CHEM 445; a lab usage fee is charged

Offered on sufficient demand

CHEM 446, Polymer Chemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 332 and 334, or consent of instructor and advisor

Offered Fall Semesters, even years

Study of the preparation, properties, and uses of macromolecules. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 546, with additional expectations for graduate credit.

CHEM 447, Medicinal Chemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 334 or consent of instructor and advisor

Molecular-level mechanisms of drug action and rational drug design. Material is drawn from the recent primary literature. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 547, with additional expectations for graduate credit.

CHEM 449, Organometallic Chemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 334 or consent of instructor and advisor

Organometallic chemistry of the main group and transition elements. Ligand classification and molecular orbital description of bonding in organometallic complexes. Structure, bonding, synthesis, and properties of transition metal compounds and their derivatives. Organometallic complexes as catalysts. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 549, with additional expectations for graduate credit.

CHEM 450, Physical Organic Chemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 334 or consent of instructor and advisor

Physical aspects of organic chemistry. Emphasizes reaction mechanisms, reaction kinetics, and electronic

theories. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 550, with additional expectations for graduate credit.

CHEM 451, Advanced Topics in Inorganic Chemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 443 or consent of instructor and advisor

Study of special topics otherwise not covered in inorganic. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lecture. Shares lectures with CHEM 551, with additional expectations for graduate credit.

CHEM 461, Advanced Topics in Biochemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 442 or consent of instructor and advisor

Study of special topics otherwise not covered in biochemistry. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lecture. Shares lectures with CHEM 561, with additional expectations for graduate credit.

CHEM 389/489, Special Topics in Chemistry, cr to be arranged

CHEM 491, Directed Study, cr to be arranged

Study under the guidance of a member of the faculty. A topic and schedule of meetings is arranged between instructor and student early in the semester.

CHEM 493, Senior Research and Thesis, 1 cr

Offered fall semester or on demand

Problem-oriented research under the direction of a faculty member. Students should consult with Chemistry faculty to find a Senior Thesis advisor. In the first semester, students will research a topic and begin work on the research project. Students are required to give a presentation and write a paper on the research topic.

CHEM 494, Senior Research and Thesis, 2 cr

Prerequisite: CHEM 493

Offered spring semester or on demand

Continuation the research begun in CHEM 493. Students are required to give a presentation and write a paper on their research project.

All courses numbered 500 will be offered on sufficient demand, unless noted otherwise.

CHEM 500, Directed Research

Prerequisite: Graduate standing in chemistry or consent of instructor.

This course may not be used to fulfill graduate degree requirements.

CHEM 501 Applied Molecular Quantum Mechanics, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor.

Review of bonding, structure and symmetry.

Application of molecular theory to contemporary problems in organic chemistry (e.g. EHMO, frontier orbital theory), inorganic chemistry (e.g. ligand field theory, Jahn-Teller effect) and analytical chemistry (e.g. photo physicochemical processes).

CHEM 512, Advanced Topics in Analytical Chemistry, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor.

Study of special topics not otherwise treated in analytical chemistry. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 412, with additional expectations for graduate credit.

CHEM 513, Separation Science, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor

Theory and practice of separation science. Topics include selective mass transport, extraction, chromatography, and electrophoresis. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 413, with additional expectations for graduate credit.

CHEM 522, Environmental Chemistry, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor

Application of chemical principles to the study of the environment. Includes natural processes and pollution problems related to water, air, and soil. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 422, with additional expectations for graduate credit.

CHEM 522L, Environmental Chemistry Laboratory, 1 cr, 3 lab hrs

Corequisite: CHEM 422/522;

Prerequisites: Graduate standing in chemistry or consent of instructor: a lab usage fee is charged

Offered spring semester, even years

Laboratory experiments related to the principles in CHEM 422/522. The graduate and undergraduate versions of the course will differ in the assignments and exams. Shares lab with CHEM 422L, with additional expectations for graduate credit.

CHEM 523, Applied Spectroscopy, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

Discussions of mass spectrometry, fluorescence, Nuclear Magnetic Resonance (NMR), X-ray (XPS, X-ray diffraction, solid state spectroscopy), Infrared (IR), Ultraviolet/Visible spectroscopic methods and techniques,

as applied to chemical and biological problems, including structure elucidation, medical diagnostics, molecular sensors. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 423, with additional expectations for graduate credit.

CHEM 524 Statistical Thermodynamics, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

Entropy, randomness, the Boltzmann distribution, and the chemical potential. Translational, rotational, vibrational, and electronic contributions to the partition function. Calculation of mean energies, heat capacities, and equilibrium constants. Stability. The influence of wave function symmetry: Bose-Einstein and Fermi-Dirac statistics. The quantum statistical operator. Coherence and the Pauli principle. (Same as Phys 508)

CHEM 525, Molecular Quantum Mechanics, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

Molecular structure; theories of the chemical bond; perturbation and variation methods; electronic and magnetic properties of molecules. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 425, with additional expectations for graduate credit.

CHEM 526, Chemical Spectroscopy, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

Principles and applications of electronic, molecular, and spin spectroscopies, laser spectroscopy; transitions; elements of group theory; quantitative correlations and analytical chemistry. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 426, with additional expectations for graduate credit

CHEM 527, Molecular Reaction Dynamics, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

Techniques in studies of chemical reaction rates. Topics commonly include: rate laws, collision theory, mechanistic studies, transition state theory, fast reactions, chemical oscillations, transport theory, and transport coefficients. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 427, with additional expectations for graduate credit.

CHEM 528, Advanced Topics in Physical Chemistry

Prerequisite: Graduate standing in chemistry or consent of instructor:

Study of special topics not otherwise covered in physical chemistry. Shares lecture with CHEM 428, with additional expectations for graduate credit.

CHEM 529 (Fall), 530 (Spring), Graduate Seminar, 1 cr each semester

Prerequisite: Graduate standing in chemistry or consent of instructor:

Offered Fall and Spring Semesters

All full time Chemistry graduate students must enroll in this course every fall and spring semester. Students giving a presentation must enroll for a letter grade. Other students should enroll using the S/U option.

CHEM 531, Chemistry of Aquatic Systems, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

The thermodynamics and aqueous chemistry of natural waters, with emphasis on groundwater. Chemical equilibrium concepts, surface chemistry, redox reactions, and biochemistry. The interaction of water with the atmosphere and geologic Materials. Basic concepts applied to problems of groundwater quality evolution, water use, and groundwater contamination. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 431, with additional expectations for graduate credit. (Same as GEOC 507 and HYD 507.)

CHEM 532, Atmospheric Chemistry, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

Chemistry of the atmosphere. Important chemical reactions and their effects on air, soil, and surface waters. Effects of anthropogenic inputs on the atmosphere, climate change. Distribution of chemical species in the atmosphere, etc. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 432, with additional expectations for graduate credit.

CHEM 533, Global Biogeochemical Cycles, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

Human activity is increasing the rate of addition of Materials to the environment, resulting in changes to the earth's climate. The transformation and movement of natural and anthropogenic sources of chemical substances between reservoirs in a global context. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 433, with additional expectations for graduate credit.

CHEM 540, The Chemistry of Energetic Materials, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

The chemistry of propellants, pyrotechnics, and explosives. Material to be covered will include history, oxidation/reduction reactivity, kinetics of decomposition, analytical characterization techniques,

performance evaluation, hazards analysis, safety testing, and structure property relationships.

CHEM 544, Advanced Topics in Organic Chemistry

Prerequisite: Graduate standing in chemistry or consent of instructor:

Study of special topics not otherwise covered in organic chemistry. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 444, with additional expectations for graduate credit.

CHEM 545, Advanced Organic Synthesis, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

Principles and practices of organic synthesis.

CHEM 546, Polymer Chemistry, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

Study of the preparation, properties, and uses of macromolecules. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 446, with additional expectations for graduate credit.

CHEM 547, Medicinal Chemistry, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

Molecular-level mechanisms of drug action and rational drug design. Material is drawn from the recent primary literature. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 447, with additional expectations for graduate credit.

CHEM 548, Experimental NMR Spectroscopy

Prerequisite: Graduate standing in chemistry or consent of instructor:

A lab usage fee is charged

Introduction to NMR instrumentation, data-acquisition, and processing.

CHEM 549, Organometallic Chemistry, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

Organometallic chemistry of the main group and transition elements. Ligand classification and molecular orbital description of bonding in organometallic complexes. Structure, bonding, synthesis, and properties of transition metal compounds and their derivatives. Organometallic complexes as catalysts. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 449, with additional expectations for graduate credit.

CHEM 550, Physical Organic Chemistry, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

Physical aspects of organic chemistry. Emphasizes reaction mechanisms, reaction kinetics, and electronic theories. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lecture with CHEM 450, with additional expectations for graduate credit.

CHEM 551, Advanced Topics in Inorganic Chemistry 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

Study of special topics otherwise not covered in inorganic. The graduate and undergraduate versions of the course will differ in the assignment and exams, while sharing the same lectures. Shares lectures with CHEM 451, with additional expectations for graduate credit.

CHEM 555, Research Proposal Writing, 2 cr, 2 cl hrs

Prerequisite: COMM 575 and graduate standing in chemistry or consent of instructor:

Students will develop an original research proposal required for their candidacy examination. The written research proposal should involve a topic, which is distinct from the student's dissertation research problem. As a partial fulfillment of CHEM 555, students are required to present a 45-minute public seminar on the original proposal. Proposal seminar will not satisfy the graduate seminar requirement (CHEM 529/530). Following the seminar, the student will defend the proposal to his or her dissertation or thesis committee. CHEM 555 will be offered in Fall and Spring semesters. Students are recommended to consult the graduate handbook for details.

CHEM 561, Advanced Topics in Biochemistry, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in chemistry or consent of instructor:

Study of special topics otherwise not covered in biochemistry. Knowledge of the material covered in CHEM 441 and 442 is assumed. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. Shares lectures with CHEM 461, with additional expectations for graduate credit.

CHEM 581, Directed Study, cr to be arranged

Prerequisite: Graduate standing in chemistry or consent of instructor:

Study under the guidance of a member of the faculty. A topic and schedule of meetings is arranged between instructor and student early in the semester.

CHEM 589 Special Topics in Chemistry, cr to be arranged

Prerequisite: Graduate standing in chemistry or consent of instructor:

CHEM 591, Thesis (master's program), cr to be arranged

Prerequisite: Graduate standing in chemistry or consent of instructor:

CHEM 595, Dissertation (doctoral degree program), cr to be arranged

Prerequisite: Successful completion of PhD candidacy exam and academic advisor recommendation for candidacy.

Faculty Research Interests

Altig — Computational Chemistry, Chemical Education

Gao — Inorganic Chemistry, Materials Chemistry

Patidar — Biochemistry, DNA Repair Pathways, Carcinogenesis

Pias — Computational Chemistry, Biophysics, Biochemistry

Piyasena — Bioanalytical Chemistry

Ranasinghe — Photonic Nanomaterials, Time-Resolved Ultrafast Laser Spectroscopy, Nonlinear Spectroscopy

Rubasinghe — Environmental Chemistry, Photocatalysis, Toxicology

Emeritus Faculty Research Interests

Brandvold — Biophysical Chemistry, Enzyme Mechanisms, Environmental Chemistry, Atmospheric Chemistry

Popp — Environmental Chemistry, Geochemistry

Communication, Liberal Arts, Social Sciences (CLASS) With Psychology & Education

Professors: Simpsons

Associate Professor: Dotson (Chair of the Department),

Durão, Kramer-Simpson, Samuels

Assistant Professors, ChoGlueck, Elliott, Johnson, Kelly,

Annemarie Pearson, Rebecca Spruill

Instructors Apodaca, Benalil, Kieffer, Rowe, Hayley

McCullough, Rachel Cruz

Adjunct Faculty, Bouchey, Phillips, Sewell, Thomas,

Wilkinson.

Emeritus Professors Campbell, Corey, Deming, D.

Dunston, S. Dunston, Etscorn, Holson, Lara-Martínez,

Olsen, Wilson, Yee

Music Director Benalil

Degree Offered: B.S and B.A in Psychology, B.S. in Technical Communication, Bachelor of General Studies (BGS), and Associate of General Studies (AGS).

Minors Offered: Secondary Education, Hispanic Studies, History, Literature, Music, Philosophy, Psychology, Science Technology and Society, Technical Communication, Graduate Certificates: Elementary Alternative Licensure, Secondary Alternative Licensure, and Scientific & Professional Communication.

The CLASS Department and Psychology and Education recently merged as of Summer 2020.

The multidisciplinary Department of Communication, Liberal Arts, and Social Sciences develops students' ability to learn, reason, and communicate in diverse fields of study and areas of human experience. The CLASS Department's mission is threefold: to help students write well, think critically, and read widely; to provide an intellectual experience that increases students' awareness of human history, human cultures, and human values; and to encourage the lifelong study of human experience.

The Department provides virtually all courses in four of the six areas of the General Education Core Curriculum required by the New Mexico Higher Education Department for the comprehensive education of undergraduates enrolled in New Mexico state institutions of higher education.

These areas are:

Area 1 — Communications (College Writing and Technical Writing)

Area 4 — Social Sciences (Cultural Anthropology, Political Science, Psychology, Social Science, Women's and Gender Studies);

Area 5 — Humanities (Communication, Creative Writing, Hispanic History, History, Languages, Literature, Media Studies, Philosophy, Popular Culture, Public Speaking, Technical Communication, Visual Art);

Area 6 — Creative and Fine Arts (Art History, Music, Theater).

The Department offers degrees: an industry-endorsed Bachelor of Science in Technical Communication, a Bachelors of Arts and Bachelors of science in Psychology, a Bachelor of General Studies, an Associate of General Studies. It also offers a graduate Certificate in Scientific and Professional Communication, and several minors, allowing students to enrich their studies at Tech to become successful professionals and knowledgeable members of society.

The program in psychology is designed to provide students with a scientific foundation in the methods and basic data in psychology and neuroscience and to prepare students for further work in all specializations within the field.

Students acquire the fundamentals of learning and memory, perception, attention, reason and problem solving, emotion, thought, language and communication, the development of all these processes and their pathology.

In addition, we apply psychology to other fields and teach techniques for measuring and studying psychological variables. Students conduct laboratory experiments on the psychological and physiological bases of behavior. The department has a modern animal care facility for laboratory classes and research. There are many opportunities for independent research.

Degrees and Curricula:

Bachelor of Science in Psychology

Minimum credit hours required—120

In addition to the General Education and Institute Core Curriculum (page 78), the following courses are required:

- PSYC 1110 (3); 2285 (3) and 2285L (1), 472 (1)
- Two courses (with associated labs) chosen from among PSYC 301 (3) and PSYC 301L (1), PSYC 305 (3) and PSYC 305L (1), PSYC 309 (3) and PSYC 309L (1)
- 15 additional credit hours in psychology
- BIOL 2110 (4), 2610 (4), and at least six (6) upper-division credits in Biology, exclusive of BIOL 471 or 472
- MATH 2350 (3) or 483 (3)
- At least four (4) additional credit hours beyond the General Education Core Curriculum and above the Psychology requirements selected from among Biology, Computer Science, Chemistry, Mathematics and Physics.
- Electives to complete 120 credit hours.

Students intending to major in psychology should complete PSYC 1110 and 2285 by the end of their sophomore year. They are advised to complete the biology and

mathematics requirements as early as possible since material from these courses will be used in upper-division courses.

Sample Curriculum for the Bachelor of Science in Psychology

Semester 1

- 3 PSYC 1110 (general)
- 3 ENGL 1110 (college English)
- 4 MATH 1510 (calculus)
- 4 CHEM 1215 & 1215L (general)
- 1 Elective
- 15 Total credit hours

Semester 2

- 4 PSYC 2285 (experimental)
- 3 ENGL 1120 (college English)
- 4 MATH 1520 (calculus)
- 4 CHEM 1225 & 1225L (general)
- 15 Total credit hours

Semester 3

- 3 PSYC 2310 (drugs and behavior)
- 3 PSYC 323 (developmental)
- 5 PHYS 1310 & 1310L (general)
- 4 BIOL 2110 (general)
- 15 Total credit hours

Semester 4

- 3 PSYC 2110 (social)
- 3 MATH 2350 (statistics)
- 5 PHYS 1320 & 1320L (general)
- 4 BIOL 2610 (general)
- 15 Total credit hours

Semester 5

- 4 PSYC 301 (perception)
- 3 HIST 1130 (world history I)
- 3 BIOL 331 (cell biology)
- 3 PHIL2255 (introduction)
- 5 Electives
- 15 Total credit hours

Semester 6

- 4 PSYC 305 (cognitive psychology)
- 3 HIST 1140 (world history II)
- 4 BIOL 351 (physiology)
- 3 ENGL 341 (technical writing)
- 1 Elective
- 15 Total credit hours

Semester 7

- 4 PSYC 309 (behavioral neuroscience)
- 3 PSYC 330 (abnormal)
- 4 BIOL 311 (genetics)
- 4 Electives
- 15 Total credit hours

Semester 8

- 1 PSYC 472 (seminar)
- 4 PSYC 362 (animal behavior)
- 10 Electives/Fine & Creative Arts
- 15 Total credit hours

Bachelor of Arts in Psychology

Minimum credit hours required—120

In addition to the General Education and Institute Core Curriculum for a B.A degree (page XX), the following courses are required:

- PSYC 1110 (3); 2285 (3) and 2285L (1) and PSYC 472 (1)
- Two courses (with associated labs) chosen from among PSYC 301 (3) and PSYC 301L (1), PSYC 305 (3) and PSYC 305L (1), PSYC 309 (3) and PSYC 309L (1) or PSYC 362(3) and 362L (1).
- 15 additional credit hours in Psychology
- BIOL 2110 & 2110L (4), 2610 & 2610L (4), and at least six (6) upper-division credits in Biology
- At least three (3) additional credit hours beyond the General Education Core Curriculum and the Psychology requirements above at the 300 level or above.
- Electives to complete 120 credit hours. Earning a minor in another field is strongly encouraged.

Sample Curriculum for the Bachelor of Arts in Psychology:

Students intending to major in psychology should complete PSYC 1110 and 2285 by the end of their sophomore year. They are advised to complete the biology and mathematics requirements as early as possible since material from these courses will be used in upper-division courses.

Semester 1:

- 3 PSYC 1110 (General Psychology)
- 3 ENGL 1110 (College English)
- 3 MATH 1430 (Applications of Calculus)
- 3 CHEM 1120 (Introduction to Chemistry)
- 3 Ethics of Science or Technology
- 15 Total credit hours

Semester 2:

- 4 PSYC 2285 + PSYC 2285L (Experimental + lab)
- 3 ENGL 1120 (Composition II)
- 3 MATH 2350 (Statistical Methods)
- 4 BIOL 2110 + BIOL 2110L (General + lab)
- 1 Elective
- 15 Total credit hours

Semester 3:

- 3 PSYC 2310 (Drugs and Behavior)
- 3 PSYC 323 (Developmental Psychology)
- 3 PHY 109 (introduction to Physics)
- 3 Humanities
- 3 Science, Technology, & Society or Policy
- 15 Total credit hours

Semester 4:

- 3 PSYC 2110 (Social Psychology)
- 4 PSYC 301 (Sensation and Perception)
- 3 Humanities

4 BIOL 2610 (General)

1 Elective

15 Total credit hours

Semester 5:

4 GEOL 1110 + L (Earth Processes +Lab)

4 PSYC 305 (Cognitive Psychology)

3 BIOL 331 (Cell biology)

3 CSE 1115 (Introduction to Data Science)

1 Electives

15 Total credit hours

Semester 6:

4 BIOL 351 (Physiology)

3 Creative and Fine Arts

3 ENGL 341 (Technical Writing)

3 PSYC 330 (Clinical Psychology)

2 Electives

15 Total credit hours

Semester 7:

4 PSYC 309 (Behavioral Neuroscience)

4 BIOL 311 (Genetics)

7 Electives

15 Total credit hours

Semester 8:

1 PSYC 472 (Senior Seminar)

4 PSYC 362 (Animal Behavior)

10 Electives

15 Total credit hours

Bachelor of Science in Technical Communication

The Technical Communication curriculum combines courses from three fields of study to prepare students for technical communication positions upon graduation:

- The TCOM courses introduce students to document design, graphics, and computer documentation, created online and for multimedia. The TCOM courses also develop students' writing, speaking, and editing abilities.
- The humanities and social science courses improve students' understanding and appreciation of history, literature, philosophy, psychology, and the arts.
- The science and technology courses provide students a background in one specific science or engineering discipline.

Sample Curriculum for the Bachelor of Science in Technical Communication

Semester 1

1 TCOM 1120 (orientation)

3 ENGL 1110 (college English)

4 MATH 1510 (calculus)

4 TCOM 1130 (visual Communication)

3 Foreign Language

1 Elective

16 Total credit hours

Semester 2

3 ENGL 1120 (college English)

4 MATH 1520 (calculus)

1 TCOM 1110

3 Foreign Language

4 Elective

15 Total credit hours

Semester 3

3 TCOM 2110 (Technical Writing)

4 CHEM 1215 & 1215L

3 Humanities

3 Social Science

2 Elective

15 Total credit hours

Semester 4

3 TCOM 2120 (Media Studies)

4 CHEM 1225 & 1225L

3 Humanities

3 Social Science

3 Science or Engineering

16 Total credit hours

Semester 5

5 PHYS 1310 & 1310L

3 TCOM 411 (Persuasive Communication and Grant Writing)

3 Technical Communication Elective

3 Science or Engineering

1 Elective

15 Total credit hours

Semester 6

3 ENGL 341 Technical Writing

3 Technical Communication Elective

5 PHYS 1320 & 1320L

3 Science or Engineering

1 Elective

15 Total credit hours

Semester 7

3 TCOM 321 (internship)

3 TCOM 420 (senior seminar)

3 Technical Communication Elective

3 Humanities/ Fine & Creative Arts

3 Science or Engineering

15 Total credit hours

Semester 8

3 Humanities

3 TCOM 422 (senior thesis)

3 TCOM 421 (Documentation and Client Project Management)

5 Electives

14 Total credit hours

Minimum credit hours required—120

In addition to the General Education and Institute Core Curriculum (page 78), the following courses are required:

- Technical Communication—35 credit hours of technical communication courses including TCOM 1110 (1), 1120 (1), 1130 (3), 2110 (3), 2120 (3), 321 (3), 411 (3), 420 (3), 421 (3), 422 (3), and nine credit hours of technical communication electives. MGT 330 is an approved TCOM

elective. All technical communication courses must be completed with grade C or better. Students may use these TCOM courses to fulfill Area 5 of the General Education Core Curriculum Requirements (page 78) with the exception of TCOM 321, TCOM 421, and TCOM 422.

- Humanities: 12 credit hours in excess of the General Education Core Curriculum Requirements and excluding TCOM courses.
- Foreign Language: Six credit hours of one language
- Science or Engineering: 12 credit hours in a single discipline in excess of general degree requirements
- Electives to complete 120 hours

Bachelor of General Studies

Minimum credit hours required—120

This degree allows a student to plan a program of courses according to individual educational goals and career plans. The Bachelor of General Studies degree will be awarded after completion of 120 credit hours with a grade-point average of 2.0 or more. Other requirements for this degree include the following:

- Completion of the General Education Core & Degree Curriculum listed below.
- 42 credit hours in courses numbered 300 or above.
- Completion of the BGS Academic Career Plan with a stated Emphasis area or areas.
- Fulfillment of the Institution's residence credit requirement (30 credit hours).
- To be admitted into the program for this degree, the candidate must meet with the CLASS department chair and the BGS academic advisor, who will be assigned by the CLASS department chair, to create a BGS Academic Career Plan that will be on file with the Registrar. Any changes to the BGS Academic Career Plan must be approved by the CLASS department chair and the student's BGS academic advisor. These changes will be on file with the Registrar and must be met, along with the above-stated requirements, before the degree will be awarded.

General Education Core Curriculum & Degree Requirements for the Bachelor of General Studies (BGS)

Area 1: Communications (9 credit hours)

- ENGL 1110 *-ENGL 1110 is waived for students who scored 27 or higher on the ACT English Test or 610 or higher on the SAT Critical Reading Test. These students must take ENGL 1120, COMM and ENGL 341 to fulfill the 9 credit hours in this area.*
- ENGL 1120
- COMM 1130 or ENGL 341

Area 2: Mathematics (3 credit hours)

- MATH 1220
- MATH 1230
- MATH 1240
- MATH 1510

Area 3: Laboratory Sciences (8 credit hours with associated labs)

- Science or Engineering with associated Lab

Area 4: Social Sciences (6 credit hours)

- Anthropology (ANTH)
- Economics (ECON)
- Political Science (PS)
- Psychology (PSYC)
- Social Sciences (SOSC)
- Women's and Gender Studies (WGS)

Area 5: Humanities (6 credit hours)

- English (ENGL), except 103, 1110, 1120, 341.
- Communication (COMM). If COMM is used to fulfill credits in Area 1, it cannot also count in Area 5.
- Art History (ART/ARTH)
- Music (MUS/MUSC)* except for performance ensembles
- History (HIST)
- Humanities (HUMA/HUMN)
- Philosophy (PHIL)
- Technical Communication (TC/TCOMM) except TCOM 321, 420, 422
- Foreign Languages

Area 6: Fine and Creative Arts (3 credit hours)

- Art History (ART/ARTH)
- Dance (DANC)
- Music (MUS/MUSC)* except for performance ensembles
- Theater (THEA)

Area 7: Additional Course from Area 4 or Area 5 (3 credit hours)

NOTE: Students who plan to pursue a career or graduate studies that require a Bachelor of Science degree are advised to pursue another degree program at New Mexico Tech.

Associate of General Studies

Minimum credit hours required—60

A two-year certificate, Associate of General Studies, may be awarded after completion of 60 credit hours of course work approved by the CLASS department chair and the student's AGS academic advisor with a grade-point average of 2.0 or above. Fulfillment of the Institution's residence requirement (30 credit hours) must also be met.

- To be admitted into the program for this degree, the candidate must meet with the CLASS department chair and the AGS academic advisor, who will be assigned by the CLASS department chair, to create a AGS Academic Career Plan that will be on file with the Registrar.
- Any changes to the AGS Academic Career Plan must be approved by the CLASS department chair and the student's AGS academic advisor. These changes will be on file with the Registrar. The certificate will be awarded only after completion of the above requirements and completion of the AGS academic Career Plan and after petition to the Vice President for Academic Affairs.
- Completion of the General Education Core Curriculum listed below.

General Education Core Curriculum for the Associate of General Studies (AGS)

Area 1: Communications (9 credit hours)

- ENGL 1110 — ENGL 1110 is waived for students who scored 27 or higher on the ACT English Test or 610 or higher on the SAT Critical Reading Test. These students must take ENGL 1120, COMM 1130 to fulfill the 6 credit hours in this area.
- ENGL 1120

Area 2: Mathematics (3 credit hours)

- MATH 1220
- MATH 1240
- MATH 1230
- MATH 1510

Area 3: Laboratory Sciences (4 credit hours with associated labs)

- Science or Engineering with associated Lab

Area 4: Social Sciences (6 credit hours)

- Anthropology (ANTH)
- Economics (ECON)
- Political Science (PS/POLS)
- Psychology (PSY/PSYC)
- Social Sciences (SS/SOSC)
- Women's and Gender Studies (WGS)

Area 5: Humanities (6 credit hours)

- English (ENGL), except 103, 1110, 1120, 341.
- Communication (COMM). If COMM 1130 is used to fulfill credits in Area 1, it cannot also count in Area 5.
- Art History (ART/ARTH)
- History (HIST)
- Humanities (HUMA)
- Music (MUS/MUSC)* except for performance ensembles
- Philosophy (PHIL)
- Technical Communication (TC/TCOM) except TCOM 321, 420, 422
- Foreign Languages

Area 6: Fine and Creative Arts (3 credit hours)

- Art History (ART/ARTH)
- Dance (DANC)
- Music (MUS/MUSC)* except for performance ensembles
- Theater (THEA)

Area 7: Additional Course from Area 4 or Area 5 (3 credit hours)

Minors

The CLASS Department offers several minors to explore a field of study in more detail.

All Minors

- *Minimum credit hours required—18*
- *Restriction: If a student takes more than one minor in the CLASS Department, only six (6) credit hours of one minor may be applied towards another minor.*
- *Additional requirements as listed under each minor.*

Minor in Creative Thinking and Practice

The following courses are required:

- HUMA 203, Creative Thinking and Practice (3 cr.)
- Capstone: "HUMA 203, Special Topics" on Creativity and Creative Practice (1 cr.)

Elective courses (14 cr.):

14 credit hours from:

- Courses in Area 6: Fine and Creative Arts.
- Courses in Area 4: Social Sciences and in Area 5: Humanities in which the student completes a creative project.
- Courses in Fine Arts and Music Performance (limit of 2 cr. hr.).

Creative assignments from courses in Area 4 Social Science and Area 5 Humanities must be verified by the course instructors.

All elective courses must be approved by the student's minor advisor.

Minor in Hispanic Studies

The following courses are required:

- One of the following sequences (6)
 - SPAN 1110 and 1120, Elementary Spanish I and II
 - SPAN 1110 and 1120, Spanish for Native Speakers
- An additional 12 credit hours in any topic relevant to Hispanic Studies with the consent of the minor advisor

Minor in History

The following courses are required:

- A 100-level history course sequence (6)
- Twelve (12) additional credit hours in history courses. Of these 12 credit hours, six (6) credit hours may be taken in art history or music surveys

Students taking the history minor are strongly encouraged to take the 12 additional credit hours from as wide a variety of topics as possible.

Minor in Literature

The following courses are required:

- 18 credit hours in ENGL literature courses

Minor in Music

The following courses are required:

Theory

- MUSC 1210 Fundamentals of Music, 3 credits (or successful audition)
- MUSC 300, 300L: Music Theory, 3+1 credits (or successful audition)
- MUSC 300: Music Composition, 3+1 credits

Elective

Students must take 3 credits from the list:

- MUSC 1130 Music Appreciation: Western Music, 3 credits (or successful audition)
- MUSC 2420 Comprehensive Musicianship

- MUSC/HUMA 309: Song and Society
- MUSC 311: Opera
- GRMN, FREN
- HUMA 311, Shakespeare and Music
- Special non-repeatable music or theater topics courses under MUSC, HUMA, THEA

Performance

At least 4 credits should be taken from any of the music performance courses (including special topics music performance courses).

Successful Auditions

If a student auditions out of MUS 1210 or MUS 300 (MUS Theory), they should replace them with credits from the “Elective” or “Performance” categories. Up to 4 of these additional credits can be satisfied by performance classes.

Music minors are required to complete a Senior Recital before graduating.

Minor in Philosophy

The following courses are required:

- Three (3) credits of philosophy (PHIL) at the 100/200 level.
- Six (6) credits of philosophy (PHIL) courses at the 300/400 level.
- Nine (9) credits of philosophy and/or similar humanities and social science courses approved by the student’s minor advisor.

Minor in Psychology

Minimum credit hours required—20

The following courses are required:

- PSYC 1110 (3), 2285 (4)
- PSYC 301 (4) or PSYC 305 (4) or PSYC 309 (4)
- Additional nine (9) credit hours in psychology

Students may also do an option in Cognitive Neuroscience as part of the Biomedical Sciences Program.

Undergraduate Minor in Secondary Education (UMSE)

The Undergraduate Minor in Secondary Education (UMSE) will allow current undergraduate students to become certified teachers for grades 7-12 in New Mexico schools. The program is accredited by New Mexico Public Education Department (NMPED) and includes 5 classes along with supervised field experiences in local secondary schools.

Note : A grade of C– or higher is required to get ALP or UMSE credit for education courses.

Requirements for the UMSE are:

- EDUC 340, Concepts in Education (3 cr.)
- EDUC 341, Matching Teaching Strategies to Student Learning (3 cr.)
- EDUC 401, Effective Reading for Diverse Learners (3

- cr.)
- EDUC 403 Methods and Practices in Teaching (3 cr.)
- EDUC 405, Assessments and Measurement (3 cr.)
- EDUC 413 Student Teaching (Secondary) (9 cr.)
- EDUC 414 Student Teaching Seminar (3 cr.)

Minor in Technical Communication

The following courses are required:

- TCOM151 (3)
- TCOM 202 (3)
- TCOM 211 (3)
- Nine (9) additional credit hours of TCOM courses

Minor in Science, Technology, and Society

The following courses are required:

- SOSC 1110, SOSC 1220, or PHIL 121 [Ethics in Science and Engineering (3)]
- Three (3) credits of science, medicine or technology related PHIL, SOSC, HIST, PSYC or POLS coursework at the 300 level or higher.
- Twelve (12) additional credits of science, medicine or technology related humanities studies and social science courses approved by the student’s minor advisor.

Graduate Programs:

Graduate Certificate: Secondary Alternative Licensure

The Secondary Alternative Licensure Graduate Certificate will allow students with at least a Bachelor’s degree to become certified teachers for grades 7-12 in New Mexico schools. Teacher candidates can start teaching on the alternative licensure as soon as they are admitted into the program. The program includes 6 credit hours of upper-level coursework and 12 credit hours of graduate classes. Note: A grade of C– or higher is required to get ALP or UMSE credit for education courses.

Requirements for the Secondary Alternative Licensure are:

- EDUC 340, Concepts in Education
- EDUC 341, Matching Teaching Strategies to Student Learning (Secondary)
- EDUC 501, Effective Reading for Diverse Learners (Secondary)
- EDUC 503 Methods and Practices of Teaching (Secondary)
- EDUC 505, Assessments and Measurements
- EDUC 511 Supervised Field Experience (Secondary)

Graduate Certificate: Elementary Alternative Licensure

The Elementary Alternative Licensure Graduate Certificate will allow students with at least a Bachelor’s degree to become certified teachers for grades K-8 in New Mexico schools. Teacher candidates can start teaching on the alternative licensure as soon as they are admitted into the

program. The program includes 6 credit hours of upper-level coursework and 12 credit hours of graduate classes.

Note: A grade of C– or higher is required to get ALP or UMSE credit for education courses.

Requirements for the Elementary Alternative Licensure are:

- EDUC 340, Concepts in Education
- EDUC 342, Matching Teaching Strategies to Student Learning (Elementary)
- EDUC 502, Effective Reading for Diverse Learners (Elementary)
- EDUC 504 Methods and Practices of Teaching (Elementary)
- EDUC 506, Teaching and Assessing Reading for Elementary Students
- EDUC 512 Supervised Field Experience (Elementary)

Graduate Certificate in Scientific and Professional Communication

Minimum credit hours required—14

The Scientific and Professional Communication Graduate Certificate offers graduate students and post-baccalaureate and industry and public sector professionals an opportunity to build and strengthen their professional communication abilities for professional and academic work. The certificate can be completed live or through distance education. The 14 hours of coursework required for the Certificate provides general foundation of communication to the public and to academic audiences (COMM 575 or TCOM 505 and TCOM 511), while elective courses are available to students with specific interests; for example professionals who work in Spanish-speaking settings might benefit from SPAN 520; students in industry or in one of New Mexico's national labs might choose courses such as TCOM 512 International Professional Communication or TCOM 505 Science Writing; and students interested in public policy and public engagement might consider PS 571 Science and Technology Policy or POLS / PS 570 Policy Sciences. The certificate concludes with a capstone project that allows students to work on a project related to their work or partner with a community organization.

Requirements for this certificate include the following:

- TCOM 511 (3)
- COMM 575 (3) or TCOM 505 (3)
- Six elective credits from the following (live or distance): COMM 575 (3) or TCOM 505 (3) (whichever was not used for the requirement above), TCOM 512 (3), TCOM 521 (3), TCOM 561 (3), TCOM 516 (3), TCOM 530 (3), PS 570 (3), POLS 571 (3), SPAN 520 (3), and 500-level special topics courses in TCOM or POLS.
- Experimental Learning Project - TCOM 501 (2)*

* We also provide the option for a concentration in Policy Sciences and Communication. Students may select from the electives above and opt to substitute a third policy-related course in place of TCOM 501.

Students must be concurrently enrolled in a graduate degree program at NMT or meet the admissions criteria to enroll in a graduate degree program (including as special graduate students).

General Education Core Curriculum Information

The courses offered through the CLASS Department fulfill four areas (Area 1, 4, 5, and 6 and 7) required for the Bachelor of Science. Additional Social Sciences are offered through the Psychology Department (PSYC courses) and the Management Department (ECON courses).

Area 1: Communications

- ENGL 1110, 1120, 341

Area 4: Social Sciences

- ANTH Anthropology
- PSYC Psychology
- POLS Political Science
- SOSOC Social Sciences
- WGS Women's and Gender Studies

Area 3: Humanities

- ARTH Art History
- COMM Communication
- ENGL English (except ENGL 103, 1110, 1120, 341)
- FREN French
- GERM German
- HIST History
- HUMA Humanities
- PHIL Philosophy
- SPAN Spanish
- TCOM Technical Communication (except TCOM 321, 420, 422)

Area 6: Fine and Creative Arts

- ART Art History
- DANC Dance
- MUS Music (Except performance ensembles)
- THEA Theater

Area 7: Additional Course from Area 4 or 5

Anthropology Courses:

The following courses may be used to fulfill Area 4: Social Sciences of the General Education Core Curriculum (page 78).

ANTH 1140, Introduction to Anthropology, 3 cr, 3 cl hr

An introduction to the science of anthropology, its terminology, theory, practice, and subject matter. The course begins with a history of anthropology and then goes into methodology of archaeology. Then, using the discoveries of archaeologists, the course presents a history of humanity from hominids to the early civilizations. The course concludes with a study of cultural anthropology, the study of human beings, their social and cultural institutions, beliefs, and practices around the world, creating a study of adaptations to

common problems.

ANTH 370, Nahuat Mythology & Anthropology, 3 cr, 3 cl hr

A study of Native language, literature, and mythology of Central America. The class explores a specific native literature in its own language and discusses an “American” worldview. Topics include the concept of a fragmented self and of multiple souls, of political community and redistribution, a quintesimal (5) and vigesimal (20) system of counting, sexuality, and the foundation of a Native philosophy. (Same as SPAN 370)

Art History Courses:

The following courses may be used to fulfill Area 6 Creative and Fine Arts of the General Education Core Curriculum (page 78).

ARTH 2210, Art History, 3 cr, 3 cl hrs

Survey of Western hemisphere visual art from prehistory to the 21st century. Focus on visual literacy: students learn to “read” images within the context of its historical and cultural time – in both form and content. Students discover methods to determine if images reinforce the classical/traditional hegemony from the ancient Greeks to the present ingrained in our culture and that are supported by dogma or, instead, if the images question that conditioning, offer innovative thinking and awareness, and promote freedom of expression and modern ideas that can be supported through the scientific method of critical thinking and evidence. Emphasis on issues that affect us as citizens sharing one nation, and ultimately, as human beings sharing one planet. Incorporates an interdisciplinary approach. Assignments include creative options.

ARTH 372, Issues in Art History, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Issues, topics, or specific periods in the visual arts. May incorporate an interdisciplinary approach. Topics may include, among others, Visual and Other Arts; Modern Art; Art and Science; Atomic Art; Literature inspired by Art; Modern Art, Sci Fi, and Film. May be repeated for credit when topic or issue changes. Assignments include creative options.

Communication Courses:

The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (pg 78).

COMM 1130, Public Speaking, 3 cr, 3 cl hrs

A study of the principles of speech; practice in the preparation and delivery of various types of speeches, classified according to function; practice in the basic skills of oral communication; the development of poise and self-confidence.

COMM 360, Advanced Public Speaking, 3 cr, 3 cl hrs

Prerequisites: COMM 1130 or consent of instructor and advisor

Theory and practice of ethical and professional speech communication. Researching, writing and presenting professional presentations. Designing and using effective visuals, including posters and electronic presentation aids. Conducting group presentations and discussions about ethical and cross-curriculum issues in historical, cultural and workplace context.

Education Courses:

EDUC 323, Psychology of Child and Adolescent Development, 3 cr, 3 cl hrs

Prerequisite: PSYC 1110

The development of human behavior from conception to adolescence. Includes cognitive, social, behavioral, and physical development. (Cross-listed as PSYC 323.)

EDUC 340, Concepts in Education, 3 cr, 3 cl hrs

The course is designed to generate a student’s general understanding of education theory. In this course, students will focus on understanding learner development, differences and how those impact student learning and achievement. Students will research different styles and modalities of learning, as well as instructional practice and strategies that support differing types of learning. During this time, students will also examine the impact the learning environment plays in overall student achievement.

EDUC 341, Matching Teaching Strategies to Student Learning (Secondary), 3 cr, 2.5 cl hrs, 0.5 field observations (grades 7-12)

Prerequisites/Co-requisites: EDUC 340 or departmental waiver

This course contains the professional body of knowledge necessary for the effective teaching of diverse learners for student success. This course focuses on understanding theories and strategies that address the needs of a diverse population that compose today’s classrooms in the public school systems. Included in this course will be diversity issues, planning techniques, effective teaching strategies, differentiated instructional and assessment strategies, motivational concepts, and informal and formal assessment practices. Field observations in local classrooms is a key component of this course where students will reflect on student learning and classroom environment in their discipline.

EDUC 342, Matching Teaching Strategies to Student Learning (Elementary), 3 cr, 2.5 cl hrs, 0.5 field observations (grades K-8)

Prerequisites/Co-requisites: EDUC 340 or departmental waiver

This course contains the professional body of knowledge necessary for the effective teaching of diverse learners for student success. This course focuses on understanding theories and strategies that address the needs of a diverse population that compose today’s classrooms in the public school systems. Included in this course will be diversity

issues, planning techniques, effective teaching strategies, differentiated instructional and assessment strategies, motivational concepts, and informal and formal assessment practices. Field observations in local classrooms is a key component of this course where students will reflect on student learning and classroom environment in their discipline.

EDUC 401/EDUC 501, Effective Reading for Diverse Learners (Secondary), 3 cr, 2.5 cl hrs, 0.5 field observations (grades 7-12)

Prerequisites/Co-requisites: EDUC 340 and EDUC 341 or departmental waiver

This course teaches key strategies to differentiate instruction in reading as a response to the needs of all learners including those differing in experience, readiness, interests, educational experiences, ability, language, culture, gender, and mode of learning. Course competencies reflect the national and state standards for secondary literacy instruction. Explicit reading instruction using research-based methods will provide guidance for education students to practice different instructional techniques for learning experiences that are accessible for the diverse needs of learners which include a Response through Intervention (RTI), Students with Disabilities (SWD, and English Language Learners (ELL). The emphasis for differentiation will be reading in the secondary classroom in various content areas. Field observations in local classrooms is a key component of this course where students will reflect on student learning and classroom environment in their discipline.

EDUC 402/EDUC 502, Effective Reading for Diverse Learners (Elementary), 3 cr, 2.5 cl hrs, 0.5 field observations (grades K-8)

Prerequisites/Co-requisites: EDUC 340 and EDUC 342 or departmental waiver

This course teaches key strategies to differentiate instruction in reading as a response to the needs of all learners including those differing in experience, readiness, interests, educational experiences, ability, language, culture, gender, and mode of learning. Course competencies reflect the national and state standards for secondary literacy instruction. Explicit reading instruction using research-based methods will provide guidance for education students to practice different instructional techniques for learning experiences that are accessible for the diverse needs of learners which include a Response through Intervention (RTI), Students with Disabilities (SWD, and English Language Learners (ELL). The emphasis for differentiation will be reading in the secondary classroom in various content areas. Field observations in local classrooms is a key component of this course where students will reflect on student learning and classroom environment in their discipline.

EDUC 403/EDUC 503 Methods and Practices of Teaching (Secondary), 3 cr, 2.5 cl hrs, 0.5 field observations (grades 7-12)

Prerequisites/Co-requisites: EDUC 340 and EDUC 341 or departmental waiver

The course is designed to build on student's general understanding of education theory from EDUC 340 as well as the foundations of curriculum design and teaching from EDUC341. In this course, students will focus on using what they have learned towards planning and developing effective instruction in their particular discipline/content focus. Students will practice different instructional techniques to create learning experiences that are accessible to the diverse needs of learners. Field observation in local classrooms is a key component of this course where students will reflect on the practice of instruction in their discipline. Field observations in local classrooms is a key component of this course where students will reflect on student learning and classroom environment in their discipline.

EDUC 404/EDUC 504 Methods and Practices of Teaching (Elementary), 3 cr, 2.5 cl hrs, 0.5 field observations (grades K-8)

Prerequisites/Co-requisites: EDUC 340 and EDUC 342 or departmental waiver

The course is designed to build on student's general understanding of education theory from EDUC 340 as well as the foundations of curriculum design and teaching from EDUC341. In this course, students will focus on using what they have learned towards planning and developing effective instruction in their particular discipline/content focus. Students will practice different instructional techniques to create learning experiences that are accessible to the diverse needs of learners. Field observation in local classrooms is a key component of this course where students will reflect on the practice of instruction in their discipline. Field observations in local classrooms is a key component of this course where students will reflect on student learning and classroom environment in their discipline.

EDUC 405/EDUC 505, Assessments and Measurement, 3 cr, 3 cl hrs.

Prerequisites/Co-requisites: PSYC 1110 or EDUC 340 or departmental waiver

Evaluation and data-driven curriculum revision. Educational and psychological tests and measurement. Classroom management as it relates to differentiated instruction. Field observation assignments that take students to local district classrooms. (Cross-listed as PSYC 405.)

EDUC 406/ EDUC 506, Teaching and Assessing Reading for Elementary Students, 3 cr, 3 cl hrs.

Prerequisites/Co-requisites: EDUC 340 and EDUC 342 or departmental waiver

This course will provide a research-informed knowledge base for teaching reading and applying it by practicing with sample lessons from the text. Instruction begins with an introduction to both English and Spanish language structure and moves through the stages of reading acquisition beginning with early literacy, decoding and word recognition, and through the essential components that lead to fluency and

comprehension in literary and informational texts. The structure of an effective reading assessment system designed for the progression of reading and how to create a diagnostic plan from the results will be an integral part of this course.

EDUC 413 Student Teaching (Secondary), 9 cr.

Prerequisites/Co-requisites: EDUC 401 and EDUC 403 or departmental waiver. Senior or graduate standing, consent of a public school principal and permission from program coordinator or department chair

This course will apply the theories from all previous coursework to practice teaching in a local public school. Students will experience all aspects of teaching via supervised field experience. Students are required to meet InTASC/NM teacher competencies through a minimum of 16 weeks of structured student teaching in an approved educational setting (grades 7-12). They must also assume all required teacher duties as appropriate including; lesson planning, assessment, individualized instruction, parent-teacher conferences, IEP/grade-level/department meetings, professional development, etc.

EDUC 414 Student Teaching Seminar, 3 cr.

Co-requisites: EDUC 413

The student teaching seminar provides opportunities for student teachers to strengthen professional growth. Areas of study include: design of instructional material, behavioral management, assessment and professional tools for exploring the job market. Emphasis is placed on guiding students from theory to the world of the professional practitioner.

EDUC 511 Supervised Field Experience (Secondary), 3 cr

Prerequisites/Co-requisites: EDUC 501 and EDUC 503 or departmental waiver. Consent of a public school principal and permission from program coordinator or department chair

This course will apply the theories from all previous coursework to student teaching/Alternative Licensure (ALP) teaching in a local public school. Students will experience all aspects of teaching via supervised field experience. Students are required to meet InTASC/NM teacher competencies through a minimum of 16 weeks of structured student teaching in an approved educational setting (grades 7-12). They must also assume all required teacher duties as appropriate including; lesson planning, assessment, individualized instruction, parent-teacher conferences, IEP/grade-level/department meetings, professional development, etc.

EDUC 512 Supervised Field Experience (Elementary), 3 cr

Prerequisites/Co-requisites: EDUC 502 and EDUC 504 or departmental waiver. Consent of a public school principal and permission from program coordinator or department chair

This course will apply the theories from all previous coursework to student teaching/Alternative Licensure (ALP) teaching in a local public school. Students will experience all aspects of teaching via supervised field experience. Students are required to meet InTASC/NM

teacher competencies through a minimum of 16 weeks of structured student teaching in an approved educational setting (grades K-8). They must also assume all required teacher duties as appropriate including; lesson planning, assessment, individualized instruction, parent-teacher conferences, IEP/grade-level/department meetings, professional development, etc.

English Courses:

The following courses (except ENGL 103, 1110, 1120, 341) may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 78).

Writing Program Courses:

ENGL 103, Pre-College English, 3 cr, 3 cl hrs

The basics of writing: sentence types, structure, and construction; topic sentences, paragraph development and coherence; the complete essay; grammar, usage, and punctuation. Prepares students for ENGL 1110 (*Does not fulfill the English portion of the General Education Core Curriculum, page 78.*)

ENGL 1230, Introductory Academic Communication, 3 cr, 3 cl hr

The course introduces students to the general culture of a US university. It provides opportunities to develop their listening, speaking, reading, and writing skills related to their coursework in science, technology, engineering, and mathematics (e.g., understanding lectures, reading academic texts, communicating with professors and TAs, etc.). Students are also introduced to strategies for drafting and editing academic writing and for preparing and giving academic presentations.

ENGL 1510, Academic Communication for Multilingual Students, 3 cr, 3 cl hr

This course allows students to apply the knowledge they have acquired in their field of study to further their development in English language skills. Students work on reading and responding to academic texts in both written and oral formats; crafting and expressing an original argument on an academic topic; and correctly summarizing, paraphrasing, and citing academic texts. Students will write and present on researched topics in their fields of study, provide constructive feedback on each other's work, and practice articulating and answering questions on academic topics.

ENGL 1110 College Writing: Exposition, 3 cr, 3 cl hrs

The essentials of academic prose; techniques and mechanics of writing well; rhetorical strategies.

ENGL 1120, College Writing: Argument and Analysis, 3 cr, 3 cl hrs

Prerequisite: ENGL 1110 or equivalent course passed with a C or better

A continuation of ENGL 1110 with critical reading and writing; writing arguments; library research paper.

ENGL 315, Academic and Scientific Communication for Multilingual Students, 3 cr, 3 cl hrs

Prerequisite: At least junior standing

This course offers a more advanced introduction to language issues in writing for scientific and technical fields. Students in this class explore language use and academic genres in their fields of study and complete an extended research project on a technical topic. The course culminates in a technical research report and conference-style presentation.

ENGL 341, 341D, Technical Writing, 3 cr, 3 cl hrs

Prerequisites: ENGL 1110 and 1120 or the equivalent passed with a grade C or better and at least junior standing

This course emphasizes clear, accurate, and precise communication and scientific and technical information to a variety of audiences, for a variety of purposes. Students will be taught how to effectively analyze the components of writing situations and appropriately conduct research, write content in a professional, yet accessible style, incorporate visuals, organize and format documents. The course culminates with a substantial technical research report and oral presentation. In addition, students work on writing documents including memos, proposals, short reports, and instructions.

Literature Courses:

ENGL 1410, Introduction to Literature and Film, 3 cr, 3 cl hrs

Survey of major works of poetry, short fiction, drama, and film in English and in translation.

ENGL 311, Creative Writing, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

The study and writing of one genre or a combination of the following genres: poetry, fiction, creative nonfiction, playwriting and screenwriting. Emphasis on reading and analyzing literature.

ENGL 312, Short Fiction, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Concentrated study of major works of short fiction written in English and in translation.

ENGL 2610, American Literature, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

An historical survey of 17th, 18th, and 19th century writing, covering the Colonial, Enlightenment, and Romantic periods. Among the authors studied are Anne Bradstreet, Benjamin Franklin, Edgar Allan Poe, Nathaniel Hawthorne, and Emily Dickinson.

ENGL 2620, American Literature, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

An historical survey of 19th and 20th century writing, covering Realism and Naturalism and the Modern period. Among the authors studied are Mark Twain, Willa Cather, Robert Frost, Eugene O'Neill, Ernest Hemingway, William Faulkner, Katherine Anne Porter, and James Baldwin.

ENGL 323, American Nature Writing, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Survey of American nature Writers, such as Lewis and Clark, Thoreau, Edward Abbey, and Leslie Marmon Silko, with literary and philosophical analysis of their observational, documentary, rhetorical, interdisciplinary, and self-reflective strategies to develop students' own skills in these areas and to produce their own nature writing. (Same as PHIL 323)

ENGL 324, Ecotopia: The Intersection of Science and Literature, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Utopian Literature, whether Paradise myths or novels set on an idyllic island or in the future, chronicles human aspirations for a better society. Ecotopia—a neologism coined in 1968—combines utopian desires for better relationships between humans with more recent desires and need for a better relationship with the environment. The course provides a review of utopian literature throughout history and focuses on contemporary science fiction novels and developments in architecture, technology, science, and alternative social structures. Shares lecture with ENGL 524, with additional expectations for graduate credit.

ENGL 325, World Literature, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Literature of the West from the Classics through the Renaissance. [NMCCNS ENGL 2613: General Education Area V]

ENGL 326, World Literature, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Literature of the West from Neoclassicism to Contemporary. [NMCCNS ENGL 2623: General Education Area V]

ENGL 331, British Literature, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

A survey of British literature from its origin through the Age of Enlightenment. Major authors studied include the Beowulf poet, Chaucer, Shakespeare, and Milton.

ENGL 332, British Literature, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

A continuation of ENGL 331, this course surveys British literature of the nineteenth and twentieth centuries. Emphasis is upon the major literary

movements of Romanticism and Realism. [NMCCNS ENGL 2423: General Education Area V]

ENGL 352, Contemporary Latin American Novel, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or equivalent

Survey of the 20th century Latin American regional novel. How contemporary writers have portrayed the Latin American continent: social-realism, surrealism, the boom, neo-baroque, magical realism, mestizaje, social-protest, negrismo, etc. Focus on reading classical works such as Arguedas, Asturias, Castellanos, Fuentes, Roa Bastos, Rulfo. (Same as Spanish 352)

ENGL 355, Latin American Fiction & the Arts, 3 cr, 3 cl hrs

A historical journey of a multi-cultural continent. Politics, economic disparity, military dictatorship, oppression and revolutionary resistance are studied through the lens of arts and literature. The most varied styles—social-realism, surrealism, fantasy, magical-realism, etc.—complement factual history to offer an accurate picture of a cruel social reality. (Same as SPAN 355)

ENGL 357, Latin American Literature, 3 cr, 3 cl hrs

A review of Latin American literary production with examples of its cultural and artistic diversity. The class examines the most important writers from Mexico, the Caribbean, Central America, the Andean region and the Southern cone, and relates their poetic legacy to the social sciences and philosophy. (Same as SPAN 357)

ENGL 366, Historical Fiction, 3 cr, 3 cl hrs

Prerequisites: ENGL 1120 or consent of instructor and advisor

An exploration of historical fiction, examining several historical fiction novels and shorter works with critical analysis of each work for its contributions to an understanding of historical and contemporary issues based on its historical accuracy and literary effectiveness. (Same as HIST 366)

ENGL 431, Literary Genres, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

The study of a particular type of literature, its origins, characteristics, subtypes, and some of its major writers and works. Possible genres are poetry, drama, short stories, science fiction, novels, and nonfiction writing. May be repeated for credit with different genres.

ENGL 435, Major Writers, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Intensive study of the writing of a major world author or authors, such as Willa Cather, Nathaniel Hawthorne, Herman Melville, William Shakespeare, Mark Twain. May be repeated for credit with different writers.

ENGL 436, Issues and Themes in Literature, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Concentrated study of issues, ideas, and themes as they affect or are embodied in literature. Possible topics include, among others, Environment, Gender, Ethnicity, Travel, and Place. May be repeated for credit with different issues.

ENGL 440, Philosophical Novels, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 and one PHIL course

Exploration of the use and articulation of philosophy in novels. (Same as Phil 440)

ENGL 491, Directed Studies, hrs and cr to be arranged

Prerequisite: ENGL 1120 or consent of instructor and advisor

French Courses:

The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 78).

FREN 110, Elementary French I, 3 cr, 3 cl hrs

Elements of French, with particular emphasis on pronunciation, through conversational Materials. Stress is placed on the fundamentals of French grammar, spelling, and written expression. Supplementary readings reinforce comprehension and give additional sources for spontaneous oral expression in class discussion. [NMCCNS FREN 1113: General Education Area V]

FREN 1120, Elementary French II, 3 cr, 3 cl hrs

Prerequisite: FREN 1110 or equivalent

Continuation of FREN 1110. [NMCCNS FREN 1123: General Education Area V]

FREN 210, Intermediate French I, 3 cr, 3 cl hrs

Prerequisite: FREN 1120 or equivalent

Introduction to literary passages of easy comprehension. Translation and practice of composition, with emphasis on oral performance in class. Review of grammar through exercises.

FREN 2120, Intermediate French II, 3 cr, 3 cl hrs

Prerequisite: FREN 2110 or equivalent

Continuation of FREN 2110.

German Courses:

The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 78).

GRMN 110, Elementary German I, 3 cr, 3 cl hrs

Elements of German, with emphasis on the spoken language. Grammar and composition are introduced in connection with the subjects of oral practice.

GRMN 1120, Elementary German II, 3 cr, 3 cl hrs

Prerequisite: GRMN 1110 or equivalent

Continuation of GRMN 1110.

History Courses:

The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 78).

HIST 1110, American History to 1865, 3 cr, 3 cl hrs

A survey of American history from pre-contact North America to the end of the Civil War. The social, cultural, intellectual, and political history of the American people.

HIST 1120, American History since 1865, 3 cr, 3 cl hrs

A continuation of HIST 1110, with attention given to the rise of the United States as a world power, urbanization and industrialization, the role of the state, and civil rights movements.

HIST 1130, World History I, 3 cr, 3 cl hrs

The evolution of the major Eurasian civilizations from the beginning of historical times to the beginning of the 16th century, with special reference to social, political, and cultural developments.

HIST 1140, World History II, 3 cr, 3 cl hrs

A continuation of HIST 1130, emphasizing social, political, and cultural developments in Eurasian civilization from 1500 to the present.

HIST 1150, Western Civilization I 5000BC—1500 AD, 3 cr, 3 cl hrs

Examines pivotal events in the history of the western world (primarily the European continent) from the early civilizations to the Renaissance. Explores the political, socio-economic, and cultural developments in the Fertile Crescent, ancient Greece and Rome, and medieval Europe. The course is organized in chronological and topical units, each within the framework of political geography, economy, religion, and culture.

HIST 1160, Western Civilization II, 1500 AD—Present, 3 cr, 3 cl hrs

Examines the political, social, economic, and cultural developments from the Reformation to the European Union. Explores the watersheds in European history that continue to shape modern politics and societies.

HIST 1166, Full STEAM Ahead Technology and Science from the Hand-Ax to the Steam Engine, Part 1, 3 cr, 3 cl hrs

This course is an introduction to the history of science and technology up to and including the invention of the steam engine. It offers an overview of historical evolution of fundamental scientific concepts and technological developments in various cultures of the world.

HIST 1166L, Full STEAM Ahead Lab Technology and Science from the Hand-Ax to the Steam Engine 1 cr, 2 lab hrs

Corequisite: HIST 1166

Optional lab accompanies the Technology and Science

from the Hand-Ax to the Steam Engine class and explores class concepts in a hands-on, collaborative environment.

HIST 1194, Europe in the 19th Century, 1815-1914, 3 cr, 3 cl hrs

An introduction to the major developments and themes in nineteenth century European history, including major international developments such as the Congress System, the Revolutions of 1848, the advance of modern ideologies and major trends in arts and sciences, and the causes of World War I.

HIST 1195, Europe in the 20th Century, 1914-2000, 3 cr, 3 cl hrs

Explores the great watersheds of the last century in Europe, from World War I to the fall of the USSR and the rise of the European Union. Several case-studies help students understand the legacy of the 20th century and the problems we face today.

HIST 2080, Americans at War, 3 cr, 3 cl hrs

America has been at war for nearly three centuries. This course will examine the causes, undercurrents and significance of America's military engagements at home and abroad and examine how each helped change the trajectory of American history and its role as a current world power. This course will take an in depth look at the major battles, players, aftermath and technological advancements during the major American engagements—the American Revolution, Mexican American War, the Civil War, Spanish American War, two World Wars and the cold war era battles in Korea and Vietnam.

HIST 2270, History of the American West, 3 cr, 3 cl hrs

This class will be an introduction to the history of the American West. Major topics will include European settlement and exploration beyond the Appalachians, changes in indigenous culture, explorations of frontier and mountain men and the settling of western lands via railroads, wagon trains, pioneers and cowboys. This course will emphasize women's roles in the west as well as the infamous men who lived during the tempestuous, violent years that gave the "Wild West" its name.

HIST 345, The Rise and Fall of the Soviet Union, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

The Bolshevik Revolution, the development of Stalinist totalitarianism, reform under Khrushchev, the "stagnation" era of Brezhnev, and the end of the "great experiment" with Gorbachev.

HIST 349, Crime and Society, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

This course explores political, socio-economic, and cultural impacts of crime on societies. Through reading, class discussions, and films the students will compare and contrast the impact of crime on the state, its institutions, and its people in America and Europe. The key topics will

reveal the role of crime in public life, the methods and integrity of law enforcement agencies, the punishment of criminals, and public perception of justice.

HIST 366, Historical Fiction, 3 cr, 3 cl hrs

Prerequisites: ENGL 1120 or consent of instructor and advisor

An exploration of historical fiction, examining several historical fiction novels and shorter works with critical analysis of each work for its contributions to an understanding of historical and contemporary issues based on its historical accuracy and literary effectiveness. **(Same as ENGL 366)**

HIST 375, Ancient and Medieval Foundations of Modern Science and Technology, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

This course discusses the history of science and technology up to the Scientific Revolution. It offers an overview of historical evolution of fundamental scientific concepts and technological developments in Western and non-Western cultures from prehistory to the seventeenth century.

HIST 385, Latin American Cultural History, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Overview of the cultural history of the Iberian world on both sides of the Atlantic from the earliest cultural expression to the current Hispanic presence in the United States. Multicultural creations of Hispanic societies. Cultural productions, i.e., fiestas, toreo, music, painting, literature, graffiti—in their political, economic, and historical background. **(Same as SPAN 385)**

HIST 472, Special Topics, 3 cr, 3 cl hrs

HIST 491, Directed Studies, hrs and cr to be arranged

Prerequisite: Senior standing or consent of instructor and advisor

Humanities Courses:

The following course may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 78).

HUMN 1220, Film Genres, 3 cr, 3 cl hrs

This course helps students become more aware of film as a constructed and contextually-bound art form by providing students with the strategies to analyze films and genres. It also helps students see film as both conventional and a sociocultural-situated artifact. U.S. and foreign films are included, and students have an opportunity to develop a genre or trans-genre short film of their own. This class helps students develop their aesthetic sensibility, creativity, storytelling, and collaboration. This will help make them well-rounded individuals valued in the workplace.

HUMA 1133, German Culture Through Film, 3 cr, 3 cl hrs

This course explores German history from the end of the monarchy in 1918 up to the 21st century, using films ranging from the silent era, through Nazi documentaries

and “rubble” films, up to modern treatments of reunified Germany. Students will learn film terminology, and analyze the director’s use of various techniques, as well as gain an understanding of important issues in recent European history.

HUMA 203 , Creative Thinking and Practice, 3 cr, 3 cl hrs

In this course, students learn how cultivating their creativity can enhance their ability to imagine new applications of scientific principles and technologies, design new experiences and products, develop innovative solutions to complex multidisciplinary problems, or engage in exciting work in industries such as film or software development. Students study examples of how creative ideas and designs have transformed society and industries. Students familiarize themselves with principles of creativity and creative practice, learning how to apply these principles to their training in their majors. Lastly, students learn brainstorming techniques and strategies to spark their creative, outside-the-box thinking, maximizing their capability to imagine innovative solutions to wicked problems and unexpected applications of emerging media and technologies.

HUMN 2410, Hackers, Politics, and Culture

Pre-requisite: ENGL 1110 or Consent of Instructor

In this course, students study the interwoven history of computer hacking, politics, and culture. Students examine how both the practices of computer hacking and hacker culture have evolved. They learn how legal and political institutions have responded to the growing phenomena of computer hacking and cyberwarfare as well as how hacktivists and online activists have used digital technologies to push for political and social change. Students will also explore pop culture’s growing interest in computer hacking and, more significantly, how works of pop culture and science fiction have directly influenced hacks and hackers throughout the history of computing. In the process, students will research and produce case studies of hacks or hacktivist actions, considering their objectives, actions, tools, and impacts. [Cross-listed with SOSC 204]

HUMA 302, Film Production, 3 cr, 3 cl

Film Production familiarizes students with the art and technique of filmmaking. Students work together in teams to write, shoot, and edit a short genre or trans-genre film of their choice. They will also help organize a yearly premiere and film festival to publicly screen their films.

HUMA 309, Song and Society, 3 cr, 3 cl hrs

Prerequisites: ENGL 1120 or consent of instructor and advisor.

This course is a dialogue about music, specifically song, and its role in the development of human society. According to a theory proposed by Dr. Daniel Levitin there are 6 categories of song which helped form our human society; Friendship, Joy, Comfort, Knowledge, Religion, and Love. These will serve as the basis for the class. Within the context of these categories there can

be many sub-divisions to be explored. Students may suggest new divisions and choose songs within those divisions. The class will include lectures, discussions, and student participation. Each student will make a personal song selection for each category, discuss and defend their choice in class, and in their final essay.

(Same as MUS 309)

HUMA 311, Shakespeare and Music, 3 cr, 3 cl hrs

Prerequisites: ENGL 1120 or consent of instructor and advisor.

An interdisciplinary study of selected works of Shakespeare through a musical lens. Shakespeare's plays were written to be spoken and heard, and this course explores the parallel issues of choice and constraint in the acts of speaking and hearing Shakespeare's words, applying tools commonly used to facilitate the performance and reception of music.

HUMA 320, 60s History and Culture, 3 cr, 3 cl hrs

Prerequisites: ENGL 1120

Perhaps the highpoint of the 20th century, the 1960s extended far beyond the decade and raised issues about the relationship of people to each other, to themselves, and to the environment. Moreover, the 1960s launched significant social revolutions and technological innovations. Using fiction and documentary films and music, 60s History and Culture will immerse students in the 1960s.

Music & Music Performance Courses:

The following courses may be used to fulfill Area 6: Creative and Fine arts General Education Core Curriculum (page 78).

MUSC 1210, Fundamentals of Music, 3 cr, 3 cl hrs

An introduction to the basic Materials of music: tones, rhythm, notation, singing, and composition.

MUSC 1130, Music Appreciation, 3 cr, 3 cl hrs

A listening-intensive study of rhythm, melody, and musical structure in Western and other music from antiquity to the present.

MUSC 2420, Comprehensive Musicianship I, 3 cr, 3 cl hrs, 1 lab hr

Prerequisite: MUS 1210 or consent of instructor and advisor

A detailed study of notation, keys, scales, intervals, chords, clefs, and transpositions. Practical application to keyboard, instruments, and voice.

MUSC 300, 300L, Music Theory, 3 cr, 3 cl hrs + 1 Lab hr

Prerequisites: MUS 1210, or successful audition

This course will explore Western music language in depth, from music notation throughout Western music history; scales in all its modes, including the Gregorian Mode, Tetrachord, Chord Function, Augmented 6 Chords, Neapolitan, the Seventh Chord formations, Cadenza; and introduction to 5 Species Counterpoint, Bach Chorale Harmonization. Practical Solfeggio metrical, and Lied Form. Final project will be presented

in Recital Format.

MUSC 301, Music Composition, 3 cr, 3 cl hrs, 1 Lab hr Area V

Prerequisite: MUS 3xx Music Theory, or successful audition

This course explores applied Western music theory, including compositional techniques from the medieval period, the Neapolitan school of music, and through the Romantic period and the modern period. Midterm project will be presented in recital format. The final project will be composed in sonata form: orchestral, chamber music. Presented in concerto format.

MUSC 309, Song and Society, 3 cr, 3 cl hrs

Prerequisites: ENGL 1120 or consent of instructor and advisor.

This course is a dialogue about music, specifically song, and its role in the development of human society. According to a theory proposed by Dr. Daniel Levitin there are 6 categories of song which helped form our human society; Friendship, Joy, Comfort, Knowledge, Religion, and Love. These will serve as the basis for the class. Within the context of these categories there can be many sub-divisions to be explored. Students may suggest new divisions and choose songs within those divisions. The class will include lectures, discussions, and student participation. Each student will make a personal song selection for each category, discuss and defend their choice in class, and in their final essay. (Same as HUMA 309)

MUSC 311, Opera, 3 cr, 3 cl hrs

A musical and socio-historical exploration opera literature and the opera genre, including operetta.

Music Performance Courses:

These courses are "offered on demand," i.e. when a sufficient number of students want to enroll, and they may be taken for elective credit only. These courses can be repeated for credit as determined by the instructor. These courses may NOT be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 78).

MUS 171, 172, Beginning Group Voice, 1 cr, 2 cl hrs

Basic techniques of correct singing.

MUS 273, 274, Intermediate Group Voice, 1 cr, 1 cl hr

Prerequisite: MUS 171, 172, or consent of instructor and advisor

Development of personal vocal technique, musicianship, diction.

MUS 331–332, Chamber Choir, 1 cr, 2 cl hrs

Prerequisite: Consent of instructor

MUS 333–334, Concert Chorus, 1 cr, 2 cl hrs

The Concert Chorus performs large-scale choral works independently and together with the Chamber Orchestra. Interested students without prior singing

experience are encouraged to participate.

MUS 336, Opera Study & Performance, 2 cr, 2 cl hrs

This class focuses on staged performance and on building an interpretation of an operatic personage. Students learn how to research and build a strong knowledge of an operatic personage, as well as the history of the opera genre and public performance.

MUS 341–342, Jazz Ensemble, 1 cr, 2 cl hrs

Prerequisite: Consent of instructor

MUS 351–352, Chamber Orchestra, 1 cr, 2 cl hrs

Prerequisite: Consent of instructor

MUS 361–362, Chamber Music, 1 cr, 1 cl hr

Prerequisite: Consent of instructor

MUS 377, 378, Vocal Performance, 1 cr, 1 cl hr

Prerequisite: MUS 273, 274, or consent of instructor and advisor

Practical and theoretical aspects of solo vocal performance.

Philosophy Courses:

The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 78).

PHIL 1115, Introduction to Philosophy, 3 cr, 3 cl hrs

An exploration of major issues and approaches in the history and practice of philosophy, including questions of value, knowledge, reality, and problems that arise in social and political philosophy. A fundamental aim of the course is to improve skills in critical thinking, problem-solving, and evaluating.

PHIL 1146, Ethics in Science and Engineering, 3 cr, 3 cl hrs

In this course, students learn about professional research ethics and the social responsibilities of scientists and engineers. They also examine the diverse roles for values throughout research and development in STEM, including judgments about funding, methodology, communication, and public engagement. The course introduces students to pressing questions about justice, equality, and democracy related to the responsibilities for technological development by surveying issues in areas such as computer science, environmental justice, global ethics, health equity, and military ethics.

PHIL2136, Understanding Technoscientific Controversies, 3 cr, 3 cl hrs

This science and technology studies course challenges students to think more carefully and critically about technoscientific environmental problems and controversies, such as climate change, vaccine

hesitancy, genetic engineering, pharmaceutical drugs, and nuclear energy. Students will examine the cognitive, cultural, economic, ethical, political, and communicative roots of disagreement, learning to recognize that these issues are not solved by presenting a “balanced view” of both sides or by simply informing “ignorant” opponents. Students will apply these thinking skills in order to develop more productive and empathic solutions to tenacious and highly polarized public conflicts. (Same as SS 211)

PHIL 2255, Western Philosophy, 3 cr, 3 cl hrs

Introduction to Western philosophical methods, metaphysics, epistemology, ethics, and major philosophers in comparison to one major Asian philosophy text such as the Tao Te Ching. [NMCCNS PHIL 1113: General Education Area V]

PHIL 2040- Science & Gender

Pre-requisites: none

This course introduces students to the complex interplay between science, technology, and gender, with special attention to intersections with sexuality, race, and ethnicity. We analyze the concepts of “sex” and “gender” by critically investigating the nature/nurture debates about sex differences. The course further prompts students to think more broadly about gender in science and technology in discussions over bias, values, and scientific objectivity. Throughout the course, we also survey different critical approaches to biomedicine such as women’s health, LGBTQ health, breast cancer, HIV/AIDS, and reproductive health. (cross-listed with GNDR 2040)

PHIL 323, American Nature Writing, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

A survey of American nature Writers, such as Lewis and Clark, Thoreau, Edward Abbey, and Leslie Marmon Silko, with literary and philosophical analysis of their observational, documentary, rhetorical, interdisciplinary, and self-reflective strategies to develop students’ own skills in these areas and to produce their own nature writing. **(Same as ENGL 323)**

PHIL 300, Philosophy of Science, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

An introduction to the philosophical bases and problems of the formal and empirical sciences. Includes the nature of scientific methods, problems and paradoxes of induction, logic of explanation, concepts of causality, determinism and probability, measurement theory, and special philosophical issues in physical, biological, and behavioral sciences.

PHIL 315, Philosophy of Digital Communication, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

A philosophical and historical overview of the shift to

digital modes of communication; explores the impact of this digital shift on culture, identity, communication, education, art, medicine, ethics, community, and the production of knowledge. (Same as TC 315.)

PHIL 321, Professional Ethics, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Ethical theories and their applications in business, research, and engineering.

PHIL 342, Philosophy of Bioethics, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Exploration of ethical issues embedded in medicine and related activities; focuses on broad areas including: the physician/patient relationship, the media's influence on medicine, the role of the pharmaceutical industry, gene therapy, cloning and stem cell research, organ transplantation, human and animal research, reproductive technologies, and the global allocation of resources.

PHIL 351, World Religions, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Survey of the theologies of Christianity, Judaism, Islam, Hinduism, Buddhism, and other religions. [NMCCNS PHIL 1113: General Education Area V]

PHIL 352, Asian Philosophy, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Survey of the philosophical traditions of China (Confucianism and Taoism), India (Hinduism and Islam), and Japan (Buddhism).

PHIL 421, Periods or Figures in Philosophy, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Study of a single philosopher's work or a philosophical school.

PHIL 440, Philosophical Novels, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 and one PHIL course

Exploration of the use and articulation of philosophy in novels. (Same as ENGL 440)

PHIL 451, American Philosophy, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Survey of American philosophy, including pragmatism from its roots in American Romantic writers such as Emerson to contemporary figures such as Richard Rorty and Stanley Fish, nature philosophers such as Thoreau and Ed Abbey, feminist philosophy, and Native-American philosophy.

Political Science Courses:

The following courses may be used to fulfill Area 4: Social Sciences of the General Education Core Curriculum (page 78).

POLS 1110, Introduction to Political Science, 3 cr, 3 cl hrs

An introduction to political ideas, events and institutions. Explores the relationships between politics and society; examines the interdependence of citizenship and community life; investigates the complex interaction between values, issues and political behavior.

POLS 1120, American National Government, 3 cr, 3 cl hrs

An examination of American democracy as a creative, evolving, and fluid process; how citizens and political institutions interact to create power, establish rights, and pursue interests. [NMCCNS GOVT 1113: General Education Area IV]

POLS 2120, Issues in International Relations, 3 cr, 3 cl hrs

Considers current international issues in light of the transforming structure of world politics; examines the changing status of America as a world power; and investigates the roles of culture, economic power, and technology in the process of global change.

POLS 370, Public Policymaking, 3 cr, 3 cl hrs

An analytical examination of the policymaking process within the American political system, with special attention to who is involved in the process, how decisions are made, and what the consequences are of alternative policy choices.

POLS 470, Policy Sciences, 3 cr, 3 cl hrs

Prerequisites: ENGL 1120 or consent of instructor

It reviews a worldwide policy movement emerging in response to the increasingly complex problems of the decision in the modern era. In the United States, the movement takes various institutional forms, including think tanks, offices of planning and evaluation, and university-based programs in public policy. This program integrates several fields of knowledge to improve policy decisions: integrate knowledge about policy decision and decision process from any discipline or other sources into the understanding of the policy sciences, and become professional in the sense of one who has acquired knowledge and skills critical to society and accepts responsibility to use them in the common interest.

POLS 471, Science and Technology Policy, 3 cr, 3 cl hrs

Prerequisites: ENGL 1120 or consent of instructor (for graduate level, Graduate Standing or consent of Instructor)

This seminar-based course provides an overview of selected topics in science and technology policy. Students will gain an understanding of the challenges, tensions, and problems within science and technology policy issues and be introduced to crafting policy-relevant documents such as op-eds, policy briefs, and longer research reports. Themes may include the proper role of experts in policy-crafting policy-relevant documents such as op-eds, policy briefs, and longer research reports. Themes may include the proper role of experts in policy-making, the regulation

of risky technologies, comparisons of democratic and expert-led decision-making, resilient environmental policy, generative justice, sustainability, forecasting and managing technological change, public and private steering of R&D funding, strategies for stimulating innovation and technological transitions, intellectual property, science and technology-based entrepreneurship, and regional and national innovation systems.

Portuguese Courses

PORT 1110, Elementary Portuguese I, 3 cr, 3 cl hrs

An introductory course designed for students with no previous exposure to Portuguese, this course provides many opportunities to acquire beginning communicative skills in Portuguese. Students practice listening, speaking, reading, and writing in the cultural context of Portuguese as a World Language. This course emphasizes students learning to communicate in everyday situations

Psychology Courses

The following courses may be used to fulfill Area 4: Social Sciences portion of the General Education Core Curriculum, page 78.

PSYC 1110, General Psychology, 3 cr, 3 cl hrs

The study of behavior. Includes perception, motivation, learning, personality, social processes, and physiological processes. [NMCCNS PSYC 1110: General Education Area IV]

PSYC 1180, Science and Pseudoscience, 3 cr, 3 cl hrs

This course examines methods for determining whether given claims are science or pseudoscience. Several controversial topics will be explored, with emphasis on coming to objective decisions about such claims. Topics include logical fallacies, the Scientific Method, creationism, global warming and climate change, hidden codes in the Bible, Relativity theory, 9/11 Truth conspiracy claims, Dark Matter, UFO sightings, Perpetual Motion Devices, Quantum Mechanics, Quack medical claims and more.

PSYC 1190, Human Factors in Science & Engineering, 3 cr, 3 cl hrs

This course explores how human capabilities and limitations influence decision making and performance and how scientists and engineers can use knowledge of these factors to design. We will focus on how cognitive processes and biases in perception, attention, memory and problem solving influence performance. Examples of "human error" and ways in which error can be averted will be studied. Comparisons will be made between human and artificial intelligence.

PSYC 2110, Social Psychology, 3 cr, 3 cl hrs

Prerequisite: PSYC 1110

Study of the manner by which the behavior of one individual is influenced by the behavior and other characteristics of others. Includes social perception and cognition, attitudes, prejudice, interpersonal attraction, cooperation, group behavior, and aggression.

PSYC 2285, Experimental Psychology, 3 cr, 3 cl hrs

Prerequisite: PSYC 1110

Corequisite: PSYC 2285L

Basic concepts and research methodology in the study of behavior; emphasis on experimental design, control, and methods in Experimental Psychology.

PSYC 2285L, Experimental Psychology Laboratory, 1 cr, 2 lab hrs

Prerequisite: PSYC 1110

Corequisite: PSYC 2285

A lab usage fee is charged.

Laboratory methods and experiments investigating behavior, cognitive processes and neuropsychology.

PSYC 2310, Drugs and Behavior, 3 cr, 3 cl hrs

Prerequisite: PSYC 1110

An overview of how drugs affect brain and behavior, with an emphasis on self-administered drugs, addiction and treatment.

PSYC 301, Sensation and Perception, 3 cr, 3 cl hrs

Prerequisite: PSYC 2285 passed with a C- or better

Corequisite: PSY 301L

An experimental and theoretical study of the special senses (vision, hearing, smell, taste and touch), including the structure, function and disorders of sensory and perceptual systems.

PSYC 301L, Sensation and Perception Lab, 1 cr, 2 lab hrs

Prerequisite: PSYC 2285

Corequisite: PSY 301

A lab usage fee is charged

Laboratory methods and experiments in Sensation and Perception.

PSYC 305, Cognitive Psychology, 3 cr, 3 cl hrs

Prerequisite: PSYC 2285 passed with a C- or better

Corequisite: PSY 305L

A study of research findings, major issues and theories of mental processes. Topics include attention, learning, memory, imagery, concept formation, language and its development, thinking, problem solving and decision making.

PSYC 305L, Cognitive Psychology Lab, 1 cr, 2 lab hrs

Prerequisite: PSYC 2285 passed with a C- or better

Corequisite: PSY 305

A lab usage fee is charged

Laboratory methods and experiments investigating cognitive processes.

PSYC 309, Behavioral Neuroscience, 3 cr, 3 cl hrs

Prerequisites: PSYC 2285 passed with a C- or better;

BIOL 2110,

Corequisite: PSY 309L and BIOL 2610

Study of the neural and other physiological bases of behavior. Functional neuroanatomy of sensory and motor systems, motivation and drives, learning and emotion.

PSYC 309L, Behavioral Neuroscience Lab, 1 cr, 2 lab hrs

Prerequisites: PSYC 2285 passed with a C- or better;

*BIOL 2110**Corequisite: PSY 309, BIOL 2610*

A lab usage fee is charged

Laboratory includes neuroanatomy and neurophysiology, either *in vivo* and/or in computer simulations.

PSYC 314, Psychotherapeutics, 3 cr, 3 cl hrs

Prerequisites: PSYC 2310, BIOL 2110, 2610

A study of approaches to treatment of disorders of the nervous system, from the function and dysfunction of the nervous system, to in depth explanations of the development and application of pharmacological, gene and cell replacement approaches to treatment of disease.

PSYC 320, Psychology of Language, 3 cr, 3 cl

hrs *Prerequisites: PSYC 1110*

Language may be the most uniquely human behavior. This class explores the evolutionary origins of language in animal communication abilities; how the brain makes sense of language and plans speech; child development of language understanding and production; and social aspects of human behavior in conversation.

PSYC 323, Psychology of Child and Adolescent Development, 3 cr, 3 cl hrs

Prerequisite: PSYC 1110

The development of human behavior from conception to adolescence. Includes cognitive, social, behavioral, and physical development.

PSYC 323L, Psychology of Child and Adolescent Development Lab, 1 cr, 2 cl hrs

Corequisite: PSY 323 and consent of instructor

This course is intended to help students understand, through firsthand observation, theories and ideas taught in Child and Adolescent Development (PSY 323). The class will focus on the biological, perceptual, cognitive, behavioral, linguistic and socialemotional development of preschoolers at the NMT Children's Center.

PSYC 324, Psychology of Adult Development and Aging, 3 cr, 3 cl hrs

Prerequisite: PSYC 1110

The development of human behavior from early adulthood to old age. Cognitive, social, behavioral, emotional, and physical development. Life tasks, careers, physical and emotional health, leisure, dying, and death.

PSY 330, Clinical Psychology, 3 cr, 3 cl hrs

Prerequisite: PSYC 1110

A psychobiological investigation of the cause, presentation, diagnosis, treatment and prognosis of behavioral and mental health issues

PSYC 350, Psychobiology of Sex, 3 cr, 3 cl hrs

Prerequisite: PSYC 1110 or consent of instructor and advisor

Sexual reproduction in a broad evolutionary context. Topics include sexual and asexual reproduction, sexual selection, the endocrinology of mammalian reproduction, development of the reproductive system and sexually differentiated behaviors, sex differences in the brain, and human behavioral sex differences.

PSYC 362, Animal Behavior, 3 cr, 3 cl hrs

Prerequisites: PSYC 1110 or consent of instructor and advisor

An overview of the study of animal behavior, focusing on presentation, adaptive advantage and mechanisms of specific behaviors. **(Same as BIOL 362)**

PSYC 362L*, Animal Behavior Lab, 1 cr, 2 lab hrs

Prerequisites: PSYC 2285 passed with a C- or better

Corequisite: PSY 362L

Observation and quantification of animal behavior in natural habitat and the laboratory. Methods of investigating behavioral mechanisms. Requires off-campus activities.

PSYC 389, Special Topics in Psychology, cr and hrs to be arranged**PSYC 391, Directed Study, hrs and cr to be arranged**

Prerequisite: Upper-division standing in psychology

Supervised individual work in psychology. May be repeated for more than one semester's work.

PSYC 400, History of Psychology, 3 cr, 3 cl hrs

Prerequisite: Nine hours in psychology

This course traces central questions and concepts of psychology from their origins in classical philosophy and medicine to modern times. Interactions between historical developments and psychological research are emphasized

PSYC 405, Assessments and Measurement, 3 cr, 3 cl hrs

Prerequisites/Co-requisites: PSYC 1110 or EDUC 340, or permission of instructor

Educational and psychological tests and measurement. Evaluation and data-driven curriculum revision. Field observation assignments that take students to public school classrooms. **(Cross-listed with EDUC 405/505)**

PSYC 409, Cell and Molecular Neuroscience, 3 cr, 3 cl hrs

Prerequisite: PSYC 1110 or BIOL 2110

A study of the molecular and cellular basis of the nervous system, covering fundamentals of cell biology, principles of neuronal signaling and neuronal circuits, and cell and molecular approaches to the investigation,

diagnosis and treatment of diseases of the nervous system. Shares lecture with BIOL 509 and BIOT 509 with additional expectations for graduate credit. (Same as BIOL 409.)

PSY 410, Neurology, 3 cr, 3 cl hrs

Prerequisite: PSYC 1110 or BIOL 2110

An examination of the non-cognitive functions of the nervous system (e.g., autonomic function, biological rhythms, and sleep), and the etiology, diagnosis and treatment of selected neurological disorders such as epilepsy, migraine and traumatic brain injury.

PSYC 414, Psychotherapeutics, 3 cr, 3 cl hrs

Prerequisites: PSYC 2310, BIOL 2110, 2610

A study of approaches to treatment of disorders of the nervous system, from the function and dysfunction of the nervous system, to in depth explanations of the development and application of pharmacological, gene and cell replacement approaches to treatment of disease

PSY 472, Senior Seminar, 1 cr, 1 cl hr each semester

Prerequisite: Upper-division standing or consent of instructor and advisor

Review and discussion of current research in psychology.

Social Science Courses:

The following courses may be used to fulfill Area 4: Social Sciences of the General Education Core Curriculum (page 78).

SOSC 120, Social Thought, 3 cr, 3 cl hrs

From Machiavelli and Marx to Steinem and Foucault, this course explores some of the major historical and contemporary theoretical works and authors in selected social sciences. The focus is on the cultural framework in which these thoughts emerged and the impact they had on society. **(Same as ANTH 120 and WGS 120)**

SOSC 1110, Introduction to Science and Technology Studies, 3 cr, 3 cl hrs

The aim of this course is to challenge commonly accepted beliefs regarding technoscience, including the presumption that the “best” technology always wins and the notion that science is never political. Through an examination of historical and contemporary examples, students will explore the cultural, organizational, economic, and political drivers and consequences of scientific R&D and technological change.

SOSC 1220, Full Steam Ahead Part 2, 3 cr, 3 cl hrs

This course examines the development of contemporary technologies, including the personal computer, nuclear energy, jet engines, chemical plants, genetic

engineering, and the automobile, in order to uncover the social, political, and ethical facets of science and engineering. By learning how historical events, pervasive ideas, business and regulatory cultures, economics, and other social stuff both drive and constrain technological development, students will acquire thinking skills necessary for being not only thoughtful technical professionals but also responsible citizens. This course is offered to the members of the Learning and Living Community and fulfills a General Education Core requirement.

SOSC 1220L, Full Steam Ahead Part 2, 3 cr, 3 cl hrs

This lab accompanies the Full STEAM Ahead class and gives students the opportunity to explore class concepts by analyzing technological solutions to a contemporary public problem in a hands-on, collaborative environment. Students will not only diagnose the issues facing a current scientific and technical undertaking but also propose how it could be redesigned to better account for the cultural and political complexities of social reality. By the end of the semester, groups of students will produce and present a research poster on their chosen topics by analyzing technological solutions to a contemporary public problem in a hands-on, collaborative environment. Students will not only diagnose the issues facing a current scientific and technical undertaking but also propose how it could be redesigned to better account for the cultural and political complexities of social reality. By the end of the semester, groups of students will produce and present a research poster on their chosen topics.

SOSC 1320, Creation of the Universe: Fact/Fiction/Myth, 3 cr, 3 cl hrs

How did we get here? Where did we come from? How were the earth, moon and sun created? From ancient tribes to modern civilization, the human race has tried to answer these questions. This course examines the myths and scientific theories of the origin of the universe. The course first covers ancient myths, progresses to modern religion and culminates with our current understanding of the Big Bang and related scientific theories. Other myths, such as the great flood, which common to many cultures, are examined. The course focuses on how science and culture interact by examining how our concept of creation has evolved.

SOSCS 2010, American Culture and Leisure Ethics, 3 cr, 3 cl hrs

Students will explore American culture throughout various historical eras and reflect on the specific beliefs and values of the American public as evidenced via consumer products, social, recreational and leisure activities. Pre-dominant themes and group activities will revolve around sports, holidays, drinking, dating, and the evolution of vacations vacations and entertainment in the form of circuses, amusement parks, music and movies. Students will be able to determine what major political, religious, tech-

nological, social and/or economic trends influenced American popular and leisure culture and shaped the overall American experience throughout history.

SOSC 2110, Environment, Science, and Technology, 3 cr, 3 cl hrs

This science and technology studies course challenges students to think more carefully and critically about tech- noscientific environmental problems and controversies, such as climate change, vaccine hesitancy, genetic engi- neering, pharmaceutical drugs, and nuclear energy. Stu- dents will examine the cognitive, cultural, economic, ethical, political, and communicative roots of disagree- ment, learning to recognize that these issues are not solved by presenting a “balanced view” of both sides or by simply informing “ignorant” opponents. Students will apply these thinking skills in order to develop more pro- ductive and empathic solutions to tenacious and highly polarized public conflicts. (Same as PHIL 211).

SOSC 2120, Unintended Consequences, Accidents, and Disasters, 3 cr, 3 cl hrs

A science and technology studies examination of how different cognitive, organizational, political, and technical factors influence people’s ability to cope with the complexities and uncertainties of technoscientific endeavors. Through a survey of unanticipated consequences, organizational failures, and other human -produced disasters, students will explore how humanity might proceed more thoughtfully, carefully, and fairly with respect to innovation and sociotechnical change

SOSC 204 – Hackers, Politics, and Culture

Prerequisite: ENGL 1110 or Consent of Instructor

In this course, students study the interwoven history of computer hacking, politics, and culture. Students examine how both the practices of computer hacking and hacker culture have evolved. They learn how legal and political institutions have responded to the growing phenomena of computer hacking and cyberwarfare as well as how hacktivists and online activists have used digital technologies to push for political and social change. Stu dents will also explore pop culture’s growing interest in computer hacking and, more significantly, how works of pop culture and science fiction have directly influenced hacks and hackers throughout the history of computing. In the process, students will research and produce case studies of hacks or hacktivist actions, considering their objectives, actions, tools, and impacts.[Cross-listed with HUMN 2410]

SS 311, The Digital Age and Its Discontents, 3 cr, 3 cl hrs

Prerequisites: ENGL 1120 or consent of instructor and advisor

This science and technology studies course examines the social and political consequences of digital technologies, including their influence on social

interaction, people’s intimate relationships, economic arrangements, and the practice of democracy. Through an exploration of recent scholarship and critical dystopian imaginaries, students will reflect upon the risks, double-binds, and injustices of the digital age as well as inquire into the possibilities for achieving more desirable digital modernity's.

Spanish Courses:

The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 78).

SPAN 1110, Elementary Spanish I, 3 cr, 3 cl hrs

Elements of Spanish, with emphasis on the spoken language. Grammar and writing are introduced in connection with the subjects of oral practice.

SPAN 1110, Spanish for Native Speakers, 3 cr, 3 cl hrs

Elements of Spanish, with emphasis on the spoken and written language. Grammar and writing are introduced in connection with the subjects of oral practice...

SPAN 1120, Elementary Spanish II, 3 cr, 3 cl hrs

Prerequisite: SPAN 1110 or equivalent

Continuation of SPAN 1110

SPAN 2110, Intermediate Spanish I, 3 cr, 3 cl hrs

Prerequisite: SPAN 1120 or equivalent

Expansion of vocabulary through conversation. Stress is placed on the correction of vocabulary and speech for native speakers. Extensive readings from literary models provide Materials for emphasis on the principles of composition. Review of grammar.

SPAN 2120, Intermediate Spanish II, 3 cr, 3 cl hrs

Prerequisite: SPAN 2110 or equivalent

Continuation of SPAN 2110; readings in Spanish literature.

SPAN 352, Contemporary Latin American Novel, 3 cr, 3 cl hrs

Prerequisite: SPAN 2110 or equivalent

Survey of the 20th century Latin American regional novel. How contemporary writers have portrayed the Latin American continent: social-realism, surrealism, the boom, neo-baroque, magical realism, mestizaje, social-protest, negrismo, etc. Focus on reading classical works such as Arguedas, Asturias, Castellanos, Fuentes, Roa Bastos, Rulfo. All readings and reports to be in Spanish. **(Same as ENGL 352)**

SPAN 355, Latin American Fiction & the Arts, 3 cr, 3 cl hrs

A historical journey of a multi-cultural continent. Politics, economic disparity, military dictatorship, oppression and revolutionary resistance are studied through the lens of arts and literature. The most varied

styles—social-realism, surrealism, fantasy, magical-realism, etc.—complement factual history to offer an accurate picture of a cruel social reality. **(Same as ENGL 355)**

SPAN 357, Latin American Literature, 3 cr, 3 cl hrs

A review of Latin American literary production with examples of its cultural and artistic diversity. The class examines the most important writers from Mexico, the Caribbean, Central America, the Andean region and the Southern cone, and relates their poetic legacy to the social sciences and philosophy. **(Same as ENGL 357)**

SPAN 370, Nahuatl Mythology & Anthropology, 3 cr, 3 cl hr

A study of Native language, literature, and mythology of Central America. The class explores a specific native literature in its own language and discusses an “American” worldview. Topics include the concept of a fragmented self and of multiple souls, of political community and redistribution, a quincennial (5) and vigesimal (20) system of counting, sexuality, and the foundation of a Native philosophy. **(Same as ANTH 370)**.

SPAN 385, Latin American Cultural History, 3 cr, 3 cl hrs

Prerequisite: SPAN 2110 or equivalent

Overview of the cultural history of the Iberian world on both sides of the Atlantic from the earliest cultural expression to the current Hispanic presence in the United States. Multicultural creations of Hispanic societies. Cultural productions, i.e., fiestas, tereo, music, painting, literature, graffiti—in their political, economic, and historical background. All readings and reports to be in Spanish. **(Same as HIST 385)**

Technical Communication Courses:

TCOM 1110, Community Service, 1 cr, 1 cl hr

Proposing and then reporting in writing on a semester-long community service activity with any nonprofit organization. To be graded S/U. May be repeated for credit.

TCOM 1120, Orientation to Technical Communication, 1 cr, 1 cl hr

Guest speakers introduce students to the myriad activities and career paths of technical communicators.

TCOM 1130, Visual Communication and Graphic Design, 3 cr, 3 cl hrs

This course supports students’ personal and professional development by exploring the principles and practices of visual communication and graphic design. Students learn best practices for creating human-centered, ethical, appealing, and effective visual communication—from presentations and data displays to signage, posters, and tutorials—for research,

education, and industry. Working individually and in groups, students create various small graphic and communication design projects that aspire to make a difference. By the end of the course, students showcase their work in a professional online portfolio.

TCOM 2110, Technical Writing, 3 cr, 3 cl hrs.

Prerequisite: ENGL 1120

Grammar review. Description of types and levels of editing. Responsibilities of editors. Use of editing and proof-reading symbols, usage guides, style guides and style sheets, Production aspect of editing. Practice in online and hard copy of short manuscript.

TCOM 2120, Media Studies, 3 cr, 3 cl hrs

This course helps students build their personal brand and identity and apply the process to an organization of their choice. It also helps students harness the power of social media to build and consolidate both a personal brand and that of organizations. Video editing and critical media analysis are included in this course. This class prepares students to make branding and social media an integral part of their day-to-day activities.

TCOM 301, Writing Theory and Practice, 3 cr, 3 cl hrs

Prerequisites: ENGL 1120 or consent of instructor and advisor

In this advanced composition course, we explore processes and theories from fields such as rhetoric, composition, and technical communication. Multiple genres of writing are discussed, from reflective to research writing.

TCOM 315, Philosophy of Digital Communication, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

A philosophical and historical overview of the shift to digital modes of communication; explores the impact of this digital shift on culture, identity, communication, unity, and the production of knowledge. **(Same as PHIL 315.)**

TCOM 321, Internship, 3 cr

Prerequisites: TCOM 2120 and 2120; ENGL 341; and consent of TCOM faculty

Work during a school term or the summer in a technical communication or media field, such as writing, gathering data, or production work, for an on- or off-campus publications agency. To receive credit, students must have their internships approved in advance by the TCOM faculty. Students produce a report about their internship program.

TCOM 330/330D Risk, Crisis, and Nonprofit Communication, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor.

Environmental, geopolitical, societal, economic, and technological risks and crises can affect corporations, industry, non-profit organizations, governments, science and education, anywhere in the world. While many of

these threats cannot be stopped, their likelihood and impacts can be reduced through communication. In this active-learning, problem-based class, students follow and critically analyze situations of risk and crisis in for-profit and non-for-profit organizations. They learn how to develop and implement risk and crisis communication plans. Students apply their knowledge and skills in a risk or crisis communication project for a for-profit or non-for-profit client of their choice, and develop a portfolio of their work.

TCOM 351, Web Design, 3 cr, 3 cl hrs

Prerequisites: TCOM 1130

This course introduces students to the fundamentals of web design, including principles of usability, aesthetics, and interactivity. Students will learn and apply current web design theories and relevant technology tools to practical course projects.

TCOM 371, Publications Management, 3 cr, 3 cl hrs

Prerequisites: TCOM 2120 and 2120 or consent of instructor and advisor

Theory and practice of meeting managerial responsibilities. Topics include communication in organizations, management and supervision, project management, technology and professional communication, legal and ethical issues, and contract employment. Includes a collaborative research project using ethnographic methods.

TCOM 403, Rhetoric and Video Games, 3 cr, 3 cl hrs

Prerequisites: ENGL 1120 or consent of instructor (for graduate level, Graduate Standing or consent of Instructor)

A reading and discussion-heavy course that focuses on the critical study of video games as a medium for communication, design, culture, and ideologies. Our primary methodological focus will be the application of rhetorical theory as a critical lens through which we examine video games as a medium. Course readings will begin with Ancient Greek rhetoric and move through modern rhetoric. Students will have the opportunity to produce both critical academic writing using video games and rhetorical theory and a creative project practicing components of game development.

TCOM 404, Design Thinking for Innovation Lab, 3 cr, 3 cl hrs

This class hones students' creativity and critical thinking skills to make innovative design solutions to products and services. This course introduces students to the "design thinking mindset", process and tools needed in this approach. The class also addresses user needs and there is an emphasis on working on client-based problems. This hands-on lab class prepares students to more easily guide strategies and actively contribute to decision-making processes in research, education and industry.

TCOM 405, Science Writing, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 and at least junior standing or consent of instructor and advisor

This course provides an overview of science writing genres designed to reach multiple audiences (e.g., specialists, policymakers, students, the public, etc.), with an emphasis on nonspecialist audiences. Course topics include, but are not limited to, the rhetorical history of science communication, popular science writing and science journalism, and public information for research groups and facilities (e.g., press releases, websites, science blogs). This course is ideal for TCOM students interested in working for one of New Mexico's many national labs and research facilities and for students in the sciences interested in improving their scientific communication skills. This course involves a service learning project providing students with opportunities for publication. Shares lecture with TC 505, with additional expectations for graduate credit.

TCOM 411, Persuasive Communication, 3 cr, 3 cl hrs

Prerequisites: English 1120 or Consent of Instructor (for graduate level, Graduate Standing or Consent of Instructor)

This course introduces rhetorical theory and persuasive techniques for communication from promotional documents to grants. Students gain practical experience in design, writing, and illustrating promotional texts. A central focus of the class is on preparing and submitting a real-world grant proposal, and introduces writing for both government and small foundation grants.

TCOM 416, International Professional Communication, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor

Producing efficient and effective information for audiences situation in different geographic locations is a major concern of companies and organizations, both large and small. This course develops the knowledge and skills needed to analyze and solve the problems posed by a world that is increasingly diverse, interconnected, and driven by knowledge, technology and the capacity to learn and adapt to new and ever changing contexts and situations. During the course, students will produce artifacts that demonstrate development and accomplishments as an international professional communicator. Shares lecture with TCOM 512, with additional expectations for graduate credit.

TCOM 420, Senior Seminar, 3 cr, 3 cl hrs

Prerequisites: TCOM 2120 and senior standing in the Technical Communication program

Readings in professional journals and discussion of current issues in technical and professional communication. Taught as a seminar with students presenting papers. Research leading to proposal for TCOM 422, Senior Thesis.

TCOM 421, Documentation and Client Project Management, 3 cr, 3 cl hrs

Prerequisites: English 1120 or Consent of Instructor

This course discusses the development and writing processes of professional communication documents, which can include computer/software documentation, websites, videos, policy and procedural manuals and instructions. Students gain practical experience working on an in-depth documentation project with real-world clients and developing Materials for users. Usability testing and individual project management are also a part of this course.

TCOM 422, Senior Thesis, 3 cr, 3 cl hrs

Prerequisite: TCOM 420

Initiation, production, and presentation (oral and written) of an original research project in technical communication.

TCOM 461/461D, Storytelling with Data, 3 cr, 3 cl hrs

Prerequisite: ENGL 1120 or consent of instructor and advisor.

Data visualization tells compelling human-centered stories with data. It supports communicating, understanding, and decision-making. In this course, students become acquainted with storytelling and the development, approaches, methods, and techniques of data visualization. Students learn best practices for creating data displays—graphs, charts, illustrations, maps, interactive displays, and other data visuals—for industry, research, education, and the media. They analyze case studies on how data is visualized in these contexts and they are able to follow practitioners in action. By the course's end, students design and build their own data visualization projects.

TCOM 491, Directed Studies, 1–3 cr, as arranged

Prerequisites: TCOM 2110 and 2120, or consent of instructor and advisor

TCOM 389, TCOM 389D, TCOM 589, TCOM 589D, Special Topics, 3 cr, 3 cl hrs

Theater Courses:

The following courses may be used to fulfill Area 5: Creative and Fine Arts General Education Core Curriculum (page 78).

THEA 1210 – Introduction to Acting, 3 cr, 3 cl

This course gives non-majors experience in the depth and craft of the actor's art. Students will learn various terms, techniques, and practices of acting and will demonstrate their learned skills in class. Through individual and collaborative exercises and improvisations as well as partnered scenes, students will be better able to appreciate the work of others as they

learn techniques of performing.

Women's and Gender Studies Courses:

The following courses may be used to fulfill Area 4: Social Sciences of the General Education Core Curriculum (page 78).

GNDR 101, Introduction to Gender Studies, 3 cr, 3 cl hrs

This chronologically organized course follows the changes in defining women and men as gendered beings in the U.S. We explore such cultural areas as the economy, politics, sexualities, medicine, religions, and more, tracing how ideas of femininity and masculinity are created and enforced in various areas of American culture.

GNDR 241- Science & Gender

Pre-requisites: none

This course introduces students to the complex interplay between science, technology, and gender, with special attention to intersections with sexuality, race, and ethnicity. We analyze the concepts of "sex" and "gender" by critically investigating the nature/nurture debates about sex differences. The course further prompts students to think more broadly about gender in science and technology in discussions over bias, values, and scientific objectivity. Throughout the course, we also survey different critical approaches to biomedicine such as women's health, LGBTQ health, breast cancer, HIV/AIDS, and reproductive health.

GNDR 301, Introduction to Women's Studies, 3 cr, 3 cl hrs

This thematically organized course introduces issues important to women and men as gendered beings. Explorations of such cultural areas as the economy, politics, sexualities, medicine, religions, and more, both in their American context as well as in comparison to other cultures.

Graduate Courses Offered:

The following courses are offered for graduate credit:

COMM 560, Professional Public Speaking, 3 cr, 3 cl hrs

Prerequisites: Consent of instructor

Theory and practice of ethical and professional speech communication. Research, writing and presenting professional presentations. Designing and using effective visuals, including posters and electronic presentation aids. Conducting group presentations and discussions about ethical and cross-curriculum issues in historical, cultural and workplace context. Design, schedule and present a formal research colloquium. *Shares lecture with (400-level version) with additional expectations and assignments for graduate credit.*

COMM 570, Communication in Engineering, 3 cr, 3 cl hrs

Prerequisites: Graduate Enrollment in Engineering

Advanced communication/writing courses linked to engineering disciplines, focusing on graduate and professional genres (e.g., conference abstracts, journal articles, and conference presentations). Emphasis on communicating technical information to a variety of audiences. *Shares lecture with (400-level version) with additional expectations and assignments for graduate credit.*

COMM 575, 575D, Communication in the Sciences 3 cr, 3 cl hrs

Prerequisites: Graduate Standing

Advanced communication/writing course focusing on graduate and scientific and engineering genres (e.g., conference abstracts, journal articles, and conference presentations). Emphasis on communicating technical information to a variety of audiences. *Shares lecture with (400-level version) with additional expectations and assignments for graduate credit.*

COMM 580, Thesis & Dissertation Boot Camp 1 cr

Boot Camp is a weeklong, intensive course on thesis-writing. Students receive short workshops on time-management and project planning, strategies for overcoming writer's block, peer review, and graduate school thesis requirements (e.g., formatting, copyright, etc.). Additionally, students spend 5-6 hours a day in a real writing environment and have opportunities for feedback from the instructor or available writing consultants.

ENGL 511, Graduate Creative Writing, 3 cr, 3 cl hrs

Prerequisite: Consent of instructor

Professional-level writing in fiction, poetry, creative non-fiction or plays. Focuses on the genre of the student's choice. Students write often, revise frequently, learn and apply methods of Creative Writing instruction. *Shares lecture with (400-level version) with additional expectations and assignments for graduate credit.*

ENGL 524, Ecotopia: The Intersection of Science and Literature, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing or consent of instructor and advisor

Utopian Literature, whether Paradise myths or novels set on an idyllic island or in the future, chronicles human aspirations for a better society. Ecotopia—a neologism coined in 1968—combines utopian desires for better relationships between humans with more recent desires and need for a better relationship with the environment. The course provides a review of utopian literature throughout history and focuses on contemporary science fiction novels and developments in architecture, technology, science, and alternative social structures. *Shares lecture with ENGL 324, with additional expectations for graduate credit.. Shares lecture with (400-level version) with additional expectations and assignments for graduate credit.*

PHIL 521D, Professional Ethics, 3 cr, 3 cl hrs

Introduce students to the concepts, theory, and practice of ethics and effective written and oral communications. Study cases and apply classical moral theory to decisions encountered in professional careers. *Shares lecture with (400-level version) with additional expectations and assignments for graduate credit.*

POLS/PS 570, 570D, Policy Sciences, 3 cr, 3 cl hrs

Prerequisites: Graduate Standing or consent of Instructor

It reviews a worldwide policy movement emerging in response to the increasingly complex problems of the decision in the modern era. In the United States, the movement takes various institutional forms, including think tanks, offices of planning and evaluation, and university-based programs in public policy. This program integrates several fields of knowledge to improve policy decisions: integrate knowledge about policy decision and decision process from any discipline or other sources into the understanding of the policy sciences, and become professional in the sense of one who has acquired knowledge and skills critical to society and accepts responsibility to use them in the common interest.

POLS/PS 571, 571D, Science and Technology Policy, 3 cr, 3 cl hrs

Prerequisites: ENGL 1120 or consent of instructor

This seminar-based course provides an overview of selected topics in science and technology policy. Students will gain an understanding of the challenges, tensions, and problems within science and technology policy issues and be introduced to crafting policy-relevant documents such as op-eds, policy briefs, and longer research reports. Themes may include the proper role of experts in policy-making, the regulation of risky technologies, comparisons of democratic and expert-led decision-making, resilient environmental policy, generative justice, sustainability, forecasting and managing technological change, public and private steering of R&D funding, strategies for stimulating innovation and technological transitions, intellectual property, science and technology-based entrepreneurship, and regional and national innovation systems.

SPAN 520, 520D, Advanced Spanish Reading & Comprehension, 1 cr, 1 cl hr

Creative writing in Spanish. The class explores the poetic and musical legacy of the Spanish speaking countries, and writes poems, short stories, or a small literary piece in Spanish. *Shares lecture with (400-level version) with additional expectations and assignments for graduate credit.*

TCOM,501, 501D, Experiential Learning Project, 2 cr

As a capstone project, students in the Graduate Certificate will develop an independent project that results in 40 hours of work. This requirement can assume the form of a TC-related project at the student's work or a community organization (e.g., a documentation project,

a promotional video, a grant proposal and/or fundraising project, etc.) *Shares lecture with (400-level version) with additional expectations and assignments for graduate credit.*

TCOM 503, 503D, Rhetoric and Video Games, 3 cr, 3 cl

hrs *Prerequisites: Graduate Standing or consent of Instructor*

A reading and discussion-heavy course that focuses on the critical study of video games as a medium for communication, design, culture, and ideologies. Our primary methodological focus will be the application of rhetorical theory as a critical lens through which we examine video games as a medium. Course readings will begin with Ancient Greek rhetoric and move through modern rhetoric. Students will have the opportunity to produce both critical academic writing using video games and rhetorical theory and a creative project practicing components of game development.

TCOM 504, 504D, Design Thinking for Innovation Lab, 3 cr, 3 cl hrs

This class hones students' creativity and critical thinking skills to make innovative design solutions to products and services. This course introduces students to the "design thinking mindset", process and tools needed in this approach. The class also addresses user needs and there is an emphasis on working on client-based problems. This hands-on lab class prepares students to more easily guide strategies and actively contribute to decision-making processes in research, education and industry.

TCOM 505, 505D, Science Writing, 3 cr, 3

cl hrs *Prerequisites: Graduate Standing*

This course provides an overview of science writing genres designed to reach multiple audiences (e.g., specialists, policymakers, students, the public) with an emphasis on nonspecialist audiences. The course is useful both to students pursuing a career as a professional science or technical writer and to students in the sciences hoping to improve their communication skills. Course topics include, but are not limited to, popular science writing (e.g., writing for mainstream magazines and newspapers) and public information (e.g., press releases, websites, science blogs, informational videos). The course involves a service learning project providing students with opportunities for publication. *Shares lecture with (400-level version) with additional expectations and assignments for graduate credit.*

TCOM 511, 511D, Persuasive Communication and Grant Writing, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or Consent of instructor

Instruction in theories and practices of effective persuasive communication. Course content will include extensive audience analysis and planning, drafting, and revising persuasive documents, with a heavy emphasis

on funding and research proposals, for targeted audiences. *Shares lecture with (400-level version) with additional expectations and assignments for graduate credit.*

TCOM 516, 516D, International Professional Communication, 3 cr, 3 cl hrs

Prerequisites: Graduate Standing

Producing efficient and effective information for audiences situated in different geographic locations is a major concern of companies and organizations, both large and small. This course develops the knowledge and skills needed to analyze and solve the problems posed by a world that is increasingly diverse, interconnected, and driven by knowledge, technology, and the capacity to learn and adapt to new and ever changing contexts and situations. Students will compile a professional portfolio demonstrating development and accomplishments as an international professional communicator. *Shares lecture with TC 316, with additional expectations for graduate credit.*

TC 521, 521D, Professional Writing Workshop, 3 cr, 3 cl hrs

Prerequisites: Graduate Standing or consent of instructor

Emphasis on the development and writing processes of professional communication documents, which might include computer/software documentation, websites, videos, policy and procedural manuals. Students gain practical experience working on an in-depth documentation project with clients and developing Materials for users. *Shares lecture with (400-level version) with additional expectations and assignments for graduate credit.*

TCOM 530/530D, Risk, Crisis, and Nonprofit Communication, 3 cr, 3 cl hrs

Environmental, geopolitical, societal, economic, and technological risks (World Economic Forum) and crises can affect corporations, industry, non-profit organizations, governments, science and education, anywhere in the world. While many of these threats cannot be stopped, their likelihood and impacts can be reduced through communication. In this active-learning, problem-based class, students follow and critically analyze situations of risk and crisis in for-profit and non-for-profit organizations. They learn how to develop and implement risk and crisis communication plans for for-profit and non-for-profit organizations. Students apply their knowledge and skills in a risk or crisis communication project for a for-profit or non-for-profit client of their choice, and develop a portfolio of their work. *Shares lecture with undergraduate section with additional expectations for graduate students.*

TCOM 561, 561D, Story Telling with Data, 3 cr, 3 cl hrs

Prerequisites: Graduate Standing or consent of instructor

Data visualization tells compelling human-centered stories with data. It supports communicating, understanding, and decision-making. In this course, students become

acquainted with storytelling and the development, approaches, methods, and techniques of data visualization. Students learn best practices for creating data displays—graphs, charts, illustrations, maps, interactive displays, and other data visuals—for industry, research, education, and the media. They analyze case studies on how data is visualized in these contexts and they are able to follow practitioners in action. By the course's end, students design and build their own data visualization projects. Share lecture with TC 461 with additional expectations for graduate students.

TCOM 589, 589D, Special Topics, 3 cr, 3 cl hrs

THEA 514, Introduction to Theater, 3 cr, 3 cl hrs

Theory and practice of analysis of the play as literature, applying basic modes of literary criticism and vocabulary of literary analysis. Coursework includes organizing and leading a discussion on such subjects as literary analysis, directing, scene or costume design, or playwriting. Practical application includes producing a readers' theater performance.

Faculty Research Interests

- Dotson — Scientific Controversies, Governing Risky Technology, Community Life.
- ChoGlueck—Philosophy of Science, Biomedical Ethics, Feminism,
- Durão — Visual Communication with an emphasis on Data Visualization, Science and Technology Studies, International professional communication
- Elliott — Neuroethology, Systems Neuroscience, Language, Music Cognition, Auditory Perception, Educational Assessment.
- Kelly— Media, technology and Culture hackers and Popular Culture, History of Computing
- Kramer -Simpson — Feedback, Transitioning from college to the workforce, Students developing research interests
- Johnson—Modern latin American Culture and Literatures.
- McCullough—Storytelling and Culture Linguistics Analysis, Integrative Complexity.
- Mikhailova — Medieval History, Gender, Russian History, History of Science
- Pearson— Spanish Translation, Literary Pilgrimage
- Samuels — Cognitive Development, Reasoning and Problem Solving, Memory, Brain Injury and Rehabilitation
- Simpson — ESL Writing, Graduate Student Communication, Technical and Scientific Communication
- Thompson — Regulation of physiology and behavior by light; health effects of exposure to artificial light and eye disease.

Earth and Environmental Science

The Department of Earth and Environmental Science administers four closely related disciplines in the Earth sciences, geology, geophysics, geochemistry, and hydrology, as well as the various options leading to a Bachelor of Science degree in Environmental Science. By its very nature, Environmental Science is an interdisciplinary program, incorporating expertise from biology, chemistry, Earth science, physics, and environmental engineering.

Earth Science

Professors Bilek, Harrison (Chair of the Department), Mozley, Person, Spinelli, Van Wijk

Associate Professors Cadol

Assistant Professors Gysi, Jones, K. Leary, R.

Leary, Hurtig, Naliboff, Rinehart, Schaefer, Waters

Research Professors Murray, Reusch, Ulmer-Scholle

Emeritus Professors Axen, Budding, Campbell,

Condie, Hendrickx, D. Johnson, Kyle, Lattman, Phillips, Wilson

Adjunct Faculty Balch, Bauer, Blamey, Boston,

Broadhead, Cather, Chamberlin, Chapin, Cohen, Conley, Creech-Eakman,

Dewars, Dunbar, Fernald, Frey, Frisbee, Goff, Velez-

Gomez, Hawley, Heath, Heizler, Kelley, Kieft, Koning, Kurilovitch,

Land, R. Leary, Love, Lueth, Luhmann, Martin,

McLemore, Newton, Oglesby, Ross, Rowe, Stephens, Stone, Tidwell, Timmons,

Underwood, Vrolijk, Will, Wolberg, Zimmerer

Degrees Offered: B.S. in Earth Science;

Graduate Certificate in Hydrology; P.M. in Hydrology;

M.S. in Geochemistry, Geology, Geophysics (Solid

Earth), and Hydrology; Ph.D. in Earth and

Environmental Science with Dissertation in

Geobiology, Geochemistry, Geology, Geophysics, or

Hydrology

Undergraduate degrees in Earth science require a broad-based background in mathematics, chemistry, and physics, as well as basic training in the Earth sciences. The curriculum emphasizes fundamentals and thus provides the background for entry into a number of Earth science professions or graduate schools.

The graduate program provides specialized training and research opportunities in theoretical or applied aspects of Earth science. Areas of particular expertise in the department include: ore genesis, origins of magmas, volcanology, tectonic history of the continents, geothermal and hydrocarbon exploration, recharge, flow, and water quality in

groundwater basins and at hazardous waste sites, modern and ancient depositional processes and environments; landscape and soil evolution, atmospheric and land surface controls on regional energy and water budgets, earthquake seismology, seismic imaging, geodesy, faults and fluid flow, marine geophysics; radiometric dating, geobiology, and cave and karst studies.

Staff members of the on-campus New Mexico Bureau of Geology and Mineral Resources participate in the graduate program by offering courses and supervising research work for theses and dissertations.

Earth science is a highly interdisciplinary field with many critical environmental, science, and resource connections to society. Graduates commonly enter professional careers in water resources, in the science, monitoring and management of geologic hazards and water quality, and in the exploration for and stewardship of energy and other natural resources.

Undergraduate Program

Bachelor of Science in Earth Science

Minimum credit hours required—120

Courses used for degree, including general degree requirements, must be taken for a letter grade. GEOL1110 + L and GEOL 200 level or GEOL 2000 level course must be passed with a grade of C or higher.

In addition to the General Education and Institute Core Curriculum Requirements (page 78), the following courses are required:

- EARTH 100 (1), GEOL 1110 (3), GEOL 1110L (1) or GEOL 1190, GEOL 1190L
- EARTH 200 (3), EARTH 200L (1), GEOL 2320 (4), GEOL 2340 (4), EARTH 206 (3), EARTH 301 (4), EARTH 340 (3), EARTH 353 (4), EARTH 380 (4)
- EARTH 480 (6), or EARTH 483 (2), EARTH 484 (2), and EARTH 485 (2)
- Earth science electives, minimum 13 credit hours from EARTH, GEOL, GEOP, GEOC, or HYD (a maximum of 4 credits from GEOL 100-level courses)
- MATH 2420 (3), 283 (3), 335 (3), or 382 (3)
- Electives, minimum 9 credit hours from PHYS, MATH, CHEM, BIOL, PETR, ME, EARTH, GEOL, GEOP, GEOC, or HYD 200-level and CSE 100 level and above.

Bachelor of Arts in Earth Science

Minimum credit hours required—120

Courses used for degree, including general degree requirements, must be taken for a letter grade. GEOL 1000 and 2000 level courses must be passed with a C or higher.

In addition to the General Education and Institute Core Curriculum Requirements (page 78), the following courses are required:

ERTH 100 (1), GEOL 1110 (3)*, GEOL 1110L(1) or GEOL 1190, GEOL 1190L, GEOL 200(3), GEOL (I), GEOL 2320(4), GEOL 2340(4), ERTH 206(4), ERTH 301(4), ERTH 340(3), ERTH 353(4), ERTH 380 (4)
 Minimum 12 credit hours from ERTH, GEOL, GEOP, GEOC OR HYD

Minor in Earth Science

Minimum credit hours required — 18

The following courses are required:

- GEOL 1110 and associated lab (4 hrs)
- Two classes from the following list: GEOL 2320, 2330 or 2304
- Additional 200-level or higher from ERTH, GEOL, GEOP, GEOC, or HYD, to reach 18 credits

Minor in Geobiology

Minimum credit hours required — 18

The following courses are required:

- GEOL 1110 (3), GEOL 1110L (1) or GEOL 1190, GEOL 1190L, ERTH 206 & 206L (4)
- BIOL 2110 & 2110L (4)
- One classes from the following list: ERTH 415 (Geomicrobiology) (3), ERTH 390 (3),
- One class from the following list : BIOL 343 (3), BIOL 344 (3),

Minor in Geophysics

Minimum credit hours required — 19-20

The following courses are required:

- GEOL 1110 (3), GEOL 1110L or or GEOL 1190, GEOL 1190L, GEOL 2340 (4), ERTH 325 (3)
- Three classes from the following list: ERTH 401 (2), ERTH 412 (3), ERTH 445 (3), ERTH 448 (3), ERTH 455 (3), any GEOP (3)

Minor in Hydrology

Minimum credit hours required — 19-20

The following courses are required:

- GEOL 1110 (3), GEOL 1110L (1) or GEOL 1190, GEOL 1190L, ERTH 440 (3), ERTH 440L (1)
- Three classes from the following list: ERTH 340 (3), ERTH 401 (2), ERTH 407 (3), ERTH 411 (3), ERTH 412 (3), ERTH 413 (3), ERTH 414 (3)
- One class from the following list: MATH 335 (3), CHEM 422 (3)

Minor in Mineral Resources

Minimum credit hours required — 20

The following courses are required:

- GEOL 1110 (3), GEOL 1110L or GEOL 1190, GEOL 1190L,, ERTH 412 (3), ERTH 200 (3), ERTH (200L), ERTG 462/ME 462 (3)
- Two classes from the following list: ERTH 431(3), GEOL 551 (3), ME 220 (3), ME 360 (3)

Minor in Petroleum Geology

Minimum credit hours required — 19-20

The following courses are required:

- GEOL 1110, GEOL 1110L (1) or GEOL 1190, GEOL 1190L, GEOL 2330 (3), ERTH 460 (3)
- Three classes from the following list: ERTH 353 (4), ERTH 445(3), ERTH 447 (3), ERTH 301 (3)

Earth Science Courses:

ERTH 100, Earth Science as a Profession. 1cr

Offered every fall semester

Introduction to field methods, laboratory & field safety, applied and basic research in Earth Sciences, professional development & professional certificates and other topics.

GEOL 1110, Earth Processes, 3 cr, 3 cl hrs

Offered fall semester

A study of the physical processes that operate on and within the Earth and determine its evolution through geologic time. Students are encouraged to enroll concurrently in GEOL 1110L or GEOL 103L.
 [NMCCNS GEOL 1114: General Education Area III]

GEOL 1110L, Earth Processes Laboratory, 1 cr, 3 lab hrs

Corequisite: GEOL 1110L

Laboratory to accompany GEOL 1110. Identification of rocks and minerals, maps and map reading, and measurement and interpretation of geologic features. Field trips.

GEOL 1140, The Catastrophic Earth: An Introduction to Natural Hazards, 3 cr, 3 cl hrs

Offered on demand

A survey of natural hazards—such as earthquakes, volcanoes, slope failures, severe weather, asteroid impacts, and fire—and their societal implications. Scientific principles such as plate tectonics, volcanology, weather, space science, and statistics of hazard occurrences, as well as topical discussions of natural hazards in the news.

GEOL 1140L, Catastrophic Earth Laboratory, 1 cr, 3 lab hrs

Corequisite: GEOL 1140

Laboratory exercises dealing with natural hazards, including locating recent earthquakes using seismograms, combining maps of earthquake and volcanic hazards with statistical hazard information, estimating flood recurrence for rivers, and tracking hurricanes using meteorological data.

GEOL 1170, Spaceship Earth, 3cr, 3 cl hrs

Offered on demand

Study of Earth as an immense system composed of a gigantic rocky mass, a planet-dominating ocean, an active

atmosphere, and an abundance of life. Consideration of subsystems interacting across time and space. Discussion of possible mechanisms that may control this megasystem including controversial topics, e.g. co-evolution, homeostatic feedback mechanisms, and the Gaia Hypothesis.

GEOL 1170L, Spaceship Earth Laboratory, 1cr, 3 lab hrs

Corequisite: GEOL 1170

Laboratory and field demonstrations of principles of global biogeochemical cycles and the interaction of life with its planetary home.

GEOL 1185 Water in the Rise and Fall of Civilizations, 3 cr, 3 cl hrs

Offered on demand

A survey of how water resources have nurtured the rise of civilizations and how changes in, or misuse of, these resources have led to their demise. The impact of hydrologic extremes such as floods and droughts on social sustainability will also be examined. Case studies from the ancient to the modern world will be considered in the context of the underlying hydrological processes and their environmental and social ramifications.

GEOL 1185L, Water in the Rise and Fall of Civilizations Laboratory, 1 cr, 3 lab hrs

Corequisite: GEOL 1185

Offered on demand

Laboratory and field exercises in hydrologic processes including flood forecasting, erosion, salinization, and groundwater overdraft.

GEOL 1190, Geology of the National Park, 3cr, 3 cl hrs

Offered in spring semester

A study of the physical process that operate on and within the Earth, and determine its evolution through geologic time, by focusing on the National Parks.

GEOL 1190L, Geology of the National Park Lab, 1cr, 3 lab hrs

Prerequisite or corequisite: GEOL 1190

Offered in spring semester

Laboratory to accompany GEOL 1xxx. Identification of rocks and minerals, maps and map reading and measurement and interpretation of geologic features

ERTH 200, Introduction to Mineralogy, 3 cr, 3 cls hrs, 3 lab hrs

Prerequisite: GEOL 1110, GEOL 1110L, CHEM 1215, CHEM 1215L

Offered spring semester.

An introduction to minerals, including identification in hand samples and thin sections, crystal structures, physical properties, chemical compositions, occurrences and uses. Lab will focus on mineral identification by physical and optical properties.

ERTH 200L, Introduction to Mineralogy Lab, 1 cr, 3 lab hrs

Prerequisite: GEOL 1110, GEOL 1110L, CHEM 1215, CHEM 1215L.

Corequisite: EARTH 200

Offered spring semester.

Laboratory to accompany GEOL 200. Lab will focus on mineral identification by physical and optical properties.

GEOL 2120, Introductory Oceanography, 3 cr, 3 cl hrs

Offered on demand

An introduction to the oceans, including aspects of physical, geological, and biological oceanography. Focus is on presentation of science in a social context. Topics include: origin and evolution of ocean basins and marine sediments; ocean currents, waves, tides, and sea level; beaches, shorelines, and coastal processes; marine life; climate; marine resources, pollution, and human impacts on the ocean.

GEOL 2120L, Oceanography Laboratory, 1 cr, 3 lab hrs

Corequisite: GEOL 2120

Hands-on laboratory exercises in oceanographic processes, including mapping of ocean basins and bathymetry, sediments and deposition, waves, salinity and thermohaline processes, tides, and marine ecosystems.

GEOL 2150, Geobiology, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: a 100-level GEOL course

Corequisite: GEOL 1110L

Offered on demand

Consideration of life and its impact on the Earth System over the course of Earth history including its preserved geochemical and fossil remains, study of the observable geological effects of life processes and in turn the impact of geological, hydrological, and atmospheric effects on the origins and subsequent evolution of life. Field trips.

GEOL 2320, Earth Surface Processes and Landforms, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: GEOL 1110

Corequisite: GEOL 1110L

Offered spring semester

A study of the interactions between the atmosphere and the internal heat of the Earth which result in the development of landscapes observable at the Earth's surface today. Topics will include atmospheric circulation, climate, fluvial processes, and the record of paleoclimate contained in the landscape. Field trips.

GEOL 2330, Sedimentology, Stratigraphy and Structural Geology for Petroleum Engineers, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: GEOL 1110L and GEOL 1110L

Offered spring semester

Overview of sedimentology, stratigraphy, and structural geology, emphasizing material relevant to petroleum engineers and other petroleum industry careers. Topics include: sediment types, sediment transport, deposition, diagenesis and lithification, controls on porosity and permeability; fault and fold types and classification;

structural controls on sedimentary deposition; basic structural and stratigraphic traps; fault-zone structure and fluid flow; elements of low-temperature geochronology. Field trips.

GEOL 2340, Introduction to Whole Earth Structure and Composition, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: GEOL 1110

Corequisite: GEOL 1110L

Offered fall semester

Introduction to geophysical and geochemical methods used to study the deep Earth. Formation, composition and internal structure of the Earth, plate tectonics, gravitational and magnetic fields, heat flow and thermal history, earthquakes, and interaction of Earth systems with emphasis on the crust, mantle and core. Introduction to mantle convection, geochemical reservoirs, and mantle plumes. Field trips.

ERTH 206, Earth History, 4 cr, 3 cl hrs, 3 lab hrs

Offered spring semesters

Prerequisite: GEOL 1110

History of the earth and its life. Formation and chemical evolution of Earth, atmosphere, and ocean. Tectonic evolution of continents. Origin of life, its patterns/processes. Fundamentals of evolution. Long-term interactions between geosphere, atmosphere, and biosphere. Field trips

ERTH 214, Introduction to Computational Methods for Geosciences, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: GEOL 1110 and GEOL 1110L

Offered on demand

An introduction to modern computational methods, techniques, and best practices as they apply to the geosciences. The course will be organized around several case studies in which students apply computational tools to understand fundamental Earth processes that are relevant to the department curriculum and industry.

ERTH 301, Sedimentology and Stratigraphy, 4 cr, 3 cl hrs, 3 lab hrs

Offered spring semesters

Prerequisite: EARTH 206

An overview of sedimentary depositional processes and sedimentary rocks. Topics include sediment transport, terrestrial and marine sedimentary deposits, sedimentary provenance analysis, basin analysis, and sequence stratigraphy. Field Trips.

ERTH 325, Near-Surface Geophysics, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: PHYS 1310; a 1000-level GEOL course and associated lab

Offered on demand

Theory and practice of geophysical methods for exploring the shallow subsurface, with emphasis on electromagnetic methods including resistivity, EM conductivity, ground-penetrating radar, and magnetic field strength. Applications to environmental hazards,

hydrogeological features, and/or archaeology are emphasized in a hands-on, field-oriented approach.

ERTH340, Global Climate Change: Origins and Impacts, 3 cr, 3 cl hrs

Corequisites: MATH 1520, PHYS 1310

Offered spring semester, even-numbered years

This course covers the radiation budget of the Earth and how it interacts with greenhouse gases in the atmospheres to regulate global temperature. Students will obtain a basic understanding of the atmospheric dynamics of the Earth and how it is affected by interactions with the oceans, cryosphere, biosphere and lithosphere. They will learn about geologic records of past climates, the history of human modifications of the atmosphere and projections for future climate. Current and future impacts of climate changes in human society and natural ecosystems will be evaluated. Alternative strategies for both mitigation of climate change and adaptation to its effects will be presented.

ERTH 353, Structural Geology, 4 cr, 3 cl hrs, 3 lab hrs

Offered fall semesters

Prerequisites: GEOL 1110, PHYS 1310, MATH 1510

Fundamentals of structural geology: geometry, kinematics, mechanics, and evolution of faults, folds and shear zones; geological map analysis, use of stereonet, and cross section construction; fault- and fold-control of contemporaneous sediment deposition; rocks formed in faults and shear zones, shear-sense indicators; fluid flow and fault zones; material types and constitutive relations (elastic, brittle, viscous, plastic); introduction to experimental rock mechanics; fundamentals of stress and strain; crystal plasticity and deformation mechanisms; stress fields in Earth's crust. Up to 2 required weekend field trips.

ERTH 360, Earth Resources and Environmental Issues, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: Any GEOL 1000 class with associated lab

Offered fall semester, on demand

Overview of the economics, geologic occurrence and extraction of earth resources. Coverage includes metallic, non-metallic, and energy resources, soils and groundwater, and the environmental impacts related to their use and extraction. Field trip.

ERTH 380, Igneous and Metamorphic Petrology, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: EARTH 200, CHEM 1215, CHEM 1225

Offered fall semesters

Origin, occurrence, identification and description of igneous and metamorphic rocks. Topics covered include fractional crystallization and melting processes, physical and chemical properties of magmas, granitic batholiths, metamorphic facies and their key mineral assemblages, metamorphic rock fabrics, and qualitative determination of P-T-t paths recorded by metamorphic rocks. Binary and ternary phase diagrams will be introduced and used. Examination and identification of

igneous and metamorphic rocks and minerals and their salient textures in thin section and hand samples.

ERTH/GEOL 401, Advanced Computational Methods for Geoscientists, 2 cr, 1 cl hr, 1 lab hr

Prerequisites: Any GEOL 1110+L class, Math 1510;

Offered on demand

An advanced course on modern computational methods, techniques, and best practices for organization, manipulation, analysis, and plotting data of various origins. The course begins with a brief review of basic tools in python, including data manipulation, input/output, and plotting. This is followed by use of advanced python packages towards Geoscience applications. The course then moves into linux command line tools, version control with github, advanced map making and plotting with the Generic Mapping Toolkit (GMT). Additional topics may include website design, high performance computing, and an overview of available open-source software within the Earth Sciences. Shares lectures and labs with GEOL 501, GEOP 501, and GEOC 501, with additional expectations for graduate credit.

ERTH 403, Introduction to Soils, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite or Corequisite: GEOL 2320

Offered spring semester

Introduction to soil formation, pedogenic processes, and soil description and mapping techniques. Meets with GEOL 503.

ERTH 407, Hydrogeochemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 1225

Pre- or Corequisite: GEOL 440

Offered fall semesters

The thermodynamics and aqueous chemistry of natural waters, with emphasis on groundwater. Chemical equilibrium concepts, surface chemistry, redox reactions, and biochemistry. The interaction of water with the atmosphere and geologic Materials. Basic concepts applied to problems of groundwater quality evolution, water use, and groundwater contamination. Shares lecture with GEOC 507, HYD 507, and CHEM 531 with additional expectations for graduate credit. **(Same as CHEM 431.)**

ERTH 408, Cooperative Education

On-the-job training to supplement the academic program. Students alternate periods (usually six months long) of full-time semiprofessional employment in their chosen field with periods of full-time academic study.

ERTH 409, Soil Geomorphology, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: GEOL 2320 and 403; or consent of instructor and advisor

Offered on demand

Discussion of the use of soils to interpret the rate and timing of geomorphic processes and changing environmental parameters. Field trips.

ERTH 411, 411D, Groundwater Hydrology, 3 cr, 3 cl hrs

Prerequisites: GEOL 440

Offered alternate spring semesters

Study of the occurrence, movement, and chemical and isotopic composition of groundwater. Hydrogeologic properties. Groundwater recharge and stream/aquifer interaction, flow net and hydrograph analysis. Groundwater exploration using geologic and geophysical methods. Groundwater in different geological, climate, and physiographic regimes. Characterization of groundwater using stable isotopes and major ion analysis. Physics of flow to wells, steady-state and transient solutions to well hydraulics equations, image well theory, responses of aquifers to perturbations. Role of groundwater in contaminant migration and heat transfer. Shares lecture with HYD 511, with additional expectations for graduate credit.

ERTH 412, Introduction to Geographic Information Systems, 3 cr, 2 cl hrs, 3 lab hrs

Offered on Demand

An introduction to the concepts of geographic information systems (GIS). Theoretical background to GIS; introduction to the nature and analysis of spatial data. ArcView and/or ArcGIS. Shares lecture with GEOL 512, with additional expectations for graduate credit. Same as ENV5 412.

ERTH 413, 413D, Watershed Dynamics & Ecohydrology, 3 cr, 3 cl hrs

Prerequisites: ERTH 440

Offered alternate spring semesters

Processes governing hydrological flow rates and pathways through watershed systems: Hillslope runoff production and in-channel flood routing. Emphasis on physical mechanisms and their treatment in models, as well as observations made in the field. Interactions between terrestrial plants and water, nutrients, and light resources in semiarid ecosystems and riparian zones. Vegetation induced flow roughness, ecohydrological processes and dynamics, and simple numerical models. Shares lecture with HYD 513, with additional expectations for graduate credit.

ERTH 414, 414D, Vadose Zone Hydrology, 3 cr, 3 cl hrs

Prerequisites: ERTH 440

Offered alternate fall semesters

Physics of unsaturated flow in porous media, multiphase flow, potentials and water retention, unsaturated hydraulic conductivity, transient flow problems. Mathematical modeling of variable-density flow. Analysis of slope stability, drainage through mine tailings and rock piles, hazardous waste migration soil moisture controls on evapotranspiration and vegetation growth. Shares lecture with HYD 514, with additional expectations for graduate credit.

ERTH/GEOL 415 Geomicrobiology, 3cr, 3cl hrs

Prerequisites: CHEM 1225, BIOL 2110, and either GEOL 1110 or ERTH 206. Offered on demand.

This course will explore the basis for interactions between the microorganisms and the geosphere. Topics include redox geochemistry, microbial metabolism and the diversity of microbial lifestyles, microbe mineral interactions, contaminant degradation and

bioremediation, microbial paleobiology, and the co-evolution of life and the Earth. The course will include a mandatory weekend field trip. Shares lectures with GEOB 515, with additional expectations for graduate credit.

ERTH 424, Sedimentary Petrography, 3 cr, 4 lab hrs

Prerequisite: EARTH 200, GEOL 2320, 2330 or consent of instructor and advisor

Offered Spring Semesters, on demand

Petrographic analysis and interpretation of sedimentary rocks, with emphasis on siliciclastics. Topics include: grain identification and provenance, identification of diagenetic minerals and textures, and interpretation of porosity and permeability characteristics.

ERTH 425, Carbonate Sedimentology and Diagenesis, 3 cr, 3 cl hrs

Prerequisite: EARTH 200, GEOL 2320 and 2330 or consent of instructor and advisor

Offered on demand

This class covers the basics of carbonate sedimentation and diagenesis and looks at the evolution of carbonate sediments through geologic time (from Precambrian to recent). Included in the class are discussions of the impact of diagenesis on petroleum reservoir and aquifer potential. Shares lecture with GEOL 525 with additional expectations for graduate credit.

ERTH 430, Active Tectonics, 3 cr hrs

Prerequisites: GEOL 2320, 2330

Offered on demand

Study of Quaternary faults, including basic field techniques, tectonic geomorphology from fault scarps to mountain fronts, patterns of faulting, structural analysis of faults in alluvium, relation of surface to subsurface structures, paleoseismology, and review of Quaternary dating methods.

ERTH 431, Exploration Geochemistry, 3 cr, 3 cl hrs

Prerequisites: EARTH 380; EARTH 462

Pre- or Corequisite: EARTH 412 or equivalent

Offered spring semester on demand

An introduction to the generation, evaluation, and interpretation of geochemical datasets used in mineral exploration. Overview of trace element behavior in geologic environments from a mineral exploration perspective. Sampling methodology and media, analytical techniques, data quality evaluation, and report writing. Field trip. Shares lecture with GEOC 531, with additional expectations for graduate credit.

ERTH 432, Interdisciplinary Field Research, 3 cr, 8 lab hrs

Prerequisite: Consent of instructor

Offered fall semester on demand

Introduction to field-based research. Activities include proposal writing, data collection, interpretation, and preparation of a written report. Field work is an important part of the course, and hiking is required. The course is team-taught by several instructors.

ERTH 434, 434D, Introduction to Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: PHYS 1320 or 132 or consent of instructor and advisor

Introduction to the theory and practical use of remotely sensed satellite images. Principles of radiation physics; sensor systems; data acquisition; image analysis; classification schemes. Remote sensing applications to atmospheric sciences, hydrology, mineral and oil exploration, natural hazards monitoring, and land and resources management. Become familiar with ERDAS Imagine remote sensing software. Laboratory exercises deal primarily with computer analysis of remotely-sensed images with some field exercises. Shares lecture/lab with GEOL/GEOP/HYD 534, with additional expectations for graduate credit.

ERTH 436, Advanced Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: EARTH 434 or HYD 534 or GEOL 534

This class deals with quantitative remote sensing for determination of the components of the energy balance (net radiation, latent and sensible heat fluxes, soil heat flux) and soil moisture, hyperspectral and multispectral image processing, radar and microwave imagery. In addition, advanced applications for geology, geophysics and geochemistry will be discussed. Shares lecture/lab with GEOL/HYD 536, with additional expectations for graduate credit.

ERTH 437, Volcanology Field Trip, 1-6 cr

Offered on demand

Field trip to study volcanic rocks in a specific area or volcanological processes at an active volcano. A weekly seminar will precede a one-to two-week field trip. A paper is required. A student may register for the class more than once for a total of six credit hours.

ERTH 440, 440D, Hydrological Theory and Field Methods, 3 cr, 3 cl hrs

Prerequisites: MATH 1520, PHYS 1320

Offered fall semester

Fundamentals of hydrological flow and transport will be presented. Precipitation, runoff processes, and flood generation. Capillarity, unsaturated flow, and infiltration. Laws of flow in porous media, hydraulic storage, and flow to wells.

ERTH 440L, Hydrological Theory and Field Methods Laboratory, 1 cr, 3 lab hrs.

Prerequisites: MATH 1520, PHYS 1320; Co- or prerequisite: EARTH 440

Offered fall semester

Laboratory and field exercises that demonstrate and implement fundamental concepts of the hydrological cycle.

ERTH 444, Principles of Isotope Geochemistry, 3 cr, 3 cl hrs

Prerequisites: CHEM 1225, GEOL 200, GEOL 390

Offered spring semester, even-numbered years

Principles of radiogenic isotope geochemistry and applications to geologic dating and to the petrogenesis of rock suites. Shares lecture with GEOC 544, with additional expectations for graduate credit.

ERTH 445, Petroleum Exploration Geophysics, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: PHYS 1320, 1320L or GEOL 2330 OR EARTH 353, GEOL 2340. Offered fall semester, odd-numbered years

An introductory course on seismic refraction and reflection imaging of the subsurface, with applications for petroleum, crustal and environmental problems. This course covers methods of data acquisition, processing, and interpretation. Topics include: survey geometries, data editing techniques, amplitude recovery, (bandpass) filtering, deconvolution, velocity analysis and migration, well log to seismic ties, contour maps, time-to-depth conversion. Designed for students with a range of Earth science and engineering backgrounds. Shares lecture with GEOL/GEOP 545 with additional expectations for graduate credit.

ERTH 447, Depositional Systems and Basin Analysis, 3 cr, 3 cl hrs

Prerequisites: GEOL 2320 and GEOL 301 and GEOL 2330 or GEOL 353

Offered fall semester, even number years

Discussion of the spectrum of modern and ancient depositional environments and their relationships to tectonic settings. Shares lecture with GEOL 547, with additional expectations for graduate credit.

ERTH 448, General Geophysics, 3 cr, 3 cl hrs

Prerequisites: PHYS 1320; a 1000 level GEOL course and associated lab; upper-class standing

Offered spring semester, odd-numbered years

An introduction to the general field of solid Earth geophysics. Subjects covered are the origin of the Earth; structure and internal properties of the Earth; gravity, magnetic, and temperature fields of the Earth; origin of the Earth's atmosphere, hydrosphere, and surface features.

ERTH 449 Astrobiology, 3 cr, 3 cl hrs

Prerequisites: CHEM 1225, PHYSICS 1320, plus one other science course and consent of instructor.

Offered spring semester, even-numbered years

An in-depth and interdisciplinary study of astrobiology, including interactions between living and non-living systems at multiple scales: stellar, planetary, meso, and microscopic. Addresses fundamental questions regarding the origin of life, and the possible extent and distribution of life in the universe. Combines principles of astrophysics, geosciences, planetary science, chemistry, and biology. Innovative interactive exercises and projects working in interdisciplinary groups and individually. Shares lecture with GEOL 549, with additional expectations for graduate credit. (Same as BIOL 449/549)

ERTH 450, Cave and Karst Systems, 3 cr, 3 cl hrs

Prerequisites: CHEM 1215 & 1225; 1000 level GEOL

course associated lab, or BIOL 2110

Offered fall semester, odd-numbered years

A system-based study of caves and karstic terrains over time including formation mechanisms (speleogenesis), hydrology, geochemistry, mineralogy, and geomicrobiology. Emphasis on caves as interactive microcosms cross-cutting many disciplines. Shares lecture with GEOL 550, with additional expectations for graduate credit.

ERTH 450L, Cave and Karst Lab, 1 cr, 3 lab hrs

Offered spring semester, even years

Corequisite: EARTH 450

Survey of techniques applicable to various aspects of speleology and karst studies. Project-based lab, developed for each student in consultation with instructor. Shares lab with GEOL 550L, with additional expectations for graduate credit.

ERTH 454 Tectonics, 3 cr, 3 cl hrs

Prerequisites: GEOL 1110 and 1110L, GEOL 2330 and GEOL 2340 (or equivalents) or consent of instructor and advisor

Recommended: EARTH 380, EARTH 453

Offered fall semester

An overview of global and orogen-scale tectonics and tectonic processes, including: historical development of concepts, methods to constrain, describe and model crustal and lithospheric strength, plate boundary types, formation and destruction of ocean lithosphere, an continental tectonics (ocean-continent and continent-continent convergence, strike-slip margins, extensional tectonics and passive-margin development). Shares lecture with GEOL 554, with additional expectations for graduate credit.

ERTH 455 Geodetic Methods and Modeling, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: MATH 2420

Corequisite: EARTH 401 or GEOP 501 or consent of instructor and advisor

Offered fall semester in odd years on demand

Theory and application of modern geodetic tools to measure Earth's surface deformation with emphasis on GPS and InSAR. Data processing from raw data to kinematic products. Evaluation of signals and modeling of their sources. Applications range from magma system characterization and analysis of slip during an earthquake to interseismic strain analysis and evaluation of changes in the hydrosphere such as glacial melt, seasonal precipitation effects and ground water level monitoring. Shares lecture with GEOP 555, with additional expectations for graduate credit.

ERTH 456, Volcanology, 3 cr, 2-3 cl hrs, 1-3 lab hrs

Prerequisite: EARTH 380 or consent of instructor and advisor

Offered on demand

Detailed studies of volcanic process, pyroclastic rocks and mechanism of volcanic eruptions. Field trips to nearby volcanic regions. Shares lecture and field work with GEOL, with additional expectations for graduate

credit.

ERTH 459, Geodynamics, 3 cr, 3 cl hrs

Prerequisites: GEOL 2330 or 204

Offered spring semester, even-numbered years

How does the Earth deform? Theory of mantle convection, rheology of the mantle and lithosphere, lithosphere deformation, heat transport in the Earth, and melting. Emphasis is on current controversies in geodynamics, and the formulation of mathematical models that explain the physical observations. Shares lecture with GEOL/GEOP 559 with additional expectations for graduate credit.

ERTH 460, Subsurface and Petroleum Geology, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: GEOL 2330

Offered spring semester

Principles of subsurface geology, geophysics, and basin analysis applied to petroleum systems. Topics include: composition, movement, and entrapment of petroleum; subsurface fluid pressure regimes (hydrostatic and dynamic); thermal evolution of sedimentary basins and petroleum source rock analysis; geodynamics of sedimentary and rock properties. Laboratory work includes measurements of porosity and permeability, structure contouring, pore pressure analysis of evolving sedimentary basins, bore hole correlation using geophysical well logs, reservoir volumetric calculations, construction of geologic cross sections; well hydraulics, and petroleum system modeling.

ERTH 461, Reservoir and Caprock Analysis 3 cr, 2 cl hrs

Prerequisite: GEOL 2320 and GEOL 2330 or consent of instructor and advisor

Offered on demand

The class focuses on the role of sedimentary and structural heterogeneities in controlling porosity, permeability, and fluid flow in the subsurface. Topics include controls on conventional and unconventional reservoir quality and performance, evaluating caprock integrity, and the influence of faults and fracture networks on fluid flow. Applications to petroleum geology, petroleum engineering, carbon sequestration, and hydrology. There is a mandatory field trip associated with the class, which involves camping and moderately strenuous hiking on uneven ground. Shares lecture with GEOL 561, with additional expectations for graduate credit.

GEOL 462, Mineral Deposits, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: EARTH 200

Offered fall semester

Geologic and geochemical characteristics of metallic mineral deposits; theories of origin and classification.

ERTH 480, Field Methods in Earth Science, 6 cr

Prerequisites: EARTH 301, 353, and 380

Offered summers (6 weeks); NMT students should register for this course in the spring semester.

Collection, processing, and interpretation of field data

developed by geologic mapping in sedimentary, igneous, and metamorphic terrane. Presentation of geologic reports involving maps, cross sections, and sample data.

ERTH 483, Field Methods in Earth Science I, 2 cr

Prerequisites: EARTH 200, 301, 353, 380, GEOL 2320

Offered Summers (2 weeks); NMT students should register for this course in the spring semester.

Collection, processing and interpretation of geological data from stratified rocks, collected by geologic mapping and other means. Presentation of geologic reports involving stratigraphic sections, maps, cross sections, and other data.

ERTH 484, Field Methods in Earth Science II, 2 cr

Prerequisites: EARTH 200, 301, 353, 380, 483

Offered summers (2 weeks); NMT students should register for this course in the spring semester.

Collection, processing and interpretation of geological data from landforms and unconsolidated regolith, collected by geologic mapping and other means. Presentation of geologic reports involving maps, cross sections, and other data.

ERTH 485, Field Methods in Earth Science III, 2 cr

Prerequisites: EARTH 200, 301, 353, 380, 483, 484

Offered summers (2 weeks); NMT students should register for this course in the spring semester.

Collection, processing and interpretation of geological data from igneous, metamorphic and/or structurally complex rocks. Presentation of geologic reports involving maps, cross sections, and other data.

ERTH 486, Field Methods in Hydrology, 2 cr

Prerequisites: EARTH 440 and one of EARTH 411, EARTH 413 or EARTH 414, or consent of instructor and advisor.

Offered summers (2 weeks); NMT students should register for this course in the spring semester.

Instrumentation and methodologies used in hydrological investigations in a field setting. Course topics may range across a variety of physical and chemical hydrological techniques in vadose, groundwater and surface hydrology. Examples of potential topical areas include, but are not limited to, aquifer, lake and stream sample collection, storage and analysis, aquifer and watershed characterization; discharge measurements and tracer tests; land surface-atmosphere flux; groundwater geophysics measurements; and hydrologic field campaigns.

ERTH 490, Principles of Geochemistry, 3 cr, 3 cl hrs

Prerequisites: CHEM 1225 and EARTH 200, GEOL 380.

Offered fall semester, even numbered years

Application of chemical principles to geologic processes. Topics include cosmochemistry, origin of the nuclides, mineral and rock chemistry, radiogenic and stable isotope geochemistry, thermodynamics and kinetics. Shares lecture with GEOC 512, with additional expectations for graduate credit.

ERTH 491, 491D, Special Topics, hrs and crs to be arranged

Individual directed study in Earth Sciences.

ERTH 492, Senior Thesis, 3 cr

Prerequisite: 3.0 GPA in Earth science courses and consent of instructor

Individual research under the direction of a faculty member. Two semesters are usually necessary to complete the research project. Grading will be based on a written report which details the research goals, data collected, interpretation, and conclusions.

ERTH 493, Seminar, 1 cr, 1 cl hr

Offered fall and spring semesters

Seminar presentations by faculty, students, and outside speakers. Provides a broad overview of current Earth Science research and directions. Graded on S/U basis. Satisfactory performance consists of regular attendance at approved seminars. Credit may not be applied toward degree requirements. Shares lecture with GEOC 593, GEOL 593, GEOP 593, HYD 593, with additional expectations for graduate credit.

Graduate Program**Master of Science in Geology**

The Master of Science degree in Geology may be earned either with thesis or without thesis, as outlined below in accordance with the general requirements of the Graduate Program

With Thesis:

The student's course of study must be approved by the advisory committee and must fulfill the general requirements for the master's degree with thesis and must include GEOL 480 or the equivalent, if not previously satisfied, two credits of GEOL 592, at least six credit hours of GEOL 591, and at least four credit hours of GEOL 593, unless the degree is completed in a shorter time. Credits earned in GEOL 592 and 593 may not be applied towards the 30 credits required for the M.S. degree.

Without Thesis:

The student's course of study must be approved by the advisory committee and must fulfill the general requirements for the master's degree without thesis and must include GEOL 480 or the equivalent, if not previously satisfied, two credits of GEOL 592, at least three credit hours of GEOL 590, and at least four credit hours of GEOL 593, unless the degree is completed in a shorter time. Credits earned in GEOL 592 and 593 may not be applied towards the 30 credits required for the M.S. degree.

Doctor of Philosophy in Earth and Environmental Science with Dissertation in Geology

Students of exceptional ability, as demonstrated in previous courses or in a master's degree program, may pursue a program leading to the doctoral degree.

The prospective doctoral candidate in Earth and environmental science with specialization in geology should develop a good background in geology, chemistry, physics, and mathematics, in addition to achieving a high level of competence in the field

of specialization. With the approval of the advisory committee, the student should select a program including a minimum of nine credit hours in graduate coursework beyond the M.S. degree, three credits of GEOL 592 and at least six credit hours of GEOL 593, unless the degree is completed in a shorter time. Additional information is found on page 53-54.

Research fields appropriate for the geology candidate include petrology, volcanology, mineral deposits, geochronology, stable isotopes, environmental geology, coal geology, geohydrology, sedimentation and stratigraphy, regional tectonics, and structural geology. Interdisciplinary programs in the Earth science fields are encouraged.

Geology Graduate Courses:**GEOL 500, Directed Research, cr to be arranged**

This course may not be used to fulfill graduate degree requirements.

Research under the guidance of a faculty member.

GEOL 501, Computational Methods for Geoscientists, 2 cr, 1 cl hrs, 1 lab hrs

Prerequisite: Any GEOL class, Any MATH class

Offered fall semester

Modern computational tools to organize, manipulate, analyze and plot data of various origins. The course begins with some background on how to break large tasks into manageable sub-problems, moves into standard features of modern programming languages, and familiarizes students with both Linux command line tools and a higher order programming language. Tools for map making and image manipulation are included as well as the generation of a basic website. Shares lectures and labs with GEOL 401, with additional expectations for graduate credit. **Same as GEOP 501.**

GEOL 503, Introduction to Soils, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: GEOL 2320 or 2330; or consent of instructor and advisor

Offered fall semester

Introduction to soil formation, pedogenic processes, and soil description and mapping techniques. Shares lecture/lab with GEOL 405 with additional expectations for graduate credit.

GEOL 509, Soil Geomorphology, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: GEOL 2320 and EARTH 403; or consent of instructor and advisor

Offered spring semester, alternate years

Discussion of the use of soils to interpret the rate and timing of geomorphic processes and changing environmental parameters. Field trips. Shares lecture/lab with GEOL 409, but is graded separately and additional graduate-level work is required.

GEOL 512, 512D, Introduction to Geographic Information Systems, 3 cr, 2 cl hrs, 3 lab hrs

Offered Spring semester on demand

An introduction to the concepts of geographic information systems (GIS). Theoretical background to

GIS; introduction to the nature and analysis of spatial data. ArcView and/or ArcGIS. Shares lecture with GEOL/ENVS 412, with additional expectations for graduate credit.

GEOL 524, Sedimentary Petrography, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: Graduate standing

Offered spring semester, alternate years

Petrographic analysis and interpretation of sedimentary rocks, with emphasis on siliciclastics. Topics include: grain identification and provenance, identification of diagenetic minerals and textures, and interpretation of porosity and permeability characteristics. Shares lecture/lab with GEOL 424, but is graded separately and additional graduate-level work is required

GEOL 525, Carbonate Sedimentology and Diagenesis, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisors

Offered fall semester, alternate years

This class covers the basics of carbonate sedimentation and diagenesis and looks at the evolution of carbonate sediments through geologic time (from Precambrian to recent). Included in the class are discussions of the impact of diagenesis on petroleum reservoir and aquifer potential. Shares lecture with GEOL 425 with additional expectations for graduate credit.

GEOL 530, Active Tectonics, 3 cr hrs

Prerequisites: GEOL 2320, 2330, or consent of instructor and advisor

Offered in alternate years

Study of Quaternary faults, including basic field techniques, tectonic geomorphology from fault scarps to mountain fronts, patterns of faulting, structural analysis of faults in alluvium, relation of surface to subsurface structures, paleoseismology, and review of Quaternary dating methods. Shares lecture/lab with GEOL 430, but is graded separately and additional graduate-level work is required.

GEOL 532, Interdisciplinary Field Research, 3 cr,

8 lab hrs

Prerequisite: Consent of instructor

Offered fall semester

Introduction to field-based research. Activities include proposal writing, data collection, interpretation, and preparation of a written report. Field work is an important part of the course, and hiking is required. The course is team-taught by several instructors. Shares lecture/lab with GEOL 432, but is graded separately, and additional graduate-level work is required.

GEOL 534, Introduction to Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: PHYS 1320 or consent of instructor and advisor

Introduction to the theory and practical use of remotely sensed satellite images. Principles of radiation physics; sensor systems; data acquisition; image analysis; classification schemes. Remote sensing applications to atmospheric sciences, hydrology, mineral and oil exploration, natural hazards monitoring, and land and resources management. Become familiar with ERDAS Imagine remote sensing software. Laboratory exercises deal primarily with computer analysis of remotely-sensed images with some field exercises. Shares lecture/lab, with GEOL 434, with additional expectations for graduate credit. **(Same as GEOP/HYD 534)**

GEOL 536, Advanced Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: GEOL 434 or HYD 534 or GEOL 534

This class deals with quantitative remote sensing for determination of the components of the energy balance (net radiation, latent and sensible heat fluxes, soil heat flux) and soil moisture, hyperspectral and multispectral image processing, radar and microwave imagery. In addition, advanced applications for geology, geophysics and geochemistry will be discussed. Shares lecture/lab with GEOL 436, with additional expectations for graduate credit. **(Same as HYD 536)**

GEOL 538, Advanced Geographic Information Systems, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: Consent of instructor

Advanced topics in geographic information systems (GIS) with a focus on applications in environmental sciences. Emphasis on theoretical aspects and practical applications of GIS science and technology and its integration with remote sensing data and field measurements. Computing exercises and programming projects utilizing GIS software. Discussion of GIS integration with environmental modeling. Shares lecture with ENVS 438, with additional expectations for graduate credit. **(Same as HYD 538)**

GEOL 540, Clastic and Carbonate Diagenesis, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Offered spring semester, alternate years

Discussion of clastic and carbonate diagenesis. Topics include: mineralogy and chemistry of authigenic minerals, rock-water interaction, mass transfer, influence of bacteria on diagenetic reactions, application of isotopes, diagenetic controls on porosity and permeability, and influence of depositional environment and detrital mineralogy on diagenesis.

GEOL 545, Petroleum Exploration Geophysics, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: PHYS 1310 or equivalent; a 100-level GEOL course and associated lab; upper-class standing
Offered fall semester, odd-numbered years

An introductory course on seismic refraction and reflection imaging of the subsurface, with applications

for petroleum, crustal and environmental problems. This course covers methods of data acquisition, processing, and interpretation. Topics include: survey geometries, data editing techniques, amplitude recovery, (bandpass) filtering, deconvolution, velocity analysis and migration, well log to seismic ties, contour maps, time-to-depth conversion. Designed for students with a range of Earth science and engineering backgrounds. Shares lecture with GEOL 445 with additional expectations for graduate credit.

GEOL 547, Depositional Systems and Basin Analysis, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Offered fall semester

Discussion of the spectrum of modern and ancient depositional environments and their relationships to tectonic settings.

GEOL 549, Astrobiology, 3cr, 3 cl hours

Prerequisites: graduate standing or consent of instructor and advisor.

Offered on demand

An in-depth and interdisciplinary study of astrobiology, including between living and non-living systems at multiple scales: stellar, planetary, meso, and microscopic. Addresses fundamental questions regarding the origin of life, and the possible extent and distribution of life in the universe. Combines principals of astrophysics and astronomy, geosciences and planetary science, chemistry and bioscience. Innovative interactive exercises and projects working in interdisciplinary groups and individually. Shares lecture with GEOL/BIOL 449 (astrobiology), with additional expectations for graduate credit. **Same as GEOC 549.**

GEOL 550, 550D, Cave and Karst Systems, 3 cr, 3 cl hrs

Prerequisites: CHEM 1215 & 1225; and either any 100 level GEOL or BIOL 2110

Offered spring semester, even years

A system-based study of caves and karstic terrains over time including formation mechanisms (speleogenesis), hydrology, geochemistry, mineralogy, and geomicrobiology. Emphasis on caves as interactive microcosms cross-cutting many disciplines. Shares lecture with GEOL 450, with additional expectations for graduate credit.

GEOL 550L, Cave and Karst Lab, 1 cr, 3 lab hrs

Offered spring semester, even years

Corequisite: GEOL 550

Survey of techniques applicable to various aspects of speleology and karst studies. Project-based lab, developed for each student in consultation with instructor. Shares lab with GEOL 450L, with additional expectations for graduate credit.

GEOL 551, Industrial Minerals, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor and advisor

Offered alternate years

Study of basic concepts of production and use of industrial minerals in modern society. Emphasis on complex interactions between economics, geology, processing, marketing, and transportation. Selected industrial minerals studied in detail. Several field trips to operations and occurrences. **(Same as ME 551)**

GEOL 554 Tectonics, 3 cr, 3 cl hrs

Prerequisites: GEOL 1110 and 1110L, GEOL 2330 and GEOL 2340 (or equivalents) or consent of instructor and advisor

Recommended: GEOL 380, GEOL 453

Offered fall semester

An overview of global and orogen-scale tectonics and tectonic processes, including: historical development of concepts, methods to constrain, describe and model crustal and lithospheric strength, plate boundary types, formation and destruction of ocean lithosphere, an continental tectonics (ocean-continent and continent-continent convergence, strike-slip margins, extensional tectonics and passive-margin development). Shares lecture with GEOL 454, with additional expectations for graduate credit.

GEOL 556, Volcanology, 3 cr, 2-3 cl hrs, 1-3 lab hrs

Prerequisite: GEOL 380 or consent of instructor and advisor

Offered on demand

Detailed studies of volcanic processes, pyroclastic rocks and mechanism of volcanic eruptions. Field trips to nearby volcanic fields. Shares lecture and field work with GEOL 456, with additional expectations for graduate credit.

GEOL 558, Mechanics of Earthquakes and Faulting, 3 cr, 3 cl hrs

Prerequisites: GEOL 453 or equivalent and graduate standing; or consent of instructor and advisor

Offered on demand

Observational and theoretical aspects of brittle failure in the Earth. Fracture mechanics; fault zone geometry and structure; earthquake sources; paleoseismic studies; seismic hazard assessments. (Same as GEOP 558)

GEOL 559, Geodynamics, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor and advisor

Offered spring semester, even-numbered years

How does the Earth deform? Theory of mantle convection, rheology of the mantle and lithosphere, lithosphere deformation, heat transport in the Earth, and melting. Emphasis is on current controversies in geodynamics, and the formulation of mathematical models that explain the physical observations. Shares lecture with GEOL 459, with additional expectations for graduate credit. Same as GEOP 559.

GEOL 561, Reservoir and Caprock Analysis 3 cr, 2 cl hrs,

Prerequisite: Graduate standing or consent of instructor and advisor

Offered on demand

The class focuses on the role of sedimentary and structural heterogeneities in controlling porosity,

permeability, and fluid flow in the subsurface. Topics include controls on conventional and unconventional reservoir quality and performance, evaluating caprock integrity, and the influence of faults and fracture networks on fluid flow. Applications to petroleum geology, petroleum engineering, carbon sequestration, and hydrology. There is a mandatory field trip associated with the class, which involves camping and moderately strenuous hiking on uneven ground. Shares lecture with GEOL 461, with additional expectations for graduate credit.

GEOL 562, Fluvial Geomorphology, 3 cr, 3 cl hrs

Prerequisites: GEOL 440

Offered in alternate spring semesters

Interactions of water and sediment flow in fluvial systems. Sediment transport rates and particle size dependence. Physical controls on channel morphology, bedforms, and microhabitat distribution. Hydraulic geometry and bank-full flow analysis, with implications for floodplain development. Basin morphometric relationships with climate and flood routing. Case studies of fluvial system response to disturbances such as wildfire, avulsion, land use change, climate change, and stream restoration. (Same as HYD 562)

GEOL 566, Regional Tectonics, 3 cr, 3 cl hrs

Prerequisite: graduate standing or consent of instructor and advisor

Offered on demand

Study of major orogenic belts and processes of orogeny, with emphasis on the tectonic evolution of western North America. Fundamentals of plate tectonics, relationships between plate tectonics and orogeny.

GEOL 571, 571D, 572, 572D, Advanced Topics in Geology, 2–3 cr

Study of a special topic in geology, normally one related to a field of research at Tech.

GEOL 581, Directed Study, cr to be arranged

Study under the guidance of a member of the geology staff. In general, subject matter will supplement that available in the other graduate offerings in geology.

GEOL 590, Independent Study, cr to be arranged

Organized independent student research coordinated with a faculty member and documented in a final written report.

GEOL 591, Thesis (master's program), cr to be arranged

GEOL 592, Graduate Seminar, 1 cr, 1 cl hr

Prerequisite: Graduate standing

Offered spring semesters

Seminar presentations by graduate students on their current research topics. M.S. students must present at least one seminar; Ph.D. students must present at least one seminar in each of two different semesters. Graded on S/U basis; credits earned may not be applied towards the 30 credits required for the M.S. degree. (Same as GEOB 592, GEOC 592, GEOP 592, HYD 592)

GEOL 593, Seminar, 1 cr, 1 cl hr

Prerequisite: Graduate standing

Offered fall and spring semesters

Seminar presentations by faculty, students, and outside speakers. Graded on S/U basis. Satisfactory performance consists of regular attendance at approved seminars. Credit earned may not be applied towards the 30 credits required for the M.S. degree. (Same as GEOB 593, GEOC 593, GEOP 593, HYD 593)

GEOL 595, Dissertation (doctoral degree program), cr to be arranged

Prerequisite: Successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.

Geobiology

Doctor of Philosophy in Earth and Environmental Science with Dissertation in Geobiology

Students of exceptional ability as demonstrated in previous courses or in a master's degree program may pursue a program leading to the doctoral degree.

The prospective doctoral candidate in Earth and environmental science with specialization in geobiology should develop a good background in chemistry, geology, mathematics, physics, and biology in addition to achieving a high level of competence in the field of specialization. With the approval of the advisory committee, the student should select a program including a minimum of nine credit hours in graduate coursework beyond the M.S. degree, three credit hours of GEOB 592 and at least six credit hours of GEOB 593, unless the degree is completed in a shorter time. Additional information is found on page 53-54.

Fields of doctoral dissertation research include geomicrobiology, biogeochemical cycling, biologically mediated diagenesis, biological mineral precipitation and dissolution, isotopic geochemistry of biologically mediated processes, origin and early evolution of life, paleobiology, paleontology, and astrobiology. Interdisciplinary programs in the Earth science fields are encouraged.

Geobiology Graduate Courses:

GEOB 500, Directed Research, cr to be arranged

This course may not be used to fulfill graduate degree requirements.

Research under the guidance of a faculty member.

GEOB 503, Advanced Geobiology, 3 cr, 3 cl hrs

Prerequisite: GEOL 2150, CHEM 1215, CHEM 1225 BIOL 2110, BIOL 2610, or consent of instructor and advisor

Offered on demand

Consideration of the interactions between biology and the earth sciences on an advanced level. Microorganisms and metazoans have exerted enormous impact on the development of Earth's crust, oceans, and atmosphere over the course of the planet's history. In turn, the physical and chemical components of the planet have shaped the development of the biota and its evolution. In depth treatment of multiple lines of evidence including geochemical traces, fossil remains, molecular phylogenies, atmospheric and aqueous chemistries, and numerical modeling of relevant processes.

GEOB 515 Geomicrobiology, 3cr, 3cl hrs

Prerequisites: Graduate standing. Offered on demand.

This course will explore the basis for interactions between the microorganisms and the geosphere. Topics include redox geochemistry, microbial metabolism and the diversity of microbial lifestyles, microbe mineral interactions, contaminant degradation and bioremediation, microbial paleobiology, and the co-evolution of life and the Earth. The course will include a mandatory weekend field trip. Shares lectures with GEOL 415, with additional expectations for graduate credit. Cross listed with GEOL 5XX, GEOC 5XX, HYD 5XX, HYD 5XX D, BIOT 5XX

GEOB 592, Graduate Seminar, 1 cr, 1 cl hr

Prerequisite: Graduate standing

Offered spring semesters

Seminar presentations by graduate students on their current research topics. M.S. students must present at least one seminar; Ph.D. students must present at least one seminar in each of two different semesters. Graded on S/U basis; credits earned may not be applied towards the 30 credits required for the M.S. degree (same as GEOC 592, GEOL 592, GEOP 592, HYD 592)

GEOB 593, Seminar, 1 cr, 1 cl hr

Prerequisite: Graduate standing

Offered fall and spring semesters

Seminar presentations by faculty, students, and outside speakers. Graded on S/U basis. Satisfactory performance consists of regular attendance at approved seminars. Credit earned may not be applied towards the 30 credits required for the M.S. degree. **(Same as GEOC 593, GEOL 593, GEOP 593, HYD 593)**

GEOB 595, Dissertation (doctoral degree program), cr to be arranged.

Prerequisite: Successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.

Geochemistry

Master of Science in Geochemistry

The Master of Science degree in Geochemistry may be earned either with thesis or without thesis, as outlined below in accordance with the general requirements of the Graduate Program.

With Thesis:

The student's course of study must be approved by the advisory committee and must fulfill the general requirements for the master's degree with thesis and must include: (i) At least six credit hours of GEOC 591 (Thesis, master's program); (ii) two credit hours of GEOC 592 (Graduate Seminar); (iii) at least four credit hours of GEOC 593 (Seminar), unless the degree is completed in a shorter time; and (iv) at least 15 credit hours in graduate geochemistry or chemistry courses, 9 of which must have a GEOC designation (up to 3 credit hours of this requirement may be replaced with non-geochemistry graduate courses with the committee's approval). As part of the degree requirements students must have completed GEOL 200 (mineralogy) and CHEM 331 (physical chemistry), unless taken in undergraduate work. These requirements may be replaced by upper division mineralogy or thermodynamics courses with approval from the student's committee.

Without Thesis:

Courses approved by the student's advisory committee must fulfill the general requirements for the master's degree without thesis and must include: (i) At least three credit hours of GEOC 590 (Independent Study); two credit hours of GEOC 592 (Graduate Seminar); at least four credit hours of GEOC 593 (Seminar), unless the degree is completed in a shorter time; and at least 15 credit hours in graduate geochemistry or chemistry courses, 9 of which must have a GEOC designation (up to 3 credit hours of this requirement may be replaced with non-geochemistry graduate courses with the committee's approval). As part of the degree requirements students must have completed GEOL 200 (mineralogy) and CHEM 331 (physical chemistry), unless taken in undergraduate work. These requirements may be replaced by upper division mineralogy or thermodynamics courses with approval from the student's committee.

Doctor of Philosophy in Earth and Environmental Science with Dissertation in Geochemistry

Students of exceptional ability as demonstrated in previous courses or in a master's degree program may pursue a program leading to the doctoral degree.

The prospective doctoral candidate in Earth and environmental science with specialization in geochemistry should develop a good background in chemistry, geology, mathematics, and physics in addition to achieving a high level of competence in the field of specialization. With the approval of the advisory committee, the student should select a program including a minimum of nine credit hours in graduate coursework beyond the M.S. degree, three credit hours of GEOC 592 and at least six credit hours of GEOC 593, unless the degree is completed in a shorter time. Additional information is found on page 53-54.

Fields of doctoral dissertation research include geochemistry of ore deposits, trace element and isotope

geochemistry of igneous and metamorphic systems, fluid-inclusion geochemistry, geochronology, hydrogeochemistry, stable isotope geochemistry, and environmental geochemistry. Interdisciplinary programs in the Earth science fields are encouraged.

Geochemistry Graduate Courses:

GEOC 500, Directed Research, cr to be arranged

This course may not be used to fulfill graduate degree requirements.

Research under the guidance of a faculty member.

GEOC 507, Hydrogeochemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 1225

Corequisite: EARTH 440

The thermodynamics and aqueous chemistry of natural waters, with emphasis on groundwater. Chemical equilibrium concepts, surface chemistry, redox reactions, and biochemistry. The interaction of water with the atmosphere and geologic materials. Basic concepts applied to problems of groundwater quality evolution, water use, and groundwater contamination. Shares lecture with GEOL 407, with additional expectations for graduate credit.

GEOC 512, Principles of Geochemistry, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing

Offered fall semester, even-numbered years

Application of chemical principles to geologic processes. Topics include cosmochemistry, origin of the nuclides, mineral and rock chemistry, radiogenic and stable isotopes geochemistry, thermodynamics and kinetics. Shares lecture with GEOL 490 with additional expectation for graduate credit.

GEOC 516, $^{40}\text{Ar}/^{39}\text{Ar}$ Geochronology, 3 cr, 3 cl hrs

Prerequisite: EARTH 444 or consent of instructor and advisor

Offered fall semester

Principles and applications of $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology and thermochronology, with applications to geologic systems.

GEOC 517, Advanced $^{40}\text{Ar}/^{39}\text{Ar}$ Geochronology, 3 cr, 3 cl hrs

Advanced topics, specialized applications, and current research in $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology.

GEOC 531, Exploration Geochemistry, 3 cr, 3 cl hrs

Pre- or Corequisite: EARTH 412 or equivalent

Offered spring semester on demand

An introduction to the generation, evaluation, and interpretation of geochemical datasets used in mineral exploration. Overview of trace element behavior in geologic environments from a mineral exploration perspective. Sampling methodology and media, analytical techniques, data quality evaluation, and report writing. Field trip. Shares lecture with GEOL 431, with additional expectations for graduate credit.

GEOC 544, Radiogenic Isotope Geochemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 1225; EARTH 200; EARTH 390, or consent of instructor and advisor

Offered spring semester, even-numbered years

Principles of radiogenic isotope geochemistry and applications to geologic dating and to the petrogenesis of rock suites. Shares lecture with GEOL 444, with additional expectations for graduate credit.

GEOC 546, Contaminant Hydrology, 3 cr, 3 cl hrs

Prerequisite: EARTH 440, HYD 507

Corequisite: HYD 508

Offered alternate fall semesters

The physics, chemistry, and biology of inorganic, organic, and microbial contaminants in groundwater and surface water systems. Mechanisms by which contaminants are introduced. Transport and transformations of contaminants in surface waters, the vadose zone, and the saturated zones. Movement, capillary trapping, and solubility of relatively immiscible organic liquids. Contaminant isolation and remediation techniques. (Same as HYD 546.)

GEOC 549, Astrobiology, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor and advisor.

Offered spring semester, even-numbered years

An in-depth and interdisciplinary study of astrobiology, including interactions between living and non-living systems at multiple scales: stellar, planetary, meso, and microscopic. Addresses fundamental questions regarding the origin of life, and the possible extent and distribution of life in the universe. Combines principles of astrophysics, geosciences, planetary science, chemistry, and biology. Innovative interactive exercises and projects working in interdisciplinary groups and individually. Shares lecture with GEOL 449, with additional expectations for graduate credit. (Same as GEOL 549)

GEOC 550, Cave and Karst Systems, 3 cr, 3 cl hrs

Prerequisites: CHEM 1215 & 1225; and either any 100 level GEOL/ERTH or BIOL 2110

Offered spring semester, even years

A system-based study of caves and karstic terrains over time including formation mechanisms (speleogenesis), hydrology, geochemistry, mineralogy, and geomicrobiology. Emphasis on caves as interactive microcosms cross-cutting many disciplines. Shares lecture with GEOL 450, with additional expectations for graduate credit. Same as GEOL 550.

GEOC 550L, Cave and Karst Lab, 1 cr, 3 lab hrs

Offered spring semester, even years

Corequisite: GEOL/GEOC 550

Survey of techniques applicable to various aspects of speleology and karst studies. Project-based lab, developed for each student in consultation with instructor. Shares lab with GEOL 450L, with additional expectations for graduate credit. Same as GEOL 550L.

GEOC 565, Stable Isotope Geochemistry, 3 cr, 3 cl hrs*Offered fall semester*

Principles of stable isotope geochemistry with applications to geologic systems.

GEOC 567, Practical Aspects of Argon Mass Spectrometry, 2 cr, 2 cl hr*Prerequisites: GEOC 516 or consent of instructor and advisor**Offered spring semester*

Theory and application of noble gas mass spectrometry. Through lectures, problem sets, and laboratory exercises, students obtain hands-on experience for analysis of geologic samples to determine sample age and/or thermal history. Each student conducts a research project and presents the results in written and oral reports.

GEOC 571, 571D, 572, 572D, Advanced Topics in Geochemistry, 2 or 3 cr

Study of a special topic in geochemistry, normally one related to a field of research at Tech.

GEOC 575, Theory and Practice of Electron Microprobe Analysis, 2 cr, 1 cl hr, 3 lab hrs*Prerequisites: EARTH 380*

Principles, techniques and applications of electron microprobe analysis of geological samples. Required for students who will use the electron microprobe as part of their research. Includes lecture and hands-on sample preparation and analysis.

GEOC 581, Directed Study, cr to be arranged

Study under the guidance of a member of the geochemistry staff. In general, subject matter will supplement that available in the other graduate offerings in geochemistry.

GEOC 590, Independent Study, cr to be arranged

Organized independent student research coordinated with a faculty member and documented in a final written report.

GEOC 591, Thesis (master's program), cr to be arranged**GEOC 592, Graduate Seminar, 1 cr, 1 cl hr***Prerequisite: Graduate standing**Offered spring semesters*

Seminar presentations by graduate students on their current research topics. M.S. students must present at least one seminar; Ph.D. students must present at least one seminar in each of two different semesters. Graded on S/U basis; credits earned may not be applied towards the 30 credits required for the M.S. degree (same as GEOB 592, GEOL 592, GEOP 592, HYD 592)

GEOC 593, Seminar, 1 cr, 1 cl hr*Prerequisite: Graduate standing**Offered fall and spring semesters*

Seminar presentations by faculty, students, and outside speakers. Graded on S/U basis. Satisfactory performance consists of regular attendance at approved seminars. Credit earned may not be applied towards the

30 credits required for the M.S. degree. (Same as GEOB 593, GEOL 593, GEOP 593, HYD 593)

GEOC 595, Dissertation (doctoral degree program), cr to be arranged.*Prerequisite: Successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.*

Geophysics (Solid Earth)

Graduate Program

Requirements for the Master of Science in Geophysics (Solid Earth)

The Master of Science degree in Geophysics (Solid Earth) may be earned under either of the plans outlined below:

With Thesis:

The student's course of study must be approved by the advisory committee and must fulfill the general requirements for the master's degree with thesis and must include (unless taken in undergraduate work): GEOL 325 and 448, or their equivalents; upper-division geology, six credit hours; competence in mathematics corresponding to nine credit hours beyond calculus; at least six credit hours of GEOP 591, two credit hours of GEOP 592, at least four credit hours of GEOP 593, unless the degree is completed in a shorter time, and twelve additional credit hours in graduate geophysics (up to six credit hours of this requirement may be replaced with non-geophysics graduate courses with the advisor's approval).

Without Thesis:

Courses approved by the student's advisory committee must fulfill the general requirements for the master's degree without thesis and must include (unless taken in undergraduate work): GEOL 325 and 448, or their equivalents; upper-division geology, six credit hours; competence in mathematics corresponding to nine credit hours beyond calculus; at least three credit hours of GEOP 590, two credit hours of GEOP 592, at least four credit hours of GEOP 593, unless the degree is completed in a shorter time, and twelve additional credit hours of graduate courses in geophysics (up to six credit hours of this requirement may be replaced with non-geophysics graduate courses with the advisor's approval).

Doctor of Philosophy in Earth and Environmental Science with Dissertation in Geophysics

Students of exceptional ability as demonstrated by previous academic achievement may pursue a program leading to the doctoral degree.

The prospective doctoral candidate in Earth and environmental science with specialization in physics of the solid Earth should develop a solid background in physics, mathematics, and geology in addition to achieving a high level of competence in the field of geophysics.

With the approval of the advisory committee, the student should select a program including a minimum of nine credit hours in graduate coursework beyond the M.S. degree, three credit hours of GEOP 592, at least four credit hours of GEOP 593, unless the degree is completed in a shorter time, plus additional courses in related fields.

Research fields appropriate for the geophysics candidate include crustal exploration, earthquake seismology, tectonophysics, environmental, and hydrogeothermal studies. Interdisciplinary programs in the Earth science fields are encouraged.

Geophysics Graduate Courses:

GEOP 500, Directed Research, cr to be arranged

This course may not be used to fulfill graduate degree requirements.

Research under the guidance of a faculty member.

GEOP 501, Advanced Computational Methods for Geoscientists, 3 cr, 2 cl hrs, 1 lab hrs

Prerequisite: Graduate standing

Offered on demand

An advanced course on modern computational methods, techniques, and best practices for organization, manipulation, analysis, and plotting data of various origins. The course begins with a brief review of basic tools in Python, including data manipulation, input/output, and plotting. This is followed by use of advanced Python packages towards Geoscience applications. The course then moves into linux command line tools, version control with github, advanced map making and plotting with the Generic Mapping Toolkit (GMT). Additional topics may include website design, high performance computing, and an overview of available open-source software within the Earth Sciences. Shares lectures and labs with GEOL 401, GEOL501, GEOP 501, and GEOC 501, with additional expectations for graduate.

GEOP 505, 505D, Analysis of Time Series and Spatial Data, 3 cr, 3 cl hrs

Offered in alternate years

An introductory overview of methods for analyzing temporal and spatial series with an emphasis on scientific applications. Linear systems in continuous and discrete time, Fourier analysis, spectral estimation, convolution and deconvolution, filtering, the z and Laplace transforms, stationary and nonstationary time series, ARIMA modeling, forecasting, and generalizations to multidimensional and multichannel applications. (Same as MATH 587)

GEOP 520, Data-Driven Modeling in Science and Engineering, 3 cr, 3 cl hrs

Prerequisites: MATH 2350 or 382 and MATH 335 or consent of instructor and advisor

Statistical learning techniques and data assimilation for science and engineering applications. Focus is on the practical applications and the understanding of the assumptions underlying techniques, allowing students to learn the basics of useful tools for data-driven modeling and revisit their theoretical and practical underpinnings as needed. Topics may include supervised and unsupervised learning, regression, classification, importance sampling, ensemble forecasting, and Kalman Filtering. The codes R and Python will be used. (Same as HYD520)

GEOP 523, 523D, Theoretical Seismology, 3 cr, 3 cl hrs

Offered in alternate years

Linear elastic wave theory including reflection and refraction of elastic waves, propagation of body and surface waves, free oscillations of an elastic sphere, seismic rays in a spherically-stratified Earth, and earthquake mechanisms.

GEOP 524, Observational Seismology, 3 cr, 3 cl hrs

Offered in alternate years

Techniques and methods in earthquake seismology including seismometry and seismic networks, earthquake location, earthquake statistics, strong-motion seismology, and seismic source parameters.

GEOP 529, 529D, Geophysical Inverse Methods, 3 cr, 3 cl hrs

Offered in alternate years

Theory and practice of the various techniques of inverting geophysical data to obtain models. Primary emphasis is on the understanding and use of linear inverse techniques.

(Same as MATH 519)

GEOP 534, Introduction to Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: PHYS 1320 or consent of instructor and advisor

Introduction to the theory and practical use of remotely sensed satellite images. Principles of radiation physics; sensor systems; data acquisition; image analysis; classification schemes. Remote sensing applications to atmospheric sciences, hydrology, mineral and oil exploration, natural hazards monitoring, and land and resources management. Laboratory exercises deal primarily with computer analysis of remotely-sensed images with some field exercises. GEOL 434 and GEOP 534 share lecture/lab, but GEOP 534 is graded separately and additional graduate-level work is required. **(Same as GEOL/HYD 534)**

GEOP 545, Petroleum Exploration Geophysics, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: PHYS 1310 or equivalent; a 100-level GEOL course and associated lab; upper-class standing
Offered fall semester, odd-numbered years

An introductory course on seismic refraction and

reflection imaging of the subsurface, with applications for petroleum, crustal and environmental problems. This course covers methods of data acquisition, processing, and interpretation. Topics include: survey geometries, data editing techniques, amplitude recovery, (bandpass) filtering, deconvolution, velocity analysis and migration, well log to seismic ties, contour maps, time-to-depth conversion. Designed for students with a range of Earth science and engineering backgrounds. Shares lecture with GEOL 445 with additional expectations for graduate credit.

GEOP 555 Geodetic Methods and Modeling, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: MATH 2420

Corequisite: EARTH 401 or GEOP 501 or GEOL 501 or consent of instructor and advisor

Offered fall semester in odd years on demand

Theory and application of modern geodetic tools to measure Earth's surface deformation with emphasis on GPS and InSAR. Data processing from raw data to kinematic products. Evaluation of signals and modeling of their sources. Applications range from magma system characterization and analysis of slip during an earthquake to interseismic strain analysis and evaluation of changes in the hydrosphere such as glacial melt, seasonal precipitation effects and ground water level monitoring. *Shares lecture with GEOL 455, with additional expectations for graduate credit.*

GEOP 558, Mechanics of Earthquakes and Faulting, 3 cr, 3 cl hrs

Prerequisites: EARTH 453 or equivalent and graduate standing; or consent of instructor and advisor

Offered on demand

Observational and theoretical aspects of brittle failure in the Earth. Fracture mechanics; fault zone geometry and structure; earthquake sources; paleoseismic studies; seismic hazard assessments. **(Same as GEOL 558)**

GEOP 559, Geodynamics, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor and advisor

Offered spring semester, even-numbered years

How does the Earth deform? Theory of mantle convection, rheology of the mantle and lithosphere, lithosphere deformation, heat transport in the Earth, and melting. Emphasis is on current controversies in geodynamics, and the formulation of mathematical models that explain the physical observations. Shares lecture with GEOL 459 with additional expectations for graduate credit. **Same as GEOL 559.**

GEOP 570, Current Topics in Earthquake Seismology, 3 cr, 3 cl hrs

Prerequisite: consent of instructor

Offered on demand

A seminar of current research topics in earthquake seismology with an emphasis on the critical review of recently published papers and preprints.

GEOP 571, 572, Advanced Topics in Geophysics, 2–3 cr each semester

Offered on demand

Study of advanced topics in geophysics.

GEOP 581, Directed Study, cr to be arranged

Study under the guidance of a member of the graduate faculty. In general, subject matter will supplement that available in the other graduate course offerings.

GEOP 590, Independent Study, cr to be arranged

Organized independent student research coordinated with a faculty member and documented in a final written report.

GEOP 591, Thesis (master's program), cr to be arranged

GEOP 592, Graduate Seminar, 1 cr, 1 cl hr

Prerequisite: Graduate standing

Offered spring semesters

Seminar presentations by graduate students on their current research topics. M.S. students must present at least one seminar; Ph.D. students must present at least one seminar in each of two different semesters. Graded on S/U basis; credits earned may not be applied towards the 30 credits required for the M.S. degree **(same as GEOB 592, GEOL 592, GEOC 592, HYD 592)**

GEOP 593, Seminar, 1 cr, 1 cl hr

Prerequisite: Graduate standing

Offered fall and spring semesters

Seminar presentations by faculty, students, and outside speakers. Graded on S/U basis. Satisfactory performance consists of regular attendance at approved seminars. Credit earned may not be applied towards the 30 credits required for the M.S. degree. **(Same as GEOB 593, GEOC 593, GEOL 593, HYD 593)**

GEOP 594, Geophysics Journal Club, 1 cr, 1 cl hr

Prerequisite: Graduate standing or consent of instructor and advisor

Offered on demand

Discussion of journal articles with high impact on the future of the field from the current geophysical literature. Students monitor journals, suggest papers, and actively participate in discussions.

GEOP 595, Dissertation (doctoral degree program), cr to be arranged

Prerequisite: Successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.

Hydrology

Graduate Program

Professional Master of Hydrology

The Professional Master of Hydrology degree is aimed at working professionals or students who wish to increase their qualifications in the hydrologic sciences. The Professional Master Program in Hydrology covers fundamentals of

atmospheric, surface, and subsurface hydrology while leaving the flexibility to focus on related areas of particular individual interest. This coursework-only degree requires a minimum of 30 credit hours of graduate level and upper division coursework. All students must take:

- GEOL 440 (3 cr)
- Twenty-one credits of graduate classes in Hydrology. Examples of available distance education course include: HYD 507, HYD 510, HYD 511, HYD 513, HYD 514, HYD 516, HYD 534, HYD 546, HYD 547, HYD 550, HYD 560.
- Six credits of elective classes outside of the Hydrology Program. Examples of available distance education elective classes include: MGT 462, MGT 472, GEOL 512, MATH 586, TC 505, TC 575.

Master of Science in Hydrology

The Master of Science degree in Hydrology requires completion of a thesis according to the general requirements of the Graduate Program.

The student's course of study must be approved by the advisory committee and must fulfill the general requirement for the master's degree and must include:

- EARTH 440, HYD 507, 508, 510
- Six additional credits from graduate-level hydrology courses listed in the course catalog.
- HYD 591 (at least six credit hours)
- HYD 592 (two credit hours) and HYD 593 (four credit hours); credits do not apply to the 30 hours required for the M.S. degree.
- GEOL 2320 or equivalent
- MATH 2350, 382, 584 or equivalent
- At least three additional graduate-level course credits approved by the advisory committee.
- The Institute Graduate Degree Requirements must also be satisfied

Examples of courses other than hydrology which are appropriate for graduate programs in hydrology include, but are not limited to: BIOL 343, 446; CHEM 331, 332, 333, 334; EARTH 405, 409, 444, 445, 448, 460; GEOL 503, 509, 547, 553; GEOP 505, 529; MATH 332, 382, 384, 410, 411, 415, 435, 436, 438, 483, 486, 488, 511, 512, 533, 586, 587; PETR 445, 523, 544, 546, 564; PHYS 421, 526.

Doctor of Philosophy in Earth and Environmental Science with Dissertation in Hydrology

Students of exceptional ability as demonstrated in previous courses or in a master's degree program may pursue a program leading to the doctoral degree.

The prospective doctoral candidate in Earth and environmental science with specialization in hydrology should develop a good background in physics, mathematics, chemistry, and geology in addition to achieving a high level of competence in the field of specialization.

With approval of the advisory committee, the student should

select a program including a minimum of nine credits of graduate coursework beyond the M.S. degree, three credits of HYD 592, six credits of HYD 593, plus additional courses in related fields. Some appropriate courses are given under the Master of Science degree requirements.

Research fields appropriate for the doctoral candidate include regional hydrology, groundwater recharge, vadose zone hydrology, stochastic subsurface hydrology, hydrogeochemistry, isotope hydrology, hydroclimatology, pollutant transport, aquifer restoration, multi-phase flow of immiscible fluids, deterministic and stochastic numerical aquifer simulation, finite difference and finite element numerical methods, and field instrumentation. Interdisciplinary programs in the Earth science fields are encouraged.

Graduate Certificate Program in Hydrology

The Hydrology Certificate program is aimed at working professionals or students who wish to increase their qualifications in Hydrology outside of a degree program. The program covers fundamentals of atmospheric, surface, and subsurface hydrology while leaving flexibility to focus on related areas of particular individual interest. The Certificate requires a minimum of 15 credit hours of graduate and upper division course work as follows:

- EARTH 440 (3)
- Twelve credits of additional advisor-approved upper division or graduate-level coursework. Examples of available distance education courses include: HYD 507, 510, 511, 513, 514, 534, 547, 550, 560.

Hydrology Graduate Courses:

HYD 500, Directed Research, cr to be arranged

This course may not be used to fulfill graduate degree requirements.

Research under the guidance of a faculty member.

HYD 507, 507D, Hydrogeochemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 1225

Pre- or Corequisite: EARTH 440

Offered fall semester

The thermodynamics and aqueous chemistry of natural waters, with emphasis on groundwater. Chemical equilibrium concepts, surface chemistry, redox reactions, and biochemistry. The interaction of water with the atmosphere and geologic Materials. Basic concepts applied to problems of groundwater quality evolution, water use, and groundwater contamination. Shares lecture with GEOL 407, with additional expectations for graduate credit. **(Same as CHEM 531 and GEOC 507.)**

HYD 508, Flow and Transport in Hydrologic Systems, 4 cr, 3 cl hrs, 3 lab/recitation hrs

Prerequisites: EARTH 440, 440L and 510

Offered spring semester

Principles of flow and transport in hydrological systems, including rivers, lakes, aquifers, the vadose zone,

glaciers and the lower atmosphere. Fluid mechanical and thermodynamic properties, fluid statics, fluid dynamics, including mass, momentum and energy conservation, and transport of heat, particles and non-reactive chemicals with fluid flow. Single and multiphase laminar flow in porous and fractured permeable media. Turbulence and related topics that are of particular interest to hydrologists.

HYD 510, 510D, Quantitative Methods in Hydrology, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: MATH 2532; Pre or Corequisite GEOL 440
Offered fall semester

Introduction to the methods of mathematical physics used in hydrologic science. Presented in the context of mathematical models of water and energy balances, fluid flow, and heat & solute transport. Application to aquifers, the vadose zone, land-surface runoff, rivers, and the atmospheric boundary layer. Methods span advanced engineering calculus, including numerics and differential equations. Use of software (Matlab, Maple, and COMSOL Multiphysics) for problem solving and solution presentation. Programming with Matlab.

HYD 511, 511D, Groundwater Hydrology, 3 cr, 3 cl hrs

Prerequisites: EARTH 440
Offered alternate spring semesters

Study of the occurrence, movement, and chemical and isotopic composition of groundwater. Hydrogeologic properties. Groundwater recharge and stream/aquifer interaction, flow net and hydrograph analysis. Groundwater exploration using geologic and geophysical methods. Groundwater in different geological, climate, and physiographic regimes. Characterization of groundwater using stable isotopes and major ion analysis. Physics of flow to wells, steady-state and transient solutions to well hydraulics equations, image well theory, responses of aquifers to perturbations. Role of groundwater in contaminant migration and heat transfer. *Shares lecture with GEOL 411, with additional expectations for graduate credit.*

HYD 513, 513D, Watershed Dynamics & Ecohydrology, 3 cr, 3 cl hrs

Prerequisites: GEOL 440
Offered alternate spring semesters

Processes governing hydrological flow rates and pathways through watershed systems: Hillslope runoff production and in-channel flood routing. Emphasis on physical mechanisms and their treatment in models, as well as observations made in the field. Interactions between terrestrial plants and water, nutrients, and light resources in semiarid ecosystems and riparian zones. Vegetation induced flow roughness, ecohydrological processes and dynamics, and simple numerical models. *Shares lecture with GEOL 413, with additional expectations for graduate credit.*

HYD 514, 514D, Vadose Zone Hydrology, 3 cr, 3 cl hrs

Prerequisites: EARTH 440
Offered alternate fall semesters

Physics of unsaturated flow in porous media, multiphase flow, potentials and water retention, unsaturated hydraulic conductivity, transient flow problems. Mathematical modeling of variable-density flow. Analysis of slope stability, drainage through mine tailings and rock piles, hazardous waste migration soil moisture controls on evapotranspiration and vegetation growth. *Shares lecture with GEOL 414, with additional expectations for graduate credit.*

HYD 516, 516D, Geofluids, 3 cr, 3 cl hrs

Corequisites: EARTH 440, HYD 511 or PETR 445
Offered alternate spring semesters

The role of groundwater in geologic processes. Fluid flow impelling mechanisms within the earth's crust to depths of 10 km. The role of groundwater in petroleum generation/migration, overpressure/underpressure formation in sedimentary basins, hydrothermal ore deposit formation, contact metamorphism, geothermal systems, seismicity, slope failure, sediment transport, and glaciation.

HYD 520, Data-Driven Modeling in Science and Engineering, 3 cr, 3 cl hrs

Prerequisites: MATH 2350 or 382 and MATH 335 or consent of instructor and advisor

Statistical learning techniques and data assimilation for science and engineering applications. Focus is on the practical applications and the understanding of the assumptions underlying techniques, allowing students to learn the basics of useful tools for data-driven modeling and revisit their theoretical and practical underpinnings as needed. Topics may include supervised and unsupervised learning, regression, classification, importance sampling, ensemble forecasting, and Kalman Filtering. The codes R and Python will be used. **(Same as GEOP 520)**

HYD 534, 534D, Introduction to Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: PHYS 1320 or consent of instructor and advisor

Introduction to the theory and practical use of remotely sensed satellite images. Principles of radiation physics; sensor systems; data acquisition; image analysis; classification schemes. Remote sensing applications to atmospheric sciences, hydrology, mineral and oil exploration, natural hazards monitoring, and land and resources management. Become familiar with ERDAS Imagine remote sensing software. Laboratory exercises using ERDAS Imagine deal primarily with computer analysis of remotely sensed images with some field exercises. *Shares lecture/lab with GEOL 434, with additional expectations for graduate credit. (Same as GEOL/GEOP 534)*

HYD 536, Advanced Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: EARTH 434 or HYD 534 or GEOL 534
Offered on demand

This class deals with quantitative remote sensing for determination of the components of the energy balance (net radiation, latent and sensible heat fluxes, soil heat flux) and soil moisture, hyperspectral and multispectral image processing, radar and microwave imagery. In addition, advanced applications for geology, geophysics and geochemistry will be discussed. Shares lecture/lab with GEOL 436, with additional expectations for graduate credit. **(Same as GEOL 536)**

HYD 538, Advanced Geographic Information Systems, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: Consent of instructor

Advanced topics in geographic information systems (GIS) with a focus on applications in environmental sciences. Emphasis on theoretical aspects and practical applications of GIS science and technology and its integration with remote sensing data and field measurements. Computing exercises and programming projects utilizing GIS software. Discussion of GIS integration with environmental modeling. Shares lecture/lab with ENVS 438, with additional expectations for graduate credit. **(Same as GEOL 538)**

HYD 541, 541D, Water Resources Management, 1 cr, 1 cl hr

Prerequisite: EARTH 440

Offered on demand

Social and economic basis for administering water. Comparison of American Indian and European attitudes toward the hydrological system. Fundamentals of water law and policy in the United States.

HYD 546, 546D, Contaminant Hydrology, 3 cr, 3 cl hrs

Prerequisites: EARTH 440; HYD 507

Pre- or Corequisite: HYD 508

Offered on demand

The physics, chemistry, and biology of inorganic, organic, and microbial contaminants in groundwater and surface water systems. Mechanisms by which contaminants are introduced. Transport and transformations of contaminants in surface waters, the vadose zone, and the saturated zones. Movement, capillary trapping, and solubility of relatively immiscible organic liquids. Contaminant isolation and remediation techniques. **(Same as GEOC 546.)**

HYD 547, 547D, Hydrological Modeling, 3 cr, 3 cl hrs

Prerequisites: EARTH 440, HYD 508, HYD 510

Offered alternate spring semesters

Analysis and synthesis of issues in hydrologic science. Related engineering problem solving. Conceptual modeling process: model conceptualization and parameterization, model diagnosis, testing and validation, and model prediction. Conceptual models for testing scientific hypotheses, assimilating data, developing policy, and solving engineering design and operational problems. Applications to land-surface, surface water, vadose zone, and groundwater, singly and together, and to their interfaces with the atmosphere and oceans.

HYD 550, Cave and Karst Systems, 3 cr, 3 cl hrs

Prerequisites: CHEM 1215 & 1225; and either a 100-level GEOL course with associated lab, or BIOL 2110
Offered alternate spring semesters

A system-based study of caves and karstic terrains over time including formation mechanisms (speleogenesis), hydrology, geochemistry, mineralogy, and geomicrobiology. Emphasis on caves as interactive microcosms cross-cutting many disciplines. *Shares lecture with GEOL 450, with additional expectations for graduate credit.*

HYD 550L, Cave and Karst Lab, 1 cr, 3 lab hrs

Offered spring semester, even years

Corequisite: HYD 550

Survey of techniques applicable to various aspects of speleology and karst studies. Project-based lab, developed for each student in consultation with instructor. *Shares lab with GEOL 450L, with additional expectations for graduate credit.*

HYD 558, Tracers in Hydrology, 3 cr, 3 cl hrs

Prerequisites: EARTH 440; HYD 507

Offered in alternate fall semesters

Environmental and artificial tracers in hydrology. Environmental tracer topics may include: atomic structure and abundances of environmental isotopes. Stable isotope fractionation. Mass spectrometry. Applications of the stable isotopes of hydrogen, oxygen, and carbon to meteorology and hydrology. Radioactive decay and radionuclide production. Applications of tritium, ^3He , ^{14}C , ^{36}Cl , and other radionuclides. Application of Cl, Br, and CFCs to hydrologic problems; and carbon, nitrogen, and phosphorus isotopes for nutrient cycling in soils and freshwater systems. Artificial tracer topics may include: fluorescent and salt tracers, drifting particles, and dissolved gas tracers. Planning and execution of tracer experiments and the analysis and interpretation of tracer data with solute transport equations, convolution integral methods, and end-member mixing analysis.

HYD 560, Advanced Well Hydraulics, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: HYD 511

Offered on demand

Topics for in-depth investigation may include production and minoring well design, aquifer pumping test design and analysis. Aquifer test analysis for unconfined aquifers, fractured bedrock aquifers, anisotropic aquifers, partially penetrating wells, and leaky confining units. Hydrogeologic field work including long-term aquifer test..

HYD 562, Fluvial Geomorphology, 3 cr, 3 cl hrs

Prerequisites: EARTH 440

Offered in alternate spring semesters

Interactions of water and sediment flow in fluvial systems. Sediment transport rates and particle size dependence. Physical controls on channel morphology, bedforms, and microhabitat distribution. Hydraulic

geometry and bank-full flow analysis, with implications for floodplain development. Basin morphometric relationships with climate and flood routing. Case studies of fluvial system response to disturbances such as wildfire, avulsion, land use change, climate change, and stream restoration. **(Same as GEOL 562)**

HYD 570, Seminar in Hydrology, 1 cr, 1 cl hrs

Review and discussion of papers relating to hydrology.

HYD 571, 571D, 572, Advanced Topics in Hydrology, 1–3 cr each semester

Offered on demand

Study of special topics in hydrology.

HYD 581, Directed Study, cr to be arranged

Study under the guidance of a member of the graduate faculty. In general, subject matter will supplement that available in the other graduate course offerings.

HYD 586, Field Methods in Hydrology, 2 cr

Prerequisite: Consent of instructor

Offered Summers (2 weeks); NMT students should register for this course in the spring semester.

Instrumentation and methodologies used in hydrological investigations in a field setting. Course topics may range across a variety of physical and chemical hydrological techniques in vadose, groundwater and surface hydrology. Examples of potential topical areas include, but are not limited to, aquifer, lake and stream sample collection, storage and analysis; aquifer and watershed characterization; discharge measurements and tracer tests; land surface-atmosphere flux, groundwater geophysics, measurements; and hydrologic field campaigns.

HYD 590, Independent Study, cr to be arranged

Organized independent student research coordinated with a faculty member and documented in a final written report.

HYD 591, Thesis (master's program), cr to be arranged

HYD 592, Graduate Seminar, 1 cr, 1 cl hr

Prerequisite: Graduate standing

Offered spring semesters

Seminar presentations by graduate students on their current research topics. M.S. students must present at least one seminar; Ph.D. students must present at least one seminar in each of two different semesters. Graded on S/U basis; credits earned may not be applied towards the 30 credits required for the M.S. degree **(same as GEOB 592, GEOL 592, GEOC 592, GEOP 592)**

HYD 593, Seminar, 1 cr, 1 cl hr

Prerequisite: Graduate standing

Offered fall and spring semesters

Seminar presentations by faculty, students, and outside speakers. Includes both Department and hydrology-specific seminars. Graded on S/U basis. Satisfactory performance consists of regular attendance at approved seminars. Credit earned may not be applied towards the

30 credits required for the M.S. degree. **(Same as GEOB 593, GEOC 593, GEOL 593, GEOP 593)**

HYD 595, Dissertation (doctoral degree program), cr to be arranged

Prerequisite: Successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.

Faculty Research Interests

Axen—Continental Tectonics, Fault Mechanics, and Geothermal Resources

Bilek—Earthquake Rupture Processes, Stresses and Structure of Fault Zones, Shallow Subduction Zone Processes, Tsunami

Cadol—Surface Water Hydrology, Ecohydrology, Fluvial Geomorphology

Harrison—Soil Properties, Recurrence Intervals of Earthquakes, Soil Salinization in Arid Environments, Soil Stability

Jones—Geomicrobiology, Cave and Karst systems, sulfur cycling

R. Leary — Global tectonics, interaction of orogenic belts and sedimentary basins, clastic depositional systems and processes, terrestrial paleoclimate records, petroleum geology.

Maher — Geochemistry and mineralogy of ore deposits, distal expressions of hydrothermal systems, copper isotope systematics

Mozley—Environmental Geology, Sedimentary Petrology, Low-Temperature Geochemistry, Carbon Sequestration

Murray — Crustal Deformation and Rheology, Geodetic Measurements, Earthquake and Volcano Hazards

Person — Paleohydrology, Basin-Scale Numerical Modeling,

- Geothermal Systems, Carbon Sequestration, Role of Groundwater in Geologic Processes
- Reusch — Polar climates and climate change through meteorology, ice cores, sea ice, climate modeling and artificial neural network techniques.
- Rinehart - Hydrogeodesy, Regional hydrogeology, Integration of larger spatial datasets, Subsidence hazards, chemo mechanics for carbon capture and storage applications.
- Spinelli — Marine Hydrogeology and Heat Flow, Groundwater Surface Water Interactions, Sediment Physical Properties
- Ulmer-Scholle—Carbonate Diagenesis; Sedimentary Petrography, Fluid Inclusions and Thermal and Fluid Histories of Carbonate Basins, Carbonate Depositional Environments, Carbon Sequestration, Computer-Based Applications and Geological Training
- Van Wijk—Geodynamics and Tectonics, Basin Analysis and Modeling, Petroleum System Modeling, Applied (Exploration) Geophysics.
- Waters — Experimental and petrologic studies of magma formation, storage, and eruption.

Adjunct Faculty Research Interests

- Bauer—Structural Geology and Tectonics, Precambrian Geology
- Broadhead—Petroleum Geology, Stratigraphy
- Cather—Clastic and Volcaniclastic Sedimentology, Basin Analysis, Regional Tectonics
- Chamberlin – Ignimbrite Calderas of Central New Mexico, Structure & Stratigraphy of Central Rio Grande Rift
- Chapin—Volcanology, Tectonics, Economic Geology
- Dunbar—Igneous Petrology, Volcanology, Trace Element Behavior in High and Low Temperature Aqueous Systems, Microprobe Geochemical Analysis
- Gomez-Velez—Environmental Flow and Transport, Groundwater-surface water interactions, Hydrogeology, Watershed hydrology, Analytical and numerical modeling, data mining and assimilation
- Hawley — Geomorphology, Quaternary Stratigraphy, Environmental Geology, Hydrogeology
- Heizler— $^{40}\text{Ar}/^{39}\text{Ar}$ Thermochronology
- Kelley—Fission-Trace Thermochronology, Tectonics, Thermal Studies
- Land—Cave and Karst Hydrology, Hydrogeology
- Love—Environmental Geology, Quaternary Geology, Sedimentology
- Luhmann—Karst Hydrogeology, Fluid-Rock Interaction, Aqueous Geochemistry, Geologic Carbon Sequestration

- McLemore — Economic Geology
- Stephens — Hydrogeology, Unsaturated Flow, Groundwater Flow Modeling
- Tidwell — Fluid Flow, Solute Transport, Media Heterogeneity, Laboratory Technologies, and Water Resources Management
- Timmons — NM StateMap Manager, Field Geology, Structural Geology and Tectonics

Emeritus Faculty Research Interests

- Budding — Metamorphic Petrology, Geotectonics
- Campbell — Metallic Ore Deposits, Stable Isotope Geochemistry, Carbon Sequestration
- Condie — Trace Element and Isotope Geochemistry, Precambrian Studies
- G. Gross — Electrical and Electrochemical Properties of Ice, Isotope Hydrology, Geophysics, Desert Geomorphology
- Hendrickx — Vadose Zone Hydrology, Remote Sensing of Energy Balance, Soil Physics, Environmental Biophysics
- D. Johnson — Biostratigraphy, Paleozoic Depositional Environments
- Kyle—Igneous Geochemistry, Antarctic Geology, Volcanology
- Lattman — Geomorphology, Remote Sensing
- Phillips — Groundwater Chemistry, Isotope Hydrology, Groundwater Dating, Quaternary Studies
- Schlue — Seismology, Surface Waves, Rift Studies, Inverse Methods
- Wilson — Groundwater Hydrology, Numerical and Analytical Modelling, Stochastic Hydrology, Colloid and Bacteria Transport

Environmental Science

Environmental Science Advisory Committee:

Dr. Bruce Harrison, Earth and Environmental Science

Dr. Rebecca Reiss, Biology

Dr. Clint Richardson, Environmental Engineering

Many faculty at New Mexico Tech have an interest in the application of their research to environmental problems. Their research interests are listed in the appropriate departmental section of the catalog.

Degrees Offered: B.S. in Environmental Science with Options in Biology, Chemistry, Geology, Hydrology.

The Bachelor of Science degree in Environmental Science draws upon courses from biology, chemistry, Earth science, physics, and environmental engineering. Students must be aware of the complexity of environmental problems, yet have a rigorous background to address specific aspects of those problems. To ensure that graduates are competitive in the marketplace for diverse environmentally oriented careers, Environmental Science students take classes in all of the disciplines listed above. They must select a specialization in biology, chemistry, geology, hydrology, or instrumentation and measurements. Each option is sufficiently in-depth to allow students to continue their education in a traditional graduate program within that disciplines.

An advisory committee, composed of faculty from the specific disciplines, is convened to help students plan their programs.

Undergraduate Program

Core Requirements for the Bachelor of Science Degree in Environmental Science

In addition to the General Education and Institute Core Curriculum Requirements (page 78) the following core program is required of all Environmental Science students:

- BIOL 331 (3), 343 & 343L (4)
- CHEM 311 & 311L (4), 333 & 333L (4), 422 & 422L (4)
- A 1000-level GEOL course and associated lab (4)
- GEOL 2150 & 201L (4), GEOL 2320 & 2320L (4), GEOL 440 (4)
- MATH 2350 (4), 283 (3)
- ENVS 472 (1)
- All students in the Environmental Science program are required to attend the Environmental Science Senior Seminar (ENVS 472) for four years or, if transfer students, for the duration of their enrollment in the Environmental Science program. In the first three years, students need only audit the seminar, but in their senior year, they are required to present at the seminar and take the class for a grade.
- Three credit hours of courses numbered 491 and 492 taken in the appropriate department in the subject area of

environmental science. These credit hours shall comprise a supervised research project, supervised scholarship project, or a supervised internship, and must result in a written paper or senior thesis. Prior to beginning the research project or internship, the student must prepare a short proposal of the activity. This proposal must be approved by the student's advisor and two faculty from the Environmental Science Advisory Committee. Following completion of the project, all three faculty must sign off on the resulting research paper.

Bachelor of Science in Environmental Science with Biology Option

Minimum credit hours required—121

In addition to the General Degree Requirements (page 78), and the core Environmental Science Requirements (above), the following courses are required:

- BIOL 2610 & 2610 L (4), 311 & 311L (4), 333 & 333L (4)
- Technical Electives (9)—Technical electives 300 level and above from the Biology Dept Catalog to be approved by the Advisory Committee

Bachelor of Science in Environmental Science with Chemistry Option

Minimum credit hours required—122

In addition to the General Degree Requirements (page 78), and the core Environmental Science Requirements (above), the following courses are required:

- CHEM 331 & 331L (4), 334 & 334L (4), 411 & 411L (4)
- Technical Electives (8)—Recommended technical electives, 300 level and above which must be approved by the advisory committee.

Bachelor of Science in Environmental Science with Geology Option

Minimum credit hours required—121

In addition to the General Degree Requirements (page 78), and the core Environmental Science Requirements (above), the following courses are required:

- GEOL 100(1), GEOL 200 & 200L(4), GEOL 353(4), GEOL 405(3)
- GEOL 2330 & 2330L (4), GEOL 2340 & 2340L (4), GEOL 380 (3), GEOL 385 (3), GEOL 405 (3)
- Technical Electives (4)—Technical electives 300 level and above from the E&ES Dept Catalog to be approved by the Advisory Committee

Bachelor of Science in Environmental Science with Hydrology Option

Minimum credit hours required—121

In addition to the General Degree Requirements (page 78), and the core Environmental Science Requirements (above), the following courses are required:

- GEOL 100(1), GEOL 340 (3)
GEOL 2340 & 2340L (4), GEOL 340 (3), GEOL 440

- (4), GEOL 441 (1), GEOL 442 (1), GEOL 443 (1)
- MATH 335 (3)
- Technical Electives (6)—Technical electives 300 level and above from the E&ES Dept Catalog to be approved by the Advisory Committee

Bachelor of Science in Environmental Science with Instrumentation and Measurements Option

Minimum credit hours required—135

In addition to the General Degree Requirements (page 78), and the core Environmental Science Requirements (above), a minimum of 25 credit hours from the following (at least 17 credit hours must be numbered 300 or above) are required:

- ES 332 (3)
- EE 211 (3), 212 & 212L (4), 231 & 231L (4), 308 & 308L (4), 321 & 321L (4)
- CHEM 331 & 331L (4), 411 & 411L (4)
- GEOL 353 (3), 370 (3)
- Electives to complete 135 credit hours

Environmental Science Courses:

ENVS 412, 412D, Introduction to Geographic Information Systems, 3 cr, 2 cl hrs, 3 lab hrs

Offered Spring semester on demand

An introduction to the concepts of geographic information systems (GIS). Theoretical background to GIS; introduction to the nature and analysis of spatial data. ArcView and/or ArcGIS. Shares lecture with GEOL 512, with additional expectations for graduate credit. Same as GEOL 412.

ENVS 438, Advanced Geographic Information Systems, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: Consent of instructor

Advanced topics in geographic information systems (GIS) with a focus on applications in environmental sciences. Emphasis on theoretical aspects and practical applications of GIS science and technology and its integration with remote sensing data and field measurements. Computing exercises and programming projects utilizing GIS software. Discussion of GIS integration with environmental modeling. Shares lecture with GEOL/HYD 538, with additional expectations for graduate credit.

ENVS 472, Senior Seminar, 1 cr, 1 cl hrs

Offered in spring semester

Undergraduate students in Environmental Science are required to give one seminar on research resulting from the paper written for 491 or 492.

Fine Arts

The fine arts program provides an opportunity for students to work in drawing, sculpture, painting, and other endeavors employing creative imagination. Although it is a nonmajor program, fine arts is significant as an area of study, offering elective possibilities in other curricula.

All fine arts offerings are dependent upon student interest and the availability of instructors.

For a complete listing of current Fine Arts offerings, visit <http://ced.nmt.edu> or call (575) 835.6581.

Fine Arts Courses:

The following sampling of Fine Arts courses are graded S/U and may be used for elective credit only. Classes may be taken multiple times for credit.

FA 189C – 03 Introduction to Digital Photography 1 cr, 2 cl hrs

A basic foundation in the use of digital SLR (Single Lens Reflex) or high-end digital point-and-shoot cameras. The first half of the course covers the technical aspects of photography, the camera and its functions. The second half of the course covers composition and the more aesthetic nature of photography and allows students to find their “eye” in photography.

FA 189C - 01 Introduction to Photoshop 1 cr, 2 cl hrs

A basic foundation in Photoshop, the premier image manipulation application from Adobe. At the end of the course, the student will be able to open an image with Photoshop, make non-destructive changes to the image, and save it as a file optimized for either print or web/email output. Advanced techniques, such as combining multiple images using layer masks and layer blending modes to create a new, unique image, will be explored.

FA 189C - 04 Drawing and Painting 1 cr, 2 cl hrs

Survey of introductory skills and techniques using a variety of drawing and painting media

ARTS 1634-1 Painting in Oils 1 cr, 2 cl hrs

Geared toward a relaxing approach to the introduction of the fine art of oil painting, the purpose of this course is to provide background for your future oil painting experiences and serve as an outlet to relax.

ARTS 1633 –01 Painting in Acrylics 1 cr, 2 cl hrs

Basic methods and skills in acrylic painting

FA 189C Photography 1 cr, 3 cl hrs

Technical and aesthetics process in Photography as an art form

ARTS 1330-1 Hand Building in Clay 2 cr, 3 cl hrs

Studio arts survey of hand forming techniques used in creating diverse utilitarian and sculptural ceramics.

Accommodates all skill levels

ARTS 1320-1 Wheel Thrown Ceramics I 2 cr, 3 cl hrs

Prerequisite: FA 270C, Hand Building in Clay

Technical and aesthetic processes used in functional wheel thrown ceramics. Accommodates all skill levels

FA 289C Wheel Thrown Ceramics II 2 cr, 3 cl hrs

Prerequisite: FA 270C, Hand Building in Clay

Students will learn and practice advanced wheel and decorative techniques.

ARTS 1802—01 Beginning Enameling 1 cr, 3 cl hrs

The art of fusing glass to metal, safe handling of equipment and chemicals in beginning techniques

ARTS 2821 –0 Enameling II 1 cr, 3 cl hrs

Prerequisite: FA 280C, Beginning Enameling

The art of fusing glass to metal using advanced techniques and methods

ARTS 1810 Beginning Metal Arts/Lapidary 1 cr, 3 cl hrs

Fabrication techniques in metal construction: cutting, shaping and soldering, lost wax casting. Lapidary works of cut stone may be incorporated into metal processes.

ARTS 2810 Metal Arts/Lapidary II 1 cr, 3 cl hrs

Prerequisite: FA 282C, Beginning Metal Arts/Lapidary

Continued development of skills and processes in lapidary and metal work

ARTS 2325 Precious Metal Clay 1 cr, 3 cl hrs

Prerequisites: FA 283C and consent of instructor

The art of kiln fired fused copper, bronze and silver metals in creating wearable art. Safe handling of kilns and equipment

ARTS 2326 Precious Metal Clay II 1 cr, 3 cl hrs

Prerequisite: FA 284C and consent of instructor

Continued exploration of skills and techniques acquired in PMC I

ARTS 2890—0 Armor Making 2 cr, 3 cl hrs

Prerequisite: FA 282C, Beginning Metal Arts/Lapidary

Hot and cold working of steel and leather in historical design and construction of wearable medieval protective clothing.

Information Technology

Professors : Jeffery (Chair of the Department, Liebrock, Shin, Soliman, Sueyoshi, Wedeward, Zheng
Associate Professors : Mazumdar (Program Coordinator), Reinow (program Coordinator)
Assistant Professors Ramyaa, Wang
Instructors Knowles, Kuo, Tong

Degree Offered: B.S. in Information Technology

Information Technology (IT) is an evolving interdisciplinary subject that has been driven and shaped by the rapid development of computing, communication, and Internet-related technologies and their tremendous impact on our daily lives.

In contrast to the more traditional Information Systems discipline, Information Technology deals with the development, utilization, interrelation, and confluence of computers, networking, telecommunication, business, and technology management in the context of the global Internet. As we enter the Information Age of the 21st century, society is increasingly dependent on Information Technology and demand for IT professionals will remain high throughout the decades to come.

The *Bachelor of Science in Information Technology* program at New Mexico Tech is administered jointly by the *Computer Science and Business Management* faculty in Computer Science and Engineering department. The curriculum includes relevant computer science, management, and engineering courses and emphasizes secure information systems and information assurance that are among the areas of research at Tech's Institute for Complex Additive Systems Analysis (ICASA) where IT students may find employment or internship opportunities. Students must also take a sequence of 6 hours of technical electives to broaden or deepen their knowledge in an IT area of their interest.

Graduates of the IT program are well prepared for immediate industry employment or graduate study in an IT-related discipline.

Student Outcomes

- By the time of their graduation, our students should have
- the ability to design, implement, test, and configure software programs
 - the ability to analyze information technology requirements, assess risk, optimize resources, monitor and evaluate progress, and manage project budgets;
 - knowledge of the fundamental principles of information processing and decision, networking, security, and database;
 - exposure to one or more information technology areas;
 - technical communication skills in written and oral forms;
 - the capacity to work as part of a team;
 - awareness of the ethical and societal impact of developments in the field of information technology;
 - the ability to develop a business case for an organizational decision to pursue an IT project.

Undergraduate Program

Bachelor of Science in Information Technology

Minimum credit hours required—120

In addition to the General Education and Institute Core Curriculum (page 78), the following courses are required:

- IT 101 (2), IT 113 (4), 122 (3), 213 (3), 221 (3), 321 (3), 326 (3), 330 (3), 353 (3), 363 (3), 373 (3), 382 (3), 462 (3), 466 (3), 481 (3), 482 (3)
- CSE 222 (3), 241 (3)
- MATH 2350 (3)
- PSY 1110 (3) (can be applied as a social science course in the general education core curriculum)
- Technical Electives: a sequence of 6 hours of computer science, information technology, or management courses numbered 300 or higher, *pre-approved* by the student's advisor and an IT Program Coordinator, with no more than one course numbered IT 485. Students are encouraged to select a coherent set of courses as technical electives that will prepare them for a specific focus in their career, for instance, IT 441 & 463 for cybersecurity focus and MGT 302 & 472 for management focus.
- Each of the above courses must be completed with a grade of C or better.

Sample Curriculum for the Bachelor of Science Degree in Information Technology

Semester 1

- 4 MATH 1510 (calculus)
- 1 IT 101 (intro to comp sci & information tech)
- 4 IT 113 (intro to programming)
- 4 CHEM 1215 & 1215L (general chemistry I)
- 3 ENGL 1110 (college English)
- 17 Total credit hours

Semester 2

- 4 MATH 1520 (calculus)
- 3 IT 122 (algorithms and data structures)
- 4 CHEM 1225 & 1225L (general chemistry II)
- 3 ENGL 1120 (college English)
- 14 Total credit hours

Semester 3

- 3 IT 221 (computer and network organization)
- 3 CSE 241 (foundations for computer science)
- 5 PHYS 1310 & 1310L (general physics I)
- 3 PSY 1110 (general psychology)
- 17 Total credit hours

Semester 4

- 3 CSE 222 (systems programming)
- 3 IT 213 (intro to object oriented programming)
- 3 MATH 2350 (introduction to applied statistics)
- 3 Humanities
- 5 PHYS 1320 & 1320L (general physics II)
- 17 Total credit hours

Semester 5

- 3 IT 321 (internet and web programming)
- 3 IT 330 (management & organization behavior)
- 3 IT 353 (introduction to computer networks)

3 IT 373 (intro to database design and management)

3 ENGL 341 (technical writing)

15 Total credit hours

Semester 6

3 IT 326 (software engineering)

3 Technical Elective

3 IT 462 (systems, risk and decision analysis)

3 IT 466 (project management)

3 Social Science

15 Total credit hours

Semester 7

3 IT 382 (legal and ethical info technology issues)

3 IT 481 (senior secure system design project)

3 IT 363 (Computer Security)

1 Physical Education

3 Humanities

13 Total credit hours

Semester 8

3 Technical Electives

3 IT 482 (senior secure system design project)

6 Humanities/Social Science/Fine & Creative Arts

12 Total credit hours

Information Technology Courses:

In the following, each prerequisite requires a grade of C or better.

IT 101, Introduction to Computer Science & Information Technology, 2 cr, 2 cl hrs

Students must register for IT 101 and IT 101L concurrently

Brief overview of the discipline of computer science and information technology topics including computer architecture, operating systems and networks, automata and models of computation, programming languages and compilers, algorithms, databases, security and information assurance, artificial intelligence, graphics, and social/ethical issues of computing. **(Same as CSE 101.)**

IT 107, Introduction to Computer Programming using Python, 4 cr, 3 cl hrs, 2 lab hrs

Co-requisite: Math 1240

Students must register for IT 107 and IT 107L concurrently

The course is designed to introduce programming and its applications to scientists and engineers. The first part of the class focuses on problem solving, algorithm development, top-down design, modular programming, debugging, testing, data types, flow-control, looping, iteration and recursion, fundamental data structures, and an introduction to object oriented programming. The second part of the class explores data analysis with Python. **(Same as CSE 107.)**

IT 113, Intro to Programming, 4 cr, 3 cl hrs, 3 lab hrs

Co-requisite: MATH 1510

Students must register for IT 113 and IT 113L concurrently

The course is designed to introduce problem solving and programming in C to Computer Science majors and those interested in applications of the language that involve

dynamic structures and memory management. Topics include algorithm development; top-down design; modular programming; debugging; testing; control structures including selection, iteration and recursion; number systems; data representation; data types including arrays, strings, pointers and dynamic structures involving memory management. Concepts implemented through extensive programming using good programming style. **(Same as CSE 113)**

IT 122, Algorithms and Data Structures, 3 cr, 3 cl hrs

Prerequisite: IT 113 with a grade of C or higher

Corequisite: Math 1520

Fundamental data structures including linked lists, trees, hash tables, and graphs. Algorithms for sorting, searching, and other fundamental operations. Introduction to mathematical foundations for analysis of iterative and recursive algorithms and for basic correctness proofs. Analysis of algorithms. Implementation of selected algorithms using sound programming methodologies. **(Same as CSE 122.)**

IT 213, Introduction to Object Oriented Programming, 3 cr, 3 cl hrs

Prerequisite: IT 101, 113, 122 each with a grade of C or higher

Introduction to programming in an object oriented language (e.g., Java): review of problem solving, algorithm development, top-down design, modular programming, debugging, testing, control structures including selection, iteration and recursion, data types including arrays, strings, pointers, and dynamic structures. Object oriented concepts will include: objects, classes, inheritance, instances, methods, interfaces, packages, encapsulation, and polymorphism. Concepts implemented through extensive programming using good programming style. **(Same as CSE 213.)**

IT 221, Computer System Organization, 3 cr, 3 cl hrs

Prerequisite: IT 101, 122 each with a grade of C or higher

The hardware/software interface. Basic organization hardware, operating systems, and computer networks. Memories, buses, interrupts, input and output, and instruction set architecture. Programming in assembly language programming. **(Same as CSE 221.)**

IT 311, 311D, Human Information Processing and Decision Making, 3 cr, 3 cl

Prerequisite: PSY 1310 with a grade of C or higher and upper division standing in the IT program

Recent advances in knowledge about how people process and act upon information are presented. Models of human decision making are analyzed in the context of secure information systems and used to assess ways to best manage the people and technology associated with secure information systems.

IT 321, Internet and Web Programming, 3 cr, 3 cl hrs

Prerequisites: IT 122 and IT 213 each with a grade of C or higher

This course has a practical emphasis on the design and techniques for developing internet-based applications,

mainly focusing on web programming. Topics include HTML, client-side scripting language (JavaScript), server-side programming (e.g., Servlets, JSP, and J2EE), and XML/web services (e.g., Java and .NET). This course will also cover some important topics needed for internet-based application development, such as Internet architectures, basic object-oriented programming (OOP) concepts, and web security. Course work includes substantial programming homework and team-based projects. **(Same as CSE 321.)**

IT 326, Software Engineering, 3hrs

Prerequisites: IT 122, 213 each with a grade of C or higher
Prerequisites/Co-requisites: ENGL 341

This course provides the introductory overview of software engineering, concentrating on large-scale software system design and implementation. Topics include software life cycle, UML-based design language, design tools and techniques, design documentation, software testing, secure software construction, and software project management. Course work includes a team-based project. **(Same as CSE 326.)**

IT 328, Secure Software Construction, 3 cr, 2 cl hrs, 1 lab hr

Prerequisite: CSE 222, IT 213 each with a grade of C or higher

Formal methods and practical techniques for the specification, design, implementation, and validation of computer software. Current software engineering and management practices, with emphasis on ensuring software reliability, safety, and security. Course work includes a team project to develop a sizeable, real-world application software. **(Same as CSE 328.)**

IT 330, Management and Organizational Behavior, 3 cr, 3cl hrs

Prerequisites: ENGL 1120 and upper-class standing or consent of instructor and advisor

Classical and contemporary organization theories, interpersonal and organization behavior, motivation, communication, leadership, decision process in organizations. **(Same as MGT 330.)**

IT 351, Modeling and Simulation Technologies for Information Systems, 3 cr, 3cl hrs

Prerequisites: IT 122; CSE 241 each with a grade of C or higher

Fundamentals and techniques for designing and using simulation, modeling, and optimization algorithms with applications in system performance modeling, business infrastructure modeling, and distributed and parallel computing. An introduction to advanced complex systems models. **(Same as CSE 351.)**

IT 353, Introduction to Computer Networks, 3 cr, 3 cl hrs

Prerequisites: CSE 222 with a grade of C or higher
Usually offered in the Fall semester

Introduction to computer networking, the ISO/OSI protocol stack, LAN, MAN, and WAN. Physical layer: transmission media (wireline and wireless); data signaling, modulation, and coding; multiplexing. Fiber optics networking technology: protocols & examples. Data link Layer: error/flow control— protocols design issues; MAC protocols for channel access and allocation. Wireless technology and protocols standards — IEEE 802.11

physical layer and MAC sublayer protocols. Network layer: subnet switching (CS/DG/VC) & routing protocols (Non/Adaptive); Congestion Control and QoS protocols. ISO vs. (TCP-UDP)/IP the Internet protocol stacks. Internet relays and protocols, e.g., routers, gateways, etc. Introduction to network security. Application layer protocols, E.G., DNS, E-mail, etc. **(Same as CSE 353.)**

IT 363 Computer Security, 3 cr, 3 cl hrs.

Prerequisite: IT 221 with a grade of C or higher; IT 353
Usually offered in the Spring semester

This course provides an overview of the principles and practices of secure computing, mainly focusing on their application in security solution design and implementation. Topics include risk/threat analysis, secure coding practices, cryptographic tools, security architectures, system security, software security, and network security. Course work include quizzes, homework, midterm and final exams, and one final team-based project. **(Same as CSE 363.)**

IT 373, Introduction to Database Systems, 3 cr, 3 cl hrs

Prerequisite: IT 122; CSE 241 each with a grade of C or higher

Conceptual modeling and database design using the entity-relationship model. The relational model; relational algebra and relational query languages. Database integrity. Physical data organization. Non-relational models such as NoSQL and graph databases. Introduction to concurrency control and recovery. Course work includes a project using SQL and the Oracle Database Management System. **(Same as CSE 373.)**

IT 382, 382D, Ethics of Computing and Information Technologies, 3 cr, 3 cl hrs

Prerequisite: CSE 326

Usually offered in the Spring semester

In this class, students will examine ethical and social questions regarding computing and information technologies. The course challenges students to think about connections among digital technologies, the responsibilities of information technology professionals, and social justice as they study topics such as social media, military applications of digital media, gendered technologies, and access to information technologies. In addition to learning the basics of research ethics and social responsibility, students will examine real-world debates regarding subjects like big data, computer code, and digital networks, and they will analyze the legal, political, and social stakes of information technologies. **(Same as CSE 382 and PHIL 382)**

This course may be used to satisfy 3 credit hours of the General Education Area 5 requirements.

IT 441, Cryptography and Applications, 3 cr, 3 cl hrs

Prerequisites: IT 122; CSE 241 each with a grade of C or higher

This course provides an introductory overview of modern cryptographic theory and techniques, mainly focusing on their application into real systems. Topics include number theory, probability and information theory, computational complexity, symmetric and asymmetric cryptosystems, one-way functions, block and stream ciphers, Kerberos

authentication systems, public key infrastructure (PKI), secure socket layer/transport layer security (SSL/TLS), and cryptographic protocols/applications in many real systems. **(Same as CSE 441.)**

IT 451, 451D, Introduction to Parallel Processing, 3 cr, 3 cl hrs

Prerequisites: IT 122 with a grade of C or higher

Introduction to supercomputers and massively-parallel machine architecture, models of parallel computation, parallel algorithms, synchronization, parallel languages, data and functional parallelism, parallel performance analysis, popular interfaces, and parallel debugging. Students will gain experience in parallelization of sequential algorithms and implementation of parallel algorithms. **(Same as CSE 451.)**

IT 453, Advances in Computer Networks and the Internet, 3 cr, 3 cl hrs

Prerequisites: IT 353

In depth. coverage of layering protocols; stacks (ISOOSI and TCP/IP) and computer networks architectures, modern examples of LANs, MANs, WANs protocols/architectures. Recent developments in Fiber optics technology — protocols and architectures. High speed “all-fiber-optics” networks. Internetworking: global addresses/ names and translation, virtual networks and tunnels, routing, subnetworks switching protocols, IPv6, multicasting, Mobile IP. End-to-end protocols, TCP and UDP. Advances in Congestion control and resource allocation. Client-server models & applications. The QoS mechanism integrated/differentiated, ATM QoS. Network security: information and link security, encryption, internetworking security, IPsec, firewalls, VPN, wireless security. Analysis of networks protocols. **(Same as CSE 453.)**

IT 462, 462D, Systems, Risk and Decision Analysis, 3 cr, 3 cl 3 hrs

Prerequisites: MATH 2350 or 382 with a grade of C or higher; upper division standing

Analysis of systems and managerial decisions under conditions of risk or uncertainty. Optimal project evaluations and ranking of alternatives using expected value and expected utility criteria. Topics include risk sharing, Bayesian revision of probabilities, value of information, and preference assessment procedures. **(Same as MGT 462.)**

IT 463, Information Assurance, 3 cr, 3 cl hrs

Prerequisite: Senior standing

Defensive and offensive information warfare. Information system security. Computer break-ins, hacking, and other attack methods. Vulnerability and risk analysis. Theory and applications of cryptography. Intrusion detection and incident response. Security planning and management. **(Same as CSE 463.)**

IT 466, 466D, Project Management, 3 cr, 3 cl hrs

Prerequisite: MATH 2350, MGT 472 each with a grade of C or higher, or consent of instructor and advisor

Development of work breakdown structures and multi-factor project simulations to be used in dynamic re-

source allocations. Assessment and evaluation of project models over time. **(Same as MGT 476.)**

IT 476, Visualization, 3 cr, 3 cl hrs

Prerequisite: CSE 222 with a grade of C or higher, or consent of instructor and advisor

This course presents application of graphical visualization to current problems, with a focus on extracting and representing information in multidimensional data sets using 2D and 3D graphics. Topics include visualization tools and techniques, human vision and perception, color mapping, sound, data representation for insight extraction, time visualization, visual analytics, volume rendering, surface extraction and rendering. Students will develop visualizations of real world problems. **(Same as CSE 476.)**

IT 481 / IT 482, Senior Secure System Design Project, 3 cr, 3 lab hrs ea

Prerequisite: must have completed all junior-level IT courses each with a grade of C or higher

A substantial system and security-related project taken over 2 regular semesters, under the supervision of a faculty member.

IT 485, Undergraduate Seminar on Special Topics 3 cr, 3 cl hrs

Prerequisite: Senior standing, one semester of upper division courses in computer science/information technology, and consent of the instructor

A research seminar for undergraduate students with a focus either on special topics in computer science/information technology or on the methodology and skills required for research in computer science/information technology. *Use as a technical elective is limited (see requirements above), but may be taken multiple times as a general elective.*

Faculty Research Interests

- Anselmo — Complex Financial Systems, Technology Commercialization, Academic Entrepreneurship
- Jeffery — Programming Languages, Program Monitoring and Visualization, Virtual Environments
- Liebrock — Computer Forensics, Information Assurance, Parallel Processing, Well Posedness, Analysis, Visualization
- Mazumdar — Mobile Security, Integrity and Privacy, Analysis and Design of Datasets, Data Science
- Ramyaa — Theory of Computation (and Complexity) and Logic; ML (focusing on bio-inspired techniques, abstraction and theoretical developments)
- Shin — System security, Usable Security, Applied Cryptography, Software Engineering/Security
- Soliman — Computer/Sensor Networks — Fiber/Wireless modern technologies, topologies, and routing/security protocols, Programming Languages principles design, Neural Networks — applications in image compression, cloud computing management/security, and sensor networks — including the design of general "smart early prediction units of any asynchronous events" (e.g., system/border intrusion, forest-fire, tsunami, earthquake, cancer development)
- Sueyoshi — Management Science, Data Envelopment Analysis Risk and Policy Analysis
- Wang — Regional Economics, Environmental and Natural Resources Economics, Sustainability Management, Spatial Economic Analysis, Agent-based Modeling
- Wedeward — Adaptive Control, Robotic Systems
- Zheng — Mobile Computing, Computer and Network security, Machine Learning and its Applications computing management, and sensor networks

Mathematics

Professors Avramidi, Borchers, Hossain (Chair of the Department), Stone, Wang
Associate Professors Aitbayev, Kerr, Makhnin, Zhang
Assistant Professors Gonzalez-Parra, Orizaga
Instructors Ballou, Phillips, Wolford
Emeritus Faculty Arterburn, Forster, Schaffer, Sharples, Starrett

Degrees Offered: B.S. in Mathematics, M.S. in Mathematics with Specialization in Operations Research and Statistics, M.S. in Mathematics with specialization in Analysis, M.S. in Mathematics with Specialization in Industrial Mathematics; Ph.D. in Mathematics with Dissertation in Applied and Industrial Mathematics

Students and faculty in the mathematics department at Tech are involved in many areas of mathematics, from pure mathematics to applied mathematics, operations research, and statistics. The department offers bachelors, masters, and Ph.D. degrees in mathematics, and plays an important role in teaching mathematics to students in other disciplines. Faculty and students are also involved in a number of research projects, many of them in conjunction with researchers in other departments at Tech and at other institutions.

There are career opportunities for mathematics students at both the bachelor's and master's levels. Students in mathematics can prepare for actuarial careers, careers in education, and careers in a number of industries, including telecommunications, aerospace, information technology, and financial engineering.

Preparation for a career in industry should include a broad background in mathematics, modeling skills, computer skills, expertise in an area outside mathematics, and communication skills. Degree requirements are designed to help students develop these important abilities.

Mathematics can also be studied in preparation for more advanced work in a variety of fields including pure mathematics, applied mathematics, operations research, statistics, scientific computing, and business administration. Many students choose to combine a major in mathematics with a major in a second field such as management, computer science, engineering, or physics. A strong background in mathematics can be very helpful in graduate studies.

Students in the mathematics department at both the undergraduate and graduate level have many opportunities to interact with faculty and participate in a variety of mathematical activities. The department has weekly seminars in which faculty, graduate students, and visitors present their research. Both undergraduates and graduates are involved in research projects.

Many students are employed by the department as graders, lab facilitators, teaching assistants, and research assistants. Undergraduate students regularly compete in the

William Lowell Putnam mathematics competition and in the COMAP contest in mathematical modeling.

Undergraduate Program

Bachelor of Science in Mathematics

Minimum credit hours required—120

In addition to the General Education and Institute Core Curriculum (page 80), the following courses are required:

Introduction to Computer Science: CSE 113 (4) CSE 107 (4) or ES 111 (3) or EE 251 (3)

Basic Mathematics: MATH 2532 (4), 2420 (3), 335 (3), 336 (3), 352 (3), 372 (3), 382 & 382L (4), 454 (3)

Mathematical Modeling: MATH 430 (3)

Mathematics Electives: Four courses from at least two of the following areas:

- Applied Mathematics: 410 (3), 411 (3), 435 (3), 436 (3), 437 (3), 438 (3)
- Pure Mathematics: 442 (3), 455 (3), 461 (3), 471 (3), 472 (3)
- Operations Research and Statistics: 415 (3), 441 (3), 483 (3), 484 (3) 486 (3), 488 (3)

Electives outside mathematics: A minor in another department or at least 18 related credit hours outside mathematics approved by the advisor. These 18 hours may include classes fulfilling other general education or degree requirements.

Science or Engineering Elective: Eight (8) credit hours from the science and engineering disciplines beyond the general degree requirements.

Minimum of 120 credit hours' coursework: Electives to complete the minimum of 120 credit hours.

Sample Curriculum for the Bachelor of Science in Mathematics

Sample Curriculum Notes: General education requirements should be fulfilled as early as possible. The sequence MATH 352, 372 is a key prerequisite to many advanced courses and should be taken as early as possible, in no case later than the junior year

Semester 1

- | | |
|----|--|
| 4 | MATH 1510 & 1510L (calculus I) |
| 4 | CHEM 1215, 1215L, 1215 R (general chemistry) |
| 4 | Science/Engineering Elective |
| 3 | ENGL 1110 (college English) |
| 15 | Total credit hours |

Semester 2

- | | |
|----|---|
| 4 | MATH 1520 (calculus II) |
| 4 | CHEM 1215, 1215L, & 1215R (general chemistry) |
| 4 | Science/Engineering Elective |
| 3 | ENGL 1120 (college English) |
| 15 | Total credit hours |

Semester 3

- | | |
|---|-------------------------------------|
| 3 | MATH 2420 (intro to linear algebra) |
| 4 | MATH 2532 (calculus) |
| 5 | Phys 1310 & 1310L |

- ___3 Elective out of Math
15 Total credit hours

Semester 4

- 3 MATH 335 (ordinary differential equations)
3 MATH 352 (basic concepts)
5 PHYS 1320 & 1320L (general)
3 or 4 CSE 113 or ES 111

- ___3 Elective outside of Math
17-18 Total credit hours

Semester 5

- 3 MATH 372 (basic concepts of analysis)
3 MATH 336 (intro to partial differential equations)
4 MATH 382 & 382L (probability & statistics)
3 Humanities/Social Science/Fine Arts

- ___3 Elective outside of Math
16 Total credit hours

Semester 6

- 3 MATH 454 (linear algebra)
3 ENGL 341 (technical writing)
3 Math Elective
3 Humanities/Social Sciences/Fine Arts

- ___3 Elective outside of Math
15 Total credit hours

Semester 7

- 3 MATH 430 (mathematical modeling)
3 Math Elective
3 Humanities/Social Science/Fine Arts
3 Humanities/Social Science/Fine Arts

- ___3 Elective outside of Math
15 Total credit hours

Semester 8

- 3 Math Elective
3 Math Elective
3 Humanities/Social Science/Fine Arts
3 Humanities/Social Science/Fine Arts

- ___3 Elective Outside of Math
15 Total credit hours

Choice of electives must include courses for approved 18-hour sequence. It is strongly recommended that elective choices include advanced science and/or a foreign language.

Minor in Mathematics

Minimum credit hours required—18

The following courses are required:

- MATH 2420 (3) or MATH 337 (3), 335 (3), 352 (3), 382 (3)
- Six (6) additional hours of upper-division mathematics

Graduate Program

Master of Science in Mathematics

A program fulfilling the general requirements must be completed. Two basic plans are offered: for the program without thesis, MATH 590 (three credit hours) must be completed; for the program with thesis, MATH 591 (six credit hours) must be completed. The student must fulfill the requirements for the undergraduate program in mathematics. In addition, the student must fulfill the requirements of one of

the following three specializations. Students interested in continuing for the PhD in Applied and Industrial Mathematics should take care to choose their courses so that they will fit that program as well.

Accelerated Master's Degree Program in Mathematics (Minimum 150 credit hours)

Accelerated Master's Degree Program in Mathematics (Minimum 150 credit hours) The Accelerated Master Degree program provides the opportunity to obtain a BS and MS degree in Mathematics in five years. Accepted students may apply at most 12 credits from 500-level courses towards both their undergraduate and graduate degrees. It is recommended to apply to the program after completion of Math 352 and before enrolling in any graduate courses. The student will work with a professor in the Mathematics Department who will assist the student in developing the course of study and advise the student on their master's thesis or independent study.

Master of Science in Mathematics with Specialization in Industrial Mathematics [Total : 30 cr hrs. of which six credit hours must be approved upper-division or graduate course work from another department]

Industry and business provide many areas for the application of advanced mathematics, and many possibilities for mathematicians to make significant contributions. New Mexico Tech offers a program to prepare students for these opportunities. Students need a basic background in numerical analysis, differential equations, and statistics at the undergraduate level. The graduate requirements are:

- 1) Modeling courses (3 credits): MATH 430 (Mathematical Modeling); MATH 530 (Modeling Case Studies)
- 2) Core industrial mathematics courses (6 credits)—two of the following: MATH 511 (Numerical Methods); MATH 518 (Nonlinear Programming); MATH 532 (Perturbation Methods); MATH 535 (Mathematical Physics); MATH 587 (Time Series)
- 3) A concentration of four related courses (12 credits), at least two at the 500-level (beyond the two in requirement 2) and at least two in one other department, and additional courses to satisfy the general requirements of the Master of Science degree. The courses to satisfy this requirement must be approved by the student's advisory committee.
- 4) Each student spends one term, usually summer, in an internship in an industrial position. This internship is arranged by the student, with the approval of the student's advisory committee and should involve mathematical modeling, computation and analysis.

Master of Science in Mathematics with Specialization in Operations Research and Statistics [Total 30 cr hrs. of which six credit hours must be approved upper - division or graduate course work from another department]

An interdisciplinary program in operations research and statistics is available at the graduate level within the various

departments at New Mexico Tech. To specialize in this area, the student must fulfill the requirements for the undergraduate program in mathematics and complete MATH 415, 483, and one of either MATH 486, 488 or 582 or the equivalent.

Graduate work would consist of:

- 1) A minimum of 12 credit hours from MATH 515, 516, 517, 518, 519, 520, 541, 582, 583, 586, 587, 588. At least one course (three credit hours) must be chosen from MATH 515, 517, or 518.
- 2) Additional courses subject to the approval of the student's advisor to complete the requirements of the Graduate School. Related courses include ES 316; MGT 462, 472, 473; CSE 464, 565, and 567.

Master of Science in Mathematics with Specialization in Analysis [Total: 30 cr hrs. of which six credit hours must be approved upper-division or graduate course work from another department.]

To specialize in this area the student must fulfill the requirements of the undergraduate program in mathematics and complete Math 435 and Math 471 or the equivalent.

Graduate work consists of:

- 1) A minimum of 12 credits from Math 531, 533, 534, 535, 536, 537, 542, 575, 576, and 577.
- 2) Additional courses subject to the approval of the student's advisor to complete the requirements of the Graduate School.

Doctor of Philosophy in Mathematics with Dissertation in Applied and Industrial Mathematics

Students of exceptional ability, as demonstrated in a master's degree program or in previous courses, may pursue a program leading to the doctoral degree. Although the master's degree is not a requirement for the Ph.D. degree, the experience gained in writing a master's thesis or independent study project is valuable.

Degree Requirements

- Up to 30 hours from a master's degree, excluding thesis and S/U courses, may be included.
- 48 hours of coursework approved by the student's advisory committee, including:
- Preliminary preparation courses may be taken: MATH 410, 411, 435, 437, 438, 471, 483, 486
- 500-level MATH courses (30 credit hours) consisting of:
 1. MATH 530, 532
 2. Three courses from MATH 511, 518, 535, 538, 539, 577, 582.
 3. Three or more of the remaining classes are to be additional core classes from the list above or courses from MATH 509, 510, 512, 519, 520, 531, 533, 536, 537, 583, 584, 586, 587, 588.
- 12 hours of upper-division or graduate-level courses from outside the math department
- Dissertation (24 credit hours): MATH 595

PhD Prelim Exam:

Preliminary exams consist of the following: Differential Equations (MATH 437 and 438), Analysis (Math 372, 435, and 471), Numerical Analysis (Math 410 and 411), and Probability and Statistics (MATH 483 and 486).

A student may choose any three areas listed above and must pass all three preliminary exams by the end of the student's fourth semester to continue in the program. A student who does not pass a preliminary exam after two attempts will be terminated from the PhD program.

Graduate Minor in Applied & Industrial Mathematics

The following courses are required:

- | | |
|------------|--|
| MS Level: | Two of Math 430, 437, 438 and Two of Math 530, 531, 532, 533, 535, 537, 538, 539 |
| PhD Level: | MS requirements plus two more of the listed 500 level courses |

Graduate Minor in Operations Research & Statistics

The following courses are required:

- | | |
|------------|--|
| MS Level: | Math 415, 483, and Two of Math 515, 516, 517, 518, 519, 520, 541, 582, 583, 586, 587, 588. |
| PhD Level: | MS requirements plus two more of the listed 500 level courses |

Graduate Minor in Numerical Analysis

The following courses are required:

- | | |
|------------|--|
| MS Level: | Math 410, 411, and Two of Math 510, 511, 512, 513 |
| PhD Level: | MS requirements plus two more of the listed 500 level courses |

Graduate Minor in Analysis

The following courses are required:

- | | |
|------------|---|
| MS Level: | Math 435, 442, 471, and Two of Math 531, 533, 534, 535, 536, 537, 575, 576, 577 |
| PhD Level: | MS requirements plus two more of the listed 500 level courses |

Mathematics Courses:

MATH 1215, Intermediate Algebra 3 cr

A study of linear and quadratic functions, and an introduction to polynomial, absolute value, rational, radical, exponential, and logarithmic functions. A development of strategies for solving single-variable equations and contextual problems.

MATH 1220, College Algebra, 3 cr

Prerequisites: ACT math score of at least 21 or MATH 1215 passed with a grade of C- or better

The study of equations, functions and graphs, reviewing linear and quadratic functions, and concentrating on polynomial, rational, exponential and logarithmic functions.

MATH 1230, 1230D, Trigonometry, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: ACT math score of at least 25 or MATH 1220 passed with a grade of C- or better or a score of at least 20/25 on the advanced portion of the placement test

A study of plane trigonometry including the definitions of the fundamental trig functions using right angle triangle and unit circle approaches. Trig functions of any real number will be evaluated and the functions graphed along with their transformations. Trigonometric identities will be developed and demonstrated including multiple angle identities and identities developed from them. Inverse Trigonometric functions will be developed and used to solve trigonometric equations. Trigonometric applications will be solved using right angle trigonometry and the laws of sines and cosines. Trigonometric methods will be applied to complex numbers and the use of 2D vectors and vector dot products.

MATH 1240, 1240D, Pre-Calculus, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite or Corequisite: MATH 1230, or a prerequisite of a score of at least 24/30 on the trig and elementary functions placement test

This course extends students' knowledge of polynomial, rational, exponential and logarithmic functions to new contexts, including rates of change, limits, systems of equations, conic sections, and sequences and series.

Math 1430, Application Of Calculus I, 3 cr,

Prerequisite: Adequate scoring on the Mathematics Placement Exam, or any ACT/SAT and GPA combination that is considered equivalent, or a C- or better in Math 1220 or higher.

An algebraic and graphical study of derivatives and integrals, with an emphasis on applications on business, social science, economics and sciences.

MATH 1510, Calculus and Analytic Geometry I, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: MATH 1230 and 1240 or the equivalent passed with grade C- or better; or ACT Math score of at least 30 or SAT Math score of at least 670 or SAT Redesign Math score of at least 700; or a score of at least 20 on the calculus readiness math placement test; or MATH 1230 and either ACT Math score of at least 26 or SAT Math score of at least 590 or SAT Redesign Math score of at least 610.

Introduces the intuitive numerical and theoretical concepts of limits, continuity, differentiation and integration. Includes the study of extrema, curve sketching, and applications involving algebraic, exponential, logarithmic and trigonometric functions.

Designed for mathematics, science and engineering majors.

MATH 1520, Calculus and Analytic Geometry II, 4 cr, 4 cl hrs,

Prerequisites: MATH 1510 passed with grade C- or better

Continuation of MATH 1510.

Continues course of study begun in Calculus I. Covers integration techniques, numerical integration, improper integrals, some differential equations, sequences, series and applications.

MATH 2350, Statistical Methods, 3 cr, 3 cl hrs, 1.5 lab hrs

Prerequisites: MATH 1220 or higher

Exploratory data analysis. Introduction to probability, random variables and probability distributions. Concepts of Central Limit Theorem and Sampling Distributions such as sample mean and sample proportion. Estimation and hypothesis testing single population parameter for means and proportions and difference of two population parameters for means and proportions. Analysis categorical data for goodness of fit. Fitting simple linear regression model and inference for regression parameters. Analysis of variance for several population means. Techniques in data analysis using statistical packages. Techniques in data analysis using statistical computer packages.

MATH 2420, Introduction to Linear Algebra, 3 cr, 3 cl hrs, 1.5 lab hrs

Prerequisite: MATH 1510 passed with grade C- or better

An introductory study of the analysis and applications of systems of linear equations, vector spaces, matrices, and linear transformations, including computer-based linear algebra.

MATH 2532, Calculus and Analytic Geometry III, 4 cr, 4 cl hrs

Prerequisite: MATH 1520 passed with grade C- or better

Vectors and vector operations in two and three dimensions, partial differentiation, multiple integration, topics in vector calculus in two and three dimensions.

Math 289 Vector Calculus, 1 cr

Prerequisite: MATH 2530

offered during spring, summer, and fall semesters.

Students enrolled in Math 289, will attend the last ¼ of Math 2532.

An introduction to topics in two and three dimension of vector calculus such as curl and divergence, line integrals and surface integrals, the Fundamental Theorem of Line Integrals, Green's Theorem, Stokes' Theorem and the Divergence Theorem will be covered.

MATH 332, Vector Analysis, 3 cr, 3 cl hrs

Prerequisite: MATH 2532 passed with grade C- or better

Scalar and vector fields, gradient, divergence, curl, del operator, general orthogonal curvilinear coordinates, line integrals, surface and volume integrals, divergence theorem, Green's theorem, Stokes's theorem, applications.

MATH 335, Ordinary Differential Equations, 3 cr, 3 cl hrs

Prerequisite: MATH 1520 passed with grade C- or better

Solution methods for first order ordinary differential equations of various types, including separable, linear, Bernoulli and exact. Solution methods for second (and higher) order linear differential equations with constant coefficients. Series solutions. Laplace transforms. Applications.

MATH 335L, Ordinary Differential Equations Computer Lab, 1 cr, 1 cl hr

Corequisite: MATH 335 or equivalent.

Optional lab to accompany MATH 335. Basic introduction to the "Maple" syntax required to solve ordinary differential equations with computers. Emphasis on modeling, using graphing capabilities to illustrate how responses (solutions) are influenced by changes in the initial data and physical parameters.

MATH 336, Introduction to Partial Differential Equations, 3 cr, 3 cl hrs

Prerequisites: MATH 2532, 335, and one of MATH 2420 or MATH 337, each passed with grade C- or better

Orthogonal functions, Sturm-Liouville theory, Fourier series and integrals, heuristic derivation of examples of partial differential equations taken from heat conduction, vibration problems, electromagnetism, etc.; separation of variables, application to boundary value problems.

MATH 337, Engineering Mathematics, 3 cr, 3 cl hrs

Prerequisites: MATH 2532

Corequisite: MATH 335

Selected topics from linear algebra are discussed, including vectors, matrices, determinants, Gaussian elimination, vector spaces and basis as well as Eigenvalues, eigenvectors and diagonalization of matrices. Of particular interest will be linear algebra techniques which are utilized of solving systems of (linear) algebraic equations and solving systems of coupled ordinary differential equations using Laplace transforms and linear algebra tools.

MATH 352, Basic Concepts of Mathematics, 3 cr, 3 cl hrs

Prerequisite: MATH 1520 passed with grade C- or better

Mathematical proofs, set theory, mathematical induction and recursion, relations and binary operations, functions, definition and development of some common number systems, cardinal numbers, abstract algebra.

MATH 372, Basic Concepts of Analysis, 3 cr, 3 cl hrs

Prerequisite: MATH 352 or equivalent passed with grade C- or better

Real numbers, sequences, limits, continuity, uniform continuity, differentiation, Riemann integral.

MATH 382, Probability and Statistics, 3 cr, 3 cl hrs

Prerequisite: MATH 1520 passed with grade C- or better

Exploratory data analysis, random variables, estimation and hypothesis testing, linear regression and analysis of variance, basic concepts of discrete and continuous probability distributions, bivariate probability distribution functions, expected values, moment generating function and weak law of large numbers. Uses of the central limit theorem and its applications. This course provides an introduction to probability theory and statistical inference. The theory of probability is the primary mathematical tool used in statistical inference and therefore this course will concentrate heavily on probability and statistics. The course has been designed for computer science and engineering students; however, it is broad enough for students from outside these disciplines.

MATH 382L, Probability and Statistics Lab, 1 cr, 1 cl hrs

Corequisite: MATH 382 or equivalent

Entering data, descriptive statistics, graphing data, cross tabulation, hypothesis testing, and calculation of probabilities from different probability distributions. Each lab introduces a problem, provides some scientific background, suggests investigations for the data, and provides a summary of the theory used in the investigations.

MATH 383, Introduction to Biostatistics, 3 cr, 3 cl hrs

Prerequisite: Math 1520 passed with a grade of C- or better

This course covers the fundamental statistical concepts related to the practice of public health: descriptive statistics, design of biological research studies, probability, sampling, statistical distributions, confidence intervals, hypothesis testing, comparison of means and proportions, chi-squared tests, one-way & two-way ANOVA, simple and multiple linear regression, Fisher's Exact test and Mantel-Hansel test for comparing several 2x2 tables. The course also uses the R statistical software and includes many applications of statistics to health sciences and medical studies, emphasizing concepts and interpretation of results. Optional topics: principal components and factor analysis.

MATH 391, Special Studies, hrs and cr to be arranged**MATH 401, Putnam Competition, 1 cr, 1 cl hr**

Graded S/U

Students in this course will prepare for and then participate in the annual William Lowell Putnam Competition in mathematics. In preparation for the competition, students will learn problem-solving strategies and practice on problems from previous competitions. May be taken multiple times for credit.

MATH 410, Numerical Methods, 3 cr, 3 cl hrs

Prerequisite: CSE 107, CSE 113, ES 111, or EE 251
Corequisite: MATH 335

Floating point arithmetic, solution of linear and nonlinear systems of equations, interpolation, approximation, numerical differentiation and integration, numerical solution of ordinary differential equations.

MATH 411, Numerical Linear Algebra, 3 cr, 3 cl hrs

Prerequisites: MATH 2420; CSE 107, CSE 113, ES 111, or EE 251

Direct and iterative methods for solving linear systems, conditioning and stability, methods for computing eigenvalues and eigenvectors, linear least squares problems, singular value decomposition, computational cost, and implementation of algorithms.

MATH 415, Introduction to Operations Research: Linear Programming, 3 cr, 3 cl hrs

Prerequisite: MATH 2420 passed with grade C- or better
Linear Programming, applications of LP, the simplex method, duality theory, computational complexity of LP, interior point methods.

MATH 430 Mathematical Modeling, 3 cr, 3 cl hrs

Prerequisites: MATH 335; one of MATH 2420 or MATH 337; MATH 382, each passed with grade C- or better
Corequisite or Prerequisite: MATH 336 passed with grade C- or better

Introduction to the process of developing, analyzing, and refining mathematical models. Deterministic and probabilistic models considered for both discrete and continuous problems. Applications to a variety of fields. *Shares lectures with MATH 530, with additional work for the graduate level. (cross-listed with Math 530)*

MATH 435, Complex Analysis, 3 cr, 3 cl hrs

Prerequisite: MATH 336 passed with grade C- or better
Algebra of complex numbers, analytic functions and Cauchy-Riemann equations, complex integration and Cauchy's theorem, integral formulae, power series, residues and contour integration, analytic continuation, Riemann surfaces.

MATH 436, Applications of Complex Analysis, 3 cr, 3 cl hrs

Prerequisite: MATH 435 passed with grade C- or better
Topics selected from linear ordinary differential equations in the complex plane, special functions, conformal mapping, Laplace transform, Fourier and Hilbert transforms.

MATH 437, Systems of Ordinary Differential Equations, 3 cr, 3 cl hrs

Prerequisites: MATH 2420 or MATH 337, and 335, each passed with grade C- or better

Theory and application of systems of ordinary differential equations, linear and nonlinear systems, two-dimensional autonomous systems, stability, periodic solutions and limit cycles, interspecies competition and predator/prey problems, pendulum equation, Duffing equation, Van der Pol equation, Lienard equation.

MATH 438, Partial Differential Equations, 3 cr, 3 cl hrs

Prerequisite: MATH 336 passed with grade C- or better
Classification of classical partial differential equations of mathematical physics, boundary conditions, uniqueness theorems, first and second order equations,

characteristics, boundary value problems, Green's functions, maximum principle.

MATH 441, Statistical Machine Learning (cross-listed as Math 541) 3 cr, 3 cl hrs

Prerequisite: MATH 382 and MATH 2420 or consent of the instructor

Basics of statistical learning. Data visualization. Linear, nonlinear and logistic regression, variable selection and regularization. Linear classification methods. Smoothing methods. Tree-based methods. Support vector machines. Unsupervised learning: principal components analysis and clustering. The R and/or Python software will be used

MATH 442, Introduction to Differential Geometry, 3 cr, 3 cl hrs

Prerequisite: MATH 2420 and MATH 2532 passed with grade C- or better

Introduction to the theory of manifolds, vector fields, tensors, differential forms, exterior derivative, integration of differential forms Stokes' theorem, Lie derivative, covariant derivative, connection, curvature, tensor analysis, geodesics.

MATH 454, Linear Algebra, 3 cr, 3 cl hrs

Prerequisites: MATH 2420 and 352, each passed with grade C- or better

Vector spaces, linear transformations, linear systems, eigenvalues and eigenvectors, Jordan canonical forms, inner product spaces, least squares problems, normal, unitary, and Hermitian transformations.

MATH 455, Introduction to Abstract Algebra, 3 cr, 3 cl hrs each semester

Prerequisite: MATH 352 passed with grade C- or better

A study of abstract algebraic structures, semi-groups, groups, rings, ideals, integral domains, fields, vector spaces, field extensions.

MATH 471, 472, Introduction to Analysis, 3 cr, 3 cl hrs each semester

Prerequisite: MATH 372 passed with grade C- or better

Basic concepts of the real-number system, elements of point-set theory, infinite sequences, limits, continuity, differentiation of functions of one variable, Riemann-Stieltjes integral, series, functions of several variables.

MATH 483, Mathematical Statistics, 3 cr, 3 cl hrs

Prerequisite: MATH 382 passed with grade C- or better

Introduction to decision theory. Multivariate distributions. Sampling distributions for the normal case. Convergence of random variables. Different methods of estimation. Principles of hypothesis testing.

MATH 484, Reliability and Quality Control, 3 cr, 3 cl hrs

Prerequisite: MATH 382 passed with grade C- or better

Order statistics, testing and estimation for common lifetime distributions in reliability, accelerated life tests, Bayesian methods in reliability. Statistical techniques of industrial quality control, sampling methods, control charts. Applications in industry.

MATH 486, Introduction to Stochastic Processes, 3 cr, 3 cl hrs

Prerequisites: MATH 2420 and 382, each passed with grade C- or better

Conditioning. The Poisson process. Theory of Markov chains, continuous time Markov and semi- Markov processes. Topics from renewal theory and Markov renewal theory. Queuing Theory. Applications in science and engineering.

MATH 488, Introduction to Operations Research: Probabilistic Methods, 3 cr, 3 cl hrs

Prerequisite: MATH 382, passed with grade C- or better
Monte Carlo Simulation Theory. Application of simulation to problems in science, engineering, and business. Queuing systems simulation. Inventory theory.

MATH 491, Directed Study, hrs and cr to be arranged

MATH 500, Directed Research, hrs and cr to be arranged

MATH 501, 502, Professional Development Seminar, 3 cr, 3 cl hrs each semester

A seminar in which students will develop skills in problem solving, communication, and research. Students will be expected to actively participate in the seminar by attending presentations, solving assigned problems, and preparing written and oral presentations. Graded S/U.

MATH 503, Graduate Seminar, 0-1 cr, 1 cl hr

Prerequisite: Graduate standing.
Attend and participate in departmental seminars. Graded on an S/U basis.

MATH 509 Graduate Internship, credit to be arranged

Prerequisite: Graduate standing

MATH 510 Computational Fluid Dynamics, 3 cr, 3 cl hrs

Prerequisite: MATH 336, 410 or equivalent; passed with a C- or better
Equations of fluid dynamics, flow models, discretization, analysis of numerical schemes, numerical methods for basic partial differential equations, numerical methods for inviscid and viscous flows.

MATH 511, Numerical Methods for Partial Differential Equations, 3 cr, 3 cl hrs

Prerequisite: MATH 410 or equivalent; passed with a C- or better
Finite difference or finite element methods for parabolic, hyperbolic and elliptic partial differential equations; implementation, approximation, stability, and convergence.

MATH 512, Numerical Methods for Wave Propagation, 3 cr, 3 cl hrs

Prerequisite: MATH 410 or equivalent; passed with a C- or better
Finite volume methods for hyperbolic partial differential equations; Riemann problems; Godunov's and Roe's methods; high resolution methods; applications.

MATH 513, Advanced Topics in Numerical Analysis, 3 cr, 3 cl hrs

Prerequisite: MATH 410 or equivalent; passed with a C- or better

Topics chosen from areas in numerical analysis, numerical partial differential equations, and numerical linear algebra. May be taken multiple times for credit.

MATH 515, Topics in Deterministic Operations Research, 3 cr, 3 cl hrs

Prerequisite: MATH 415 or consent of instructor and advisor; passed with a C- or better
Study of a special topic in deterministic operations research. May be taken multiple times for credit.

MATH 516, Topics in Stochastic Operations Research, 3 cr, 3 cl hrs

Prerequisites: MATH 486 or consent of instructor and advisor; passed with a C- or better
Study of a special topic in stochastic operations research. May be taken multiple times for credit.

MATH 517, Combinatorial Optimization, 3 cr, 3 cl hrs

Prerequisite: MATH 415 or consent of instructor and advisor; passed with a C- or better
Maximum flow, shortest path, and minimum cost flow problems on networks. Matching. Matroids. Cutting plane and branch and bound methods for integer programming. Computational complexity of combinatorial optimization problems.

MATH 518, Convex Optimization and Nonlinear Programming, 3 cr, 3 cl hrs

Prerequisite: MATH 410 or 415 or consent of instructor and advisor; passed with a C- or better
Theory and applications of constrained and unconstrained optimization, convexity, Lagrangian duality theory, Newton and quasi-Newton methods, first order methods.

MATH 519, 519D, Inverse Problems, 3cr, 3 cl hrs

Prerequisite: MATH 335 or consent of instructor and advisor; passed with a C- or better
Theory and practice of the various techniques of inverting geophysical data to obtain models. Primary emphasis is on the understanding and use of linear inverse techniques. (Same as GEOP 529.)

MATH 520, Applied Multivariate Analysis, 3 cr, 3 cl hrs

Prerequisite: MATH 382; MATH 483; passed with a C- or better
Multivariate normal distribution and tests assessing multivariate normality. Estimation and hypotheses testing regarding the parameters of multivariate normal populations. Principal component analysis, factor analysis, canonical correlations analysis, classification and discriminant analysis, cluster analysis, multivariate linear models, and multivariate analysis of variance and covariance. Applications in science and engineering.

MATH 530 Mathematical Modeling, 3 cr, 3 cl hrs

Prerequisites: MATH 335; one of MATH 2420 or MATH 337; MATH 382, each passed with grade C- or better
Corequisite or Prerequisite: MATH 336 passed with grade C- or better
Introduction to the process of developing, analyzing, and refining mathematical models. Deterministic and probabilistic models considered for both discrete and

continuous problems. Applications to a variety of fields. Shares lectures with MATH 430, with additional work for the graduate level (MATH 530 students will complete an additional term project). **Cross-listed as MATH 430**

MATH 531, 531D, Topics in Ordinary Differential Equations, 3 cr, 3 cl hrs each semester

Prerequisite: MATH 437 or equivalent; passed with a C– or better

Study of a special topic in ordinary differential equations not usually treated. Normally one related to a field of research interest at Tech. May be taken multiple times for credit.

MATH 532, 532D, Perturbation Methods, 3 cr, 3 cl hrs

Prerequisite: MATH 437 or equivalent; passed with a C– or better

A survey of expansion techniques. Regular and singular perturbations. Poincaré-Linstedt method. Matched asymptotic expansions. Multiple scales.

MATH 533, 534, Topics in Partial Differential Equations, 3 cr, 3 cl hrs each semester

Prerequisite: MATH 438 or equivalent; passed with a C– or better

Study of a special topic in partial differential equations not usually treated. Normally one related to a field of research interest at Tech. May be taken multiple times for credit.

MATH 535, 536, Methods of Mathematical Physics, 3 cr, 3 cl hrs each semester

Prerequisite: MATH 372 or consent of instructor and advisor; passed with a C– or better

Hilbert spaces, orthonormal systems, spectral theory of self-adjoint operators, integral equations, ordinary and partial differential operators, distributions and fundamental solutions, asymptotic expansions, Laplace method, stationary phase method, asymptotic expansion of fundamental solutions, mathematical foundations of quantum mechanics.

MATH 537, 537D, Bifurcation Theory, 3 cr, 3 cl hrs

Prerequisite: MATH 437 or equivalent; passed with a C– or better

Discrete and continuous models. Nonlinear buckling, expansion of the bifurcated solution, stability analysis, Hopf bifurcation, degree theory, the Rabinowitz theorem, and other topics.

MATH 538, 538D, Wave Phenomena, 3 cr, 3 cl hrs

Prerequisite: MATH 438 or equivalent or consent of instructor and advisor; passed with a C– or better

Hyperbolic and dispersive waves. Characteristic methods, breaking and shock fitting, and weak solutions. Examples drawn from water waves, traffic flow problems, supersonic flight, and other areas.

MATH 539, 539D, Fluid Dynamics, 3 cr, 3 cl hrs

Prerequisite: MATH 438 or equivalent; passed with a C– or better

The Navier-Stokes equations, inviscid flow, irrotational

fluids, viscosity, and turbulence. Other topics as time and interest permit.

MATH 540, Calculus of Variations, 3 cr, 3 cl hrs

Prerequisite: MATH 437 or graduate standing; passed with a C– or better

Development of the classical theorems of Calculus of Variations, applications, some numerical approaches. Includes Euler equations, broken extremals and the Weierstrass-Erdmann conditions, the second variation and Hamilton-Jacobi equation, the Weierstrass E-function, and the Ritz method.

MATH 541, Statistical Machine Learning (cross-listed as MATH 441) 3cr, 3 cl hrs

Prerequisites: MATH 382 and MATH 2420 or consent of the instructor

Basics of statistical learning. Data visualization. Linear, nonlinear and logistic regression, variable selection and regularization. Linear classification methods. Smoothing methods. Tree-based methods. Support vector machines. Unsupervised learning: principal components analysis and clustering. The R and/or Python software will be used. Shares lectures with Math 441, with additional work for the graduate level (Math 541 students will have extra in-depth questions on the homework and stronger requirements for the final project).

MATH 542, Topics in Differential Geometry, 3 cr, 3 cl hrs

Prerequisite: MATH 442 or consent of instructor and advisor; passed with a C– or better

Study of advanced topics in differential geometry such as: Brouwer degree, fundamental group, homology groups, De Rham cohomology, Betti numbers, fibre bundles, Morse theory, Lie groups, covering spaces, homotopy groups. May be taken multiple times for credit.

MATH 575, 576, Functions of a Real Variable, 3 cr, 3 cl hrs each semester

Prerequisites: MATH 471, 472; MATH 461 or MATH 561 recommended; passed with a C– or better

Topological concepts, category, measure theory, Lebesgue measure and integration, derivatives and the Radon-Nikodym theorem, product spaces and measures, function spaces, normed linear spaces.

MATH 577 Functional Analysis, 3 cr, 3 cl hrs

Prerequisite: MATH 471 or equivalent; passed with a C– or better

Normed vector spaces, Banach spaces, Banach fixed point theorem. Lebesgue integral, Lebesgue measure. Hilbert spaces and orthonormal systems, strong and weak convergence. Linear operators on Hilbert spaces, self-adjoint operators, compact operators, spectral theory, Fourier transform. Applications to integral and differential equations, Fredholm theory. Distributions and partial differential equations, fundamental solutions, resolvent, Green's functions, weak solutions.

MATH 581, Directed Study, hrs and cr to be arranged

An advanced course offered on demand under the guidance of a senior staff member.

MATH 582, Linear Statistical Models with Applications, 3 cr, 3 cl hrs

Prerequisite: MATH 483 or consent of instructor and advisor; passed with a C– or better

An in-depth study of regression and analysis of variance models. Topics include multiple regressions and model building, analysis of residuals, analysis of variance as regression analysis, generalized linear models, generalized linear mixed models, nonlinear models, multi-factor models with equal and unequal sample sizes, random and fixed effects models, randomized complete block designs, and analysis of covariance. The statistical packages SAS and Minitab will be used for data analysis.

MATH 583, 584, Topics in Probability and Statistics, 3 cr, 3 cl hrs each semester

Prerequisites: MATH 483; MATH 486 or consent of instructor and advisor; passed with a C– or better

Advanced topics selected from linear regression analysis, the design of experiments, decision theory. Bayes and empirical Bayes procedures. Markov chains, Markov and semi-Markov processes, renewal theory. May be taken multiple times for credit.

MATH 586, 586D, Spatial Variability and Geostatistics, 3 cr, 3 cl hrs

Prerequisite: MATH 382; passed with a C– or better

Introduction to spatial and temporal variability. Stationary and intrinsic random fields, variograms and estimation. Kriging, co-kriging, and simulation of random fields. Conditioning and conditional simulation. Indicator kriging and simulation. Applications from hydrology, mining, petroleum engineering, and other fields of science and engineering.

MATH 587, 587D, Analysis of Time Series and Spatial Data, 3 cr, 3 cl hrs

Offered in alternate years on demand

An introductory overview of methods for analyzing temporal and spatial series with an emphasis on scientific applications. Linear systems in continuous and discrete time, Fourier analysis, spectral estimation, convolution and deconvolution, filtering, the z and Laplace transforms, stationary and nonstationary time series, ARIMA modeling, forecasting, and generalizations to multidimensional and multichannel applications. (Same as GEOP 505)

MATH 588, Advanced Data Analysis, 3 cr, 3 cl hrs

Prerequisite: MATH 483 or consent of instructor and advisor; passed with a C– or better

Topics include linear regression, inferential tools for regression, model checking and refinement, experimental design, repeated measures and other multivariate responses, comparisons of proportions or

odds, logistic regressions and power analysis. Principal components and factor analysis are also introduced.

MATH 590, Independent Study, cr to be arranged

Under the direction of a faculty member appointed by the department, the student shall prepare a paper making use of standard reference sources on some topic not covered by other course work.

MATH 591, Thesis (master's program), cr to be arranged**MATH 595 Dissertation (doctoral degree program), credit to be arranged**

Prerequisite: Successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.

Faculty Research Interests

- Aitbayev — Numerical Methods for Partial Differential Equations, Numerical Analysis
- Avramidi — Mathematical Physics, Analysis on Manifolds, Quantum Field Theory
- Borchers — Optimization, Inverse Problems
- Gonzalez-Parra — Applied Mathematics, Mathematical Biology, Dynamical Systems, Numerical Analysis
- Hossain — Multivariate Analysis, Survival Analysis, Estimation Reliability and Regression Diagnostics
- Kerr — Compact Models for Circuit Simulators, Applied Mathematics, Mixed Boundary Value Problems
- Makhnin — Stochastic Processes, Statistics
- Stone — Differential Equations, Mathematical Biology, Industrial Mathematics
- Orizaga — Applied Mathematics, numerical solutions to PDE's math modeling and application.
- Wang — Partial Differential Equations, Dynamical Systems, Applied Mathematics
- Zhang — Applied Mathematics, Mathematical Biology, Dynamical Systems and Differential Equations

Optical Science and Engineering

Advisory Board Members:

Fuierer (Materials Engineering)

Teare (Electrical Engineering)

Wedeward (Electrical Engineering)

Westpfahl (Physics)

Offered: Minor in Optical Science and Engineering

Students in the minor program in Optical Science and Engineering receive a broad introduction to optics as well as to specialized applications related to optical research activities on campus. The areas of research at New Mexico Tech include adaptive optics, interferometry, wavefront propagation, atmospheric turbulence, polarimetry and applications to directed energy, astronomy and communications.

The prime optical research site at New Mexico Tech is the Magdalena Ridge Observatory (MRO), a dedicated astronomical observatory that will support a large optical interferometer and a 2.4m single telescope. This facility provides a world-class facility for scientific research in optics, optical controls and astronomical science applications. On campus, the Etscorn Observatory provides access to commercial telescopes and imaging cameras.

A Tech student may earn a minor in Optical Science and Engineering as part of a Bachelor of Science degree. While fulfilling the requirements for a Bachelor of Science degree the student must complete a minimum of ten (10) hours of core optics courses, three (3) hours of electromagnetic theory, and at least five (5) additional hours from approved optional courses.

Minor in Optical Science and Engineering

Minimum credit hours required—18

- OPT 300 (4), OPT 400 (3), OPT 410 (3)
- One of: PHYS 333 (3); EE 332 (3); MTLS 447 (3)
- Two of: EE 351 (3), EE 324 (3), EE 431 (3); MTLS 441 (3), MTLS 452 (3); PHYS 334 (3), PHYS 444 (3); OPT 420 (3), OPT 430 (3), OPT 460 (3), OPT 490 (2).

Course Descriptions:

OPT 300, Introduction to Optics, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: PHYS 1320 or 132; MATH 2532

An introduction to geometrical optics, aberration theory, image formation, Fourier optics, radiometry and photometry and engineering practice in working with optical systems. The course will also introduce optical fabrication concepts and optical coatings.

OPT 400, Mathematical and Computational Optics, 3 cr, 3 cl hrs

Prerequisites: OPT 300; EE 271 or MATH 2420

A mathematical approach to optics introducing standard aberration and optical calculation techniques. Topics include paraxial optics, polarization matrices, Seidel aberrations, ray tracing and wavefront propagation through Materials. Students will be introduced to modern ray tracing tools.

OPT 410, Advanced Optics, 3 cr, 3 cl hrs

Prerequisite: OPT 400

Topics include image evaluation, wavefront propagation, mode analysis, interferometry, spectrometers, optical testing and multilayer dielectric coatings.

OPT 420, Interferometry and Optical Testing, 3 cr, 3 cl hrs

Prerequisite: OPT 400 or consent of instructor and advisor.

An advanced course in optical testing and interferometric systems.

OPT 430, Thin Films, 3 cr, 3 cl hrs

Prerequisite: OPT 400 or consent of instructor and advisor.

An advanced course in designing and using thin film coatings.

OPT 460, Optical Laboratory, 3 cr, 6 lab hrs

Prerequisite: OPT 300

An advanced laboratory in optics and photonic systems.

OPT 490, Special Topics in Optics, cr and topics arranged

Prerequisite: OPT 300

Special topics course in optics. Topics may include lasers, fiber optics, adaptive optics and other subjects of interest.

Physical Recreation

The Physical Recreation program provides students with the opportunity to take part in a wide variety of sports and activities. Classes entail basic skill instruction, and participation is required for credit.

PR classes are generally offered for one credit and are dependent upon student interest and the availability of instructors.

For a complete listing of current Physical Recreation offerings, visit <http://ced.nmt.edu> or call (575) 835.6581.

Physical Recreation Courses:

The following sample PR courses are graded S/U and may be used for elective credit only. Classes may be taken multiple times for credit.

PHED 1510C Weight Lifting 1 cr, 2 cl hrs

Introduction to basic principles and techniques of weight training

PHED 1230C Beginning Golf 1 cr, 2 cl hrs

Instruction in the basic skills, equipment, rules, etiquette and shot-making and use of irons and woods.

PHED 206C Intermediate Golf 1 cr, 2 cl hrs

Prerequisite: PR 106C or consent of instructor and advisor.

Instruction emphasizing actual play

PHED 110C Volleyball 1 cr, 2 cl hrs

Introduction to basic skills, rules, and strategies

PHED 1210C Basketball 1 cr, 2 cl hrs

Instruction and practice of game skills in a team setting

PHED 1290C Indoor Soccer 1 cr, 2 cl hrs

Instruction and practice of basic skills in an indoor setting

PHED 1410C Beginning Yoga 1 cr, 2 cl hrs

Introductory practices focus on alignment, strength, breath relaxation, and restoration

PHED 121C Gentle Yoga 1 cr, 2 cl hrs

Focus on stress reduction, body/breath awareness and flexibility

PHED 122C Slow Flow Yoga 1 cr, 2 cl hrs

Instruction supports structural integrity of spine, back and abdominals

PHED 123C Pilates Matwork 1 cr, 2 cl hrs

Designed exercise program involves the entire body while focusing on strengthening the core muscles of

the torso. Exercises promote coordination, balance and strength

PHED 1420C Stretch and Relaxation 1 cr, 2 cl

hrs Instruction emphasizes stretch and relaxation techniques

PHED 1140C Zumba 1 cr, 2 cl hrs

The trademark name for Salsa Aerobics instruction emphasizing exercise and cardiovascular endurance with the use of Latin music

PHED 1440C Tai Chi Chuan 1 cr, 2cl hrs

Instruction and practice in techniques to enhance body awareness, reduces stress, improve balance and increase strength.

PHED 1110C Beginning Belly Dance 1 cr, 2 cl hrs

Instruction in the basic moving steps and rhythms of the belly dance

PHED 160C Outdoor Rec 1 cr, 2 cl hrs

Prerequisite: Good Physical Condition and able to hike several miles on rough terrain.

Selected outdoor activities such as rappelling, rock climbing, paddling, caving, and hiking

PHED 1910C Beginning Rock Climbing 1 cr, 2 cl hrs

Introduction to basic climbing technique with an emphasis on safety, safe knot and belay

PHED 220C Intermediate Yoga 1 cr, 2 cl hrs

Prerequisite: PR 120C or consent of instructor and advisor.

Intermediate training and skill techniques in Yoga

PHED 2110C Intermediate Belly Dance 1 cr, 2 cl hrs

Instruction on the isolation and slow movements of Middle Eastern dance, including use of the veil and improvisation

PHED 261C Intermediate Rock Climbing 1 cr, 2 cl hrs

Prerequisite: PR 161C or consent of instructor and advisor

Continuation of safety, rope set-up, belaying lead climb, rappelling and anchor set-up

PHED 101C Weight Lifting for Women 1 cr, 2 cl hrs

Physics

Professors Creech-Eakman, Hofner, Minschwaner, Romero, Sessions, Sonnenfeld, Wells, Westpfahl, Young (Chair of Department)

Associate Professors Meier, Morales-Juberias

Assistant Professors Arendt, da Silva, Lopez Carrillo, Norris

Adjunct Faculty Avramidi, Buscher, Butler, Carilli, Dubey, Elias,

Elvis, Friesen, Gaulme, Goss, Haniff, Haertel, Jurgenson,

Kimball, Manney, Myers, Ott, Owen, Rison, Spargo, Swain,

Teare, D.Thomas, R.Thomas, Wozniak

Emeritus Professors Eilek, Hankins, Krehbiel, LeFebvre, Meason, Raymond, Schery, Winn

Research Associate Professor Fuchs

Degrees Offered: *B.S. in Physics and in Physics with options in Astrophysics, Atmospheric Physics; M.S. in Physics; M.S. in Physics with Concentration in Instrumentation; Ph.D. in Physics; Ph.D. in Physics with dissertation in Astrophysics, Atmospheric Physics, Instrumentation, or Mathematical Physics*

Departmental web site: <https://www.nmt.edu/academics/physics/index.php>

Students in the Department of Physics are encouraged to pursue a broad scientific background and to master theory as well as experiment. The fundamental courses are offered in the principal areas of physics—atomic and nuclear physics, classical mechanics, electricity and magnetism, optics, quantum mechanics, statistical physics, and thermodynamics. The department also offers several laboratory classes.

There is the opportunity for students to participate in research projects during the semesters and the summertime, over and above the class and lab work. Many undergraduate students become involved in faculty research and often co-author published papers.

There are two options to accompany the basic physics undergraduate degree: astrophysics or atmospheric physics. They are designed around the main research interests of the faculty, so students can take advantage of the expertise of the faculty and the facilities that are offered on or near the campus. In addition, we encourage students to consider a minor in computer science, electrical engineering or mathematics. Several of the faculty have expertise in these areas.

The areas of research in atmospheric physics include thunderstorm electricity, precipitation, cloud dynamics, large-scale atmospheric dynamics, atmospheric chemistry and climate, and the dynamics of planetary atmospheres.

The Langmuir Laboratory for Atmospheric Research, located on a mountaintop a one hour drive from the campus, offers an unparalleled opportunity for active undergraduate and graduate student participation in observation and research.

The atmospheric physics group also operates a Beowulf cluster for atmospheric modeling, the Lightning Mapping Array, E-field-A lightning interferometer networks, and an active scientific ballooning program

focused on charge motion and X-rays produced during storms. In addition, faculty members, as well as undergraduate and graduate students, participate in field programs that use the aircraft and radars of the National Center for Atmospheric Research (NCAR) in Boulder, Colorado.

Research in astrophysics includes pulsar radio emission, the dynamics and kinematics of nearby galaxies, radio galaxies, plasma astrophysics, stellar evolution and mass loss, and star formation. The Jansky Very Large Array (VLA) and Very Long Baseline Array (VLBA) radio telescopes, operated by the National Radio Astronomy Observatory (NRAO), are headquartered on campus and offer unique opportunities for research in radio astronomy for faculty and undergraduate and graduate students alike. In addition, New Mexico Tech's Magdalena Ridge Observatory Interferometer (MROI) is under construction. This last facility is already involving students in research and development activities, especially related to instrumentation.

Undergraduate Program

Bachelor of Science in Physics

Minimum credit hours required—120

In meeting the General Education Core Curriculum (page 78, physics majors must choose PHYS 1310 and 1320 and labs.

In addition, the following courses are required:

- PHYS 2250 (4), 2250L (1), 2251 (4), 2251L (1), 2420 (3), 2425 (3), 321 (3), 333 (3), 334 (3), 336L (1), 340 (3), 380 (1), 411 (3), 443 (3), 451 (2)
- MATH 2532 (4), 2420 (3), 332 (3), 335 (3), 336 (3), and three hours of approved upper-division courses
- Eight hours (with associated labs) from the disciplines of: Biology (BIOL), Earth Science (GEOL), Engineering (ChE, CE, EE, ENVE, MTLs, ES, MENG, ME, PETR), Computer Science Engineering (CSE), or PHYS 1410 (Introduction to Weather and Climate). No fewer than 8 credits are required in the lecture/lab pairs. If a lecture/lab pair is taken worth fewer than 4 credits, more than two pairs will need to be taken to satisfy the requirement.
- Language—three hours
- Electives—to complete 120 credit hours; in some instances, additional elective credit hours may be desired.

Sample Curriculum for the Bachelor of Science in Physics

Semester 1

5 PHYS 1310 & 1310L
 4 MATH 1510 (calculus)
 4 CHEM 1215 & 1215L (general)
 3 ENGL 1110 (college English)
 16 Total credit hours

Semester 2

5 PHYS 1320 & 1320L
 4 MATH 1520 (calculus)
 4 CHEM 1225 & 1225L (general)
 3 ENGL 1120 (college English)
 16 Total credit hours

Semester 3

- 5 PHYS 2250 & 2250L
- 3 PHYS 2420 (computational)
- 4 MATH 2532 (calculus)
- 3 MATH 2420 (linear algebra)
- 15 Total credit hours

Semester 4

- 5 PHYS 2251 & 2251L
- 3 PHYS 2425 (computational 2)
- 3 MATH 332 (vector analysis)
- 3 MATH 335 (ordinary differential equations)
- 1 Electives
- 15 Total credit hours

Semester 5

- 3 PHYS 321 (mechanics)
- 3 PHYS 333 (electricity & magnetism)
- 3 MATH 336 (intro to PDE's)
- 3 ENGL 341 (technical writing)
- 3 Social Science
- 16 Total credit hours

Semester 6

- 3 PHYS 334 (radiation and optics)
- 1 PHYS 336L (electrical & magnetic measurements lab)
- 3 PHYS 340 (quantum theory)
- 1 PHYS 380 (practicum in problem solving)
- 4 Biology/Earth Science/Engineering with lab
- 3 Social Science
- 15 Total credit hours

Semester 7

- 3 PHYS 411 (thermodynamics)
- 3 PHYS 443 (atomic and nuclear)
- 4 Biology/Earth Science/Engineering with lab
- 3 Humanities/Language
- 3 Social Science/Humanities/Fine & Creative Arts
- 16 Total credit hours

Semester 8

- 2 PHYS 451 (senior lab)
- 3 MATH Elective
- 3 Humanities/Language
- 3 Humanities/Social Science
- 1 Electives
- 12 Total credit hours

Bachelor of Science in Physics with Astrophysics Option

Minimum credit hours required—132

In meeting the General Education Core Curriculum (page 78), physics majors must choose PHYS 1310 and 1320 and labs. Requirements include the courses listed above for the Bachelor of Science Degree in Physics and the following courses:

PHYS 325 (3), 326 (3), 327L (1), 328L (1), 425 (3), 426 (3)

Sample Curriculum for the Bachelor of Science in Physics with Astrophysics Option*Semester 1*

- 5 PHYS 1310 & 1310L
- 4 MATH 1510 (calculus)
- 4 CHEM 1215 & 1215L (general)
- 3 ENGL 1110 (college English)
- 16 Total credit hours

Semester 2

- 5 PHYS 1320 & 1320L
- 4 MATH 1520 (calculus)
- 4 CHEM 1225 & 1225L (general)
- 3 ENGL 1120 (college English)
- 16 Total credit hours

Semester 3

- 5 PHYS 2250 & 2250L
- 3 PHYS 2420 (computational)
- 4 MATH 2532 (calculus)
- 3 MATH 2420 (linear algebra)
- 3 Humanities/Language
- 18 Total credit hours

Semester 4

- 5 PHYS 2251 & 2251L
- 3 PHYS 2425(waves)
- 3 MATH 332 (vector analysis)
- 3 MATH 335 (ordinary differential equations)
- 3 Humanities/Language
- 17 Total credit hours

Semester 5

- 3 PHYS 321 (mechanics)
- 4 PHYS 325 & 327L (astrophysics)
- 3 PHYS 333 (electricity & magnetism)
- 3 MATH 336 (intro to PDE's)
- 3 ENGL 341 (technical writing)
- 16 Total credit hours

Semester 6

- 4 PHYS 326 & 328L (astrophysics)
- 3 PHYS 334 (radiation and optics)
- 1 PHYS 336L (electrical & magnetic measurements lab)
- 3 PHYS 340 (quantum theory)
- 1 PHYS 380 (practicum in problem solving)
- 3 Social Science
- 15 Total credit hours

Semester 7

- 3 PHYS 411 (thermodynamics)
- 3 PHYS 425 (advanced astrophysics)
- 3 PHYS 443 (atomic and nuclear)
- 3 Humanities/Social Science
- 4 Biology/Earth Science/Engineering with lab
- 16 Total credit hours

Semester 8

- 3 PHYS 426 (advanced astrophysics)
- 2 PHYS 451 (senior lab)
- 3 MATH Elective
- 4 Biology/Earth Science/Engineering with lab

3 Social Science
 3 Humanities/Social Science
 18 Total credit hours

Bachelor of Science in Physics with Atmospheric Physics Option

Minimum credit hours required—130

In meeting the General Education Core Curriculum (page 78), physics majors must choose PHYS 1310 and 1320 and labs. Requirements include the courses listed above for the Bachelor of Science Degree in Physics and the following courses:

PHYS 427 (3), 428 (3), 432 (3), 433 (3)

Note: PHYS 427, 428, and 432 are offered in alternate years. Students may take either of the following two sequences:

1. Junior year: PHYS 427 (fall); PHYS 428 (spring)
 Senior year: PHYS 432 (fall); PHYS 433 (spring)
2. Junior year: PHYS 432 (fall)
 Senior year: PHYS 427 (fall), PHYS 428, PHYS 433 (spring)

Sample Curriculum for the Bachelor of Science in Physics with Atmospheric Physics Option

Semester 1

5 PHYS 1310 & 1310L
 4 MATH 1510 (calculus)
 4 CHEM 1215 & 1215L (general)
 3 ENGL 1110 (college English)
 16 Total credit hours

Semester 2

5 PHYS 1320 & 1320L
 4 MATH 1520 (calculus)
 4 CHEM 1225 & 1225L (general)
 3 ENGL 1120 (college English)
 16 Total credit hours

Semester 3

5 PHYS 2250 & 2250L
 3 PHYS 2420 (computational)
 4 MATH 2532 (calculus)
 3 MATH 2420 (linear algebra)
 3 Humanities/Language
 18 Total credit hours

Semester 4

5 PHYS 2251 & 2251L
 3 PHYS 2425 (computational 2)
 3 MATH 332 (vector analysis)
 3 MATH 335 (ordinary differential equations)
 3 Humanities (Language)
 17 Total credit hours

Semester 5

3 PHYS 321 (mechanics)
 3 PHYS 427 (atmospheric physics)
 3 PHYS 333 (electricity and magnetism)

3 MATH 336 (intro to PDE's)
 3 ENGL 341 (technical writing)
 15 Total credit hours

Semester 6

3 PHYS 428 (climate physics)
 3 PHYS 334 (radiation/optics)
 1 PHYS 336L (electricity and magnetism lab)
 3 PHYS 340 (quantum)
 1 PHYS 380 (practicum in problem solving)
 4 Biology/Earth Science/Engineering with lab
 15 Total credit hours

Semester 7

3 PHYS 411 (thermodynamics)
 3 PHYS 432 (atmospheric remote sensing)
 3 PHYS 443 (atomic and nuclear)
 3 Social Science
 3 Social Science/Humanities
 15 Total credit hours

Semester 8

3 PHYS 433 (special atmospheric problems)
 2 PHYS 451L (senior lab)
 3 MATH Elective
 4 Biology/Earth Science/Engineering with lab
 3 Social Science
 3 Social Science/Humanities
 18 Total credit hours

See the Physics Department website at www.physics.nmt.edu for sample curricula for a B.S. in Physics with minors in electrical engineering and mathematics.

Minor in Physics

Minimum credit hours required—18 (beyond general degree requirements)

- PHYS 2420 (3), 2425 (3)
- Twelve (12) additional hours of upper-division physics

Graduate Program

New Mexico Tech faculty primarily have expertise in Astrophysics and Atmospheric Physics, and also in developing instrumentation. Most graduate students work in one of these areas. We also have research opportunities in cooperation with other departments on campus, in particular Mathematics and Electrical Engineering. Other interdisciplinary programs are also available through research organizations both on (e.g. shock physics at EMRTC) and off campus (Air Force Research Laboratory, Sandia National Laboratory, and Los Alamos National Laboratory).

Astrophysics

Astrophysics research at NMT encompasses planets, exoplanets, stars, the interstellar medium, galaxies, and active galactic nuclei. Specific faculty interests include stellar formation, galactic dynamics and evolution and interstellar chemistry. The Jansky Very Large Array (VLA) and the Very Long Baseline Array (VLBA) radio telescopes, operated by the National Radio Astronomy Observatory (NRAO), are headquartered on campus, and offer unique opportunities for

research in radio astronomy. The Magdalena Ridge Observatory (MRO) operates a 2.4-meter optical telescope and is developing an optical/infrared interferometer (MROI) that provides both opportunities in optical instrumentation design as well as scientific research once first light is achieved. Students may pursue dissertation work not only with regular faculty but also with a number of NRAO staff who have adjunct appointments at Tech.

Atmospheric Physics

Atmospheric physicists at Tech study convection and dynamics (on Earth and other solar system planets), lightning, atmospheric electricity, and the middle and upper atmosphere (including ozone and space weather). Langmuir Laboratory for Atmospheric Physics is a facility unique in the world, providing an instrumented mountaintop specializing in lightning research. Langmuir also includes balloon-launch facilities and a capability in compact instrumentation appropriate for remote and airborne deployments. The convection and dynamics group has its own Beowulf cluster, while the upper atmospheric group supports extremely sensitive spectrographs. Students in our graduate program can acquire deep, hands-on experience with custom scientific instrumentation and electronics, computer modeling and automated data analysis and theoretical and mathematical methods of physics.

Master of Science Program

All students are required to pass a preliminary exam (“prelim”) at the MS level. The prelim covers material in physics and mathematics normally included in the undergraduate physics curriculum. The department offers the exam at the beginning of the Fall and Spring semesters. Failure to pass this exam in the time-line established on entry to the program usually results in dis-enrollment from the graduate physics program. See “Preliminary Exam Policy” on the department website for further details.

The Master of Science degree in Physics may be earned with thesis or independent study:

With Thesis:

The student’s course of study and thesis topic must be approved by the student’s advisory committee. A thesis consists of directed research, and a write-up of the research. An oral defense of the thesis is required. The thesis is an archival document published electronically and kept in the NMT Library.

Without Thesis:

The student’s course of study must be approved by the student’s advisory committee. The student’s committee may require additional coursework beyond that listed below. A student who elects to not write a thesis may or may not participate in research, but they typically write a paper on a topic selected with guidance by the advisory committee. Unlike a thesis, this paper is not archived electronically by the NMT Library.

Master of Science in Physics

In addition to the general master’s degree requirements,

all students enrolled in the Master of Science degree in Physics must satisfy the following course requirements:

All students must complete PHYS 501 (2) and 502 (2) in their first two semesters.

- PHYS 509 (3)
- PHYS 505 (3) or 521 (3)
- PHYS 579 (1),
- Graduate-Faculty seminar, must be taken for the first four semesters.
- 6 credit hours chosen from PHYS 508 (3), PHYS 510 (3), PHYS 518 (3)

While the listed courses are the simplest route to achieving this credit, a student may petition their committee and the department chair either with proposed substitute course work or other prior experience that demonstrates competence in any of these areas.

Master of Science in Physics with Concentration in Instrumentation

In addition to the general master’s degree requirements, all students enrolled in the Master of Science degree in Physics with Specialization in Instrumentation must satisfy the following course requirements:

- All students must complete PHYS 501 (2) and 502 (2) in their first two semesters.
- PHYS 509 (3)
- MATH 587 (3)
- 6 credit hours chosen from PHYS 508 (3), PHYS 510 (3), PHYS 518 (3)

In addition, the student must take an additional 9 credit hours to be approved by their committee. Potential topics include advanced undergraduate or graduate courses in digital or analog electronics, control theory, optics, optical engineering, spectroscopy, NMR, laser physics, shop techniques, Materials (metals, ceramics, polymers), explosives, mechanical design, robotics, vacuum and cryogenic techniques. Students are reminded that it is possible to pursue a limited number of credits at other approved higher education institutions, and so this course work might also be pursued as part of an internship.

PHYS 579 (1), Graduate-Faculty seminar, must be taken for the first four semesters.

Accelerated B.S./M.S. in Physics

The Student’s course of study must be approved by the student advisory committee. The student committee. The student must complete all requirement for an MS in Physics as outlined on page 177. The candidate for the program should apply for admission no later than the end of his/her 5th regular semester of study. The student must have a minimum cumulative GPA of 3.0, and also specifically an average minimum GPA of 3.0 in all physics and mathematics courses to be eligible to apply for the program. Meeting the GPA criterion does not automatically guarantee admission to

the program.

After successful admission to the 5 year program, the student will apply for graduate standing no later than the 7th semester of study, and thus be dually enrolled their senior year. During the 7th semester, the candidate should select an advisory committee and research topic for the M.S. (Students will complete and be awarded the B.S. at the end of the 4th year, and M.S. at the end of the 5th year.) Students may apply Phys 509 to both the B.S. and M.S. degree requirements (see sample curriculum below), however all other courses must be counted toward either the B.S. (and thus completed by the 8th semester) or the M.S. The candidate M.S. student may take the department's preliminary examination as soon as the 8th semester of study, and must pass the examination at the M.S. level by the beginning of the 10th semester.

For the M.S. degree, the 6 credit-hours of required electives must be non-Physics courses at the 300-level or above and not explicitly counted toward the B.S. A student may pursue either a M.S. with Thesis (6 credits) or a M.S. with Independent Study (3 credits), normally taken during the 9th and/or 10th regular semesters of study. A student is strongly encouraged to pursue research or take courses to apply toward the M.S. during the summer between the 8th and 9th semesters. After completing the B.S., the student may apply for a graduate teaching or research assistantship (TA or RA).

Doctor of Philosophy in Physics Program

Students of exceptional ability as demonstrated in previous courses in physics and mathematics may pursue a program leading to the doctoral degree. Our department offers the following five doctoral paths (with requirements for each specified in the next sections.)

Doctor of Philosophy in Physics with Dissertation in Astrophysics

Doctor of Philosophy in Physics with Dissertation in Atmospheric Physics

Doctor of Philosophy in Physics with Dissertation in Instrumentation

Doctor of Philosophy in Physics with Dissertation in Mathematical Physics

Doctor of Philosophy in Physics with Concentration in Instrumentation

Doctor of Philosophy in Physics

Doctoral Programs — General Requirements

All doctoral students are required to pass a preliminary exam (“prelim”) at the Ph.D. level. The prelim covers material in physics and mathematics normally included in the undergraduate physics curriculum. The department offers the exam at the beginning of the Fall and Spring semesters. Although doctoral students take the same prelim as MS students, a higher score is required of them.

Doctoral students must pass the exam at the Ph.D. level by the time-line established on their entry into the program. A student without a Master’s degree in Physics must pass the exam at the MS level within their first year in the Ph.D.

program. Failure to pass this exam with the required scores and within the specified time usually results in dis-enrollment from the Ph.D. physics program. See the “Preliminary Exam Policy” on the department website for further details.

In addition to the general doctoral degree requirements, the following course requirements apply to all curricula:

- All students must complete PHYS 501 (2) and 502 (2) in their first two semesters.
- PHYS 505 (3), 508 (3), 509 (3), 510 (3), 518 (3), and 521 (3). While the listed course are the simplest route to achieving this credit, a student may petition their committee and the department chair either with proposed substitute course work or other prior experience that demonstrates equivalent competence in any of these areas. Further, New Mexico Tech students who took one of the listed courses as part of a prior degree program at Tech and passed it with a grade of B- or higher are not required to retake the course.
- PHYS 579 (1), Graduate-Faculty seminar, must be taken for the first four semesters.
- 9 credit hours in mathematics beyond that required of an undergraduate physics major.

Doctor of Philosophy in Physics with Dissertation in Astrophysics

In addition to the degree requirements specified above, students completing their dissertation in astrophysics must also complete:

- 6 credit hours chosen from PHYS 426 (3), 564 (3), 565 (3), 566 (3). PHYS 426 must be completed unless the student has had equivalent material in previous courses.
- 6 credit hours chosen from PHYS 425 (3), 562 (3), 563 (3), 567 (3).

Doctor of Philosophy in Physics with Dissertation in Atmospheric Physics

In addition to the degree requirements specified above, students completing their dissertation in atmospheric physics must also complete:

- PHYS 427 (3), 428 (3)
- An additional 6 credit hours must be taken in areas pertinent to the student’s program. This can be achieved by taking PHYS 527 (3), 532 (3), 533 (3), 535 (3), 536 (3), and/or other courses approved by the student’s advisory committee.

Doctor of Philosophy in Physics with Dissertation in Instrumentation

In addition to the degree requirements specified above, students completing their dissertation in instrumentation must also complete:

PHYS 546 (3), PHYS 301 (1), PHYS 546L (1).

PHYS 580 (4), Graduate Internship for 4 credits/2months minimum

MATH 587 (3) or MATH 519 (3). These may be used to satisfy the 9 credit hours in mathematics required for all curricula.

An additional 9 credits (assumed to be 3 courses), at least 6 of which are in an Engineering or Science area outside the Physics department for courses rated 300-level or above. Courses may be taken at another institution in consultation with the student's committee as appropriate to the area of study. Additional course in the Physics department may include graduate-level disciplinary courses beyond the Physics core.

The following courses are *examples* recommended for the breadth requirement depending on the candidate's interests and dissertation/professional focus. When labs are associated with these courses, they should ideally also be taken, but will not count toward the 9-credit requirement.

Any upper level UG/Graduate CSE course as applicable, EE 308, EE 321, EE 422, EE 451, EE 443, OPT 410, MTLs 479 or MATH 483, MTLs 441, MTLs 443, MTLs 402, MTLs 420, MENG 405, MENG 441, MENG 483, BIOT 502, BIOT 503, BIOT 504, BIOT 505, BIOT 576, CHEM 523.

Doctor of Philosophy in Physics with Dissertation in Mathematical Physics

In addition to the degree requirements specified above, students completing their dissertation in mathematical physics must also complete:

MATH 435 (3), 438 (3), 442 (3), 471 (3), 535 (3). These may be used to satisfy the 9 credit hours in mathematics required for all curricula.

An additional 6 credits in mathematics and 6 credits in physics, approved by the student's advisory committee.

Doctor of Philosophy in Physics

In addition to the degree requirements specified above, (12) credit hours of graduate physics or appropriate related fields, approved by the student's advisory committee, should be completed in his/her field of specialization.

Doctor of Philosophy in Physics with Concentration in Instrumentation

The concentration in instrumentation teaches graduate physics with an additional focus on laboratory work and practical applications of physics concepts and technologies. The program aims to produce an experimental physicist with broad skills and background in one or more areas of scientific instrumentation. A graduate of this program should be able to create their own custom instrumentation for the study of new areas. The skills of such a graduate are explicitly transferable to industrial design and employment in national labs.

In addition to the degree requirements specified above, students completing their Doctor of Philosophy in Physics with concentration in instrumentation must also complete:

Instrumentation Core: Physics 301, 536L, 545 and 580.

Specialized Math Requirement: Of the required 9-credit hours in advanced mathematics, 3 credit hours should be from either Math 587 OR Math 519 OR Math 588.

Instrumentation Breadth Requirement: 9 additional units (assumed to be 3 courses), at least 6 of which are in an Engineering or Science area outside the Physics department for courses rated 300-level or above. Courses may be taken at another institution in consultation with student's committee as appropriate to the area of study. Additional courses in the Physics department may include graduate level disciplinary courses beyond the Physics core.

The following courses are *examples* recommended for the breadth requirement depending on the candidate's interests and dissertation/professional focus. When labs are associated with these courses, they should also be taken, but will not count toward the 9 credit requirement.

- 1) EE 308 (Microcontrollers)
- 2) EE 321 (Analog Electronics)
- 3) EE 422 (Advanced Electronics)
- 4) EE 451 (Digital Signal Processing)
- 5) EE 443 (Intermediate Control Theory)
- 6) EE 521 (Instrumentation and Measurements)
- 7) Optics 410 (Advanced Optics)
- 8) Materials 479 or 483 (Scanning or Transmission Electron Microscopy)
- 9) Materials 441 (X-ray Diffraction)
- 10) Materials 443 (Magnetic Materials)
- 11) Materials 402 (Physical Ceramics)
- 12) Materials 420 (Biomedical Materials)
- 13) MechE 405 (Dynamics Systems and Controls)
- 14) MechE 441 (Dynamics and Vibrations in Structural Design)
- 15) MechE 483 (Mechatronics)
- 16) Biotech 502, 503, 504 or 505 (Biotechnology introductory graduate courses – several areas)
- 17) Biotech 576 (Drug Delivery)
- 18) Chemistry 523 (Applied Spectroscopy)

Graduate Minor in Physics

A student seeking a graduate minor in physics must complete at least 6 hours from the following: PHYS 505, PHYS 508, PHYS 510, PHYS 511, PHYS 518, PHYS 519, or PHYS 521. The remaining physics courses must be graded, at least 300-level or above, and be approved by the minor advisor. A total of 12 credits hours in physics (minimum 6 hours at the 500-level) are required for a minor at the level, and 18 hours (minimum 12 hours at the 500-level) for the doctorate level minor.

Physics Courses:

PHYS 109, Introduction to Physics, 3 cr, 3 cl hrs

Co-requisite: MATH 1220

This is an introductory, algebra-based course covering kinematics, Newtonian mechanics, conservation

principles and thermodynamics. The course is taught in a laboratory setting, with emphasis on hands-on work, the scientific method, and formal laboratory reports. Successful completion of the course will satisfy the PHYS 1310 Laboratory requirement.

PHYS 1310, General Physics I, 4 cr, 3 cl hrs, 2 recitation hrs

Corequisites: PHYS 1310L; MATH 1510

Introductory concepts. Mechanics, including Newton's Laws of force, linear and angular momentum, energy, gravitation, heat and thermodynamics, and applications. [NMCCNS PHYS 1310: General Education Area III]

PHYS 1310L, General Physics Laboratory I, 1 cr, 3 lab hrs

Corequisite: PHYS 1310

Experiments from the subject matter of PHYS 1310. [NMCCNS PHYS 1315: General Education Area III]

PHYS 1320, General Physics II, 4 cr, 3 cl hrs, 2 recitation hrs

Prerequisite: PHYS 1310

Corequisites: MATH 1520; PHYS 1320L

Continuation of PHYS 1310 including electricity, magnetism and optics. [NMCCNS PHYS 1320: General Education Area III]

PHYS 1320L, General Physics Laboratory II, 1 cr, 3 lab hrs

Corequisite: PHYS 1320

Experiments from the subject matter of PHYS 1320. [NMCCNS PHYS 1320: General Education Area III]

PHYS 2250, Comprehensive Physics I, 4 cr, 3 cl hrs, 2 recitation hrs

Prerequisites: PHYS 1310; MATH 1510

Corequisite: PHYS 2250L

A treatment of physics for science and engineering students from a modern point of view. The subject is logically developed starting with optics and the theory of relativity. Quantum and classical mechanics are then introduced. This course is required for physics majors. [NMCCNS PHYS 1310: General Education Area III]

PHYS 2250L, Comprehensive Physics Laboratory I, 1 cr, 2 lab hrs

Corequisite: PHYS 2250

Laboratory experiments from the subject matter of PHYS 2250. [NMCCNS PHYS 1310: General Education Area III]

PHYS 2251, Comprehensive Physics II, 4 cr, 3 cl hrs, 2 recitation hrs

Prerequisites: PHYS 2250; MATH 1510

Corequisites: PHYS 2251L; MATH 1520, PHYS 1320

Continuation of PHYS 2250. Attempts to probe successively smaller scales are explored. The four forces of nature; practical applications of gravity and electromagnetism. Dynamics of large numbers of particles are introduced, resulting in applications to the everyday world. This course is required for physics

majors. [NMCCNS PHYS 1320: General Education Area III]

PHYS 2251L, Comprehensive Physics Laboratory II, 1 cr, 2 lab hrs

Corequisite: PHYS 2251

Laboratory experiments from the subject matter of PHYS 2251. [NMCCNS PHYS 1320: General Education Area III]

PHYS 2420, Computational Physics I, 3 cr, 2 cl hrs, 2 hr recitation/computer lab

Prerequisite: PHYS 1320

Corequisite: MATH 2420

This course will provide an introduction to a programming language and basic algorithms that can be used to solve introductory physics problems (e.g. statics, relative motion, projectile motion) with a computer. Most of the problems will be deterministic in nature and will have analytical solutions that the students will be able to use to verify their numerical solutions. The course will also cover topics related to data analysis and visualization.

PHYS 2425, Computational Physics II, 3 cr, 2 cl hrs, 2 hr recitation/computer lab

Prerequisite: PHYS 2420

This course will go more in depth into numerical methods to solve problems involving the numerical solution of differential equations (oscillations, orbital motion, waves and vibrations.) different algorithms will be compared to determine their level of accuracy and applicability. The course will explore other aspects of physics that cannot be solved using deterministic algorithms (e.g. random walks).

PHYS 301, Laboratory and Shop Techniques, 1 cr, 1 afternoon per week

Instruction in drill and tool bit sharpening, use of hand tools, drill press, lathe, milling machine, shaper, and sheet metal brake.

PHYS 313, 313D, Orbital Mechanics, 3 cr, 3 cl hrs

Prerequisite: PHYS 1320 or 2251; MATH 332 or MENG 305

This is a first upper-division course covering the Newtonian mechanics of orbits. Applications include ballistic missiles, satellites, and lunar and interplanetary orbits. Spaceflight is simulated using Kerbal Space Program or similar tools. (Same as AE 313.)

PHYS 321, Intermediate Mechanics, 3 cr, 3 cl hrs

Prerequisites: PHYS 2425, MATH 2420; transfer students may take PHYS 2420 as a co-requisite

Corequisite: MATH 335

An intermediate course in the dynamics and statics of particles and rigid bodies. Introduction to Lagrangian and Hamiltonian mechanics.

PHYS 325, Astrophysics I: Stars, 3 cr, 3 cl hrs

Prerequisites: PHYS 2425

Astrophysics is the application of physics to the universe. This course begins with a review of relevant

physics and then applies those concepts to the lives of stars. The subject matter includes stellar atmospheres, stellar interiors, star formation, stellar evolution, variable stars, and compact objects.

PHYS 326, Astrophysics II: Planetary and Extragalactic Systems, 3 cr, 3 cl hrs

Prerequisites: PHYS 325

This course continues the application of physics to the rest of the universe. Our own solar system and its formation and evolution, normal galaxies, active galaxies, the large-scale structure of the universe, and cosmology.

PHYS 327L, 328L, Astronomy Laboratory, 1 cr, 3 lab hrs per week

PHYS 327L: Corequisite: PHYS 325; or consent of instructor and advisor

PHYS 328L: Prerequisite: PHYS 327L; or consent of instructor and advisor

An introduction to astronomical observing and data reduction. Emphasis on the techniques of operating telescopes and their auxiliary equipment, including CCD imaging, photometry, spectroscopy, and data handling. Exercise are chosen from topics in solar system, stellar, galactic, and extragalactic astronomy. This class includes a nighttime observing component.

PHYS 333, Electricity and Magnetism, 3 cr, 3 cl hrs

Prerequisites: PHYS 1320 or PHYS 2251; PHYS 2425; MATH 332; transfer students may take PHYS 2420 as a co-requisite

Corequisite: MATH 335

Maxwell's four short equations use the language of vector calculus to describe problems involving charge, current, voltage, electric fields, and magnetic fields. These equations will be developed and unpacked, with applications to statics and varying electric fields and magnetic fields, electric circuits, and dielectric materials. Conductors and conductivity of metals, semiconductors and gasses will be considered. Additional topics may include magnetic materials.

PHYS 334, Radiation and Optics, 3 cr, 3 cl hrs

Prerequisite: PHYS 333

Corequisite: MATH 336

This course explores the behavior of electromagnetic waves, including optical waves, using Maxwell's equations and the Lorentz force law. Included in the course are the topics of radiation, conservation laws, relativistic and non-relativistic electrodynamics, basic geometrical optics and aberration theory, and specific phenomena such as polarization, diffraction and interference. The class will include discussions of modern optical devices.

PHYS 336L, Electrical and Magnetic Measurements Lab, 1 cr, 3 lab hrs

Prerequisite: PHYS 333

A set of experiments reinforce the concepts of electromagnetism learned in Physics 333 and give students added facility with common laboratory

instrumentation. The behaviors of resistors, capacitors and inductors is studied with oscilloscopes and function generators and understood with the formalism of complex impedance. Transformers, transistors and operational amplifier circuits are studied. Data acquisition and digital control techniques are introduced using the Arduino embedded platform.

PHYS 340, Introduction to Quantum Theory, 3 cr, 3 cl hrs

Prerequisites: PHYS 321; MATH 2420, 335, or consent of instructor and advisor

Fundamental ideas of quantum physics including the postulates of quantum theory, wave functions, stationary and non-stationary states, operators, measurements, the Schrodinger equation, one-dimensional and three-dimensional systems including the hydrogen atom.

PHYS 380, Practicum in Problem Solving, 1 cr, 2 cl hrs

Prerequisite: PHYS 321, or consent of instructor and advisor

Methods of problem solving, including dimensional and scale analysis, rapid estimation, and combining knowledge from various disciplines. Class time will be spent analyzing and solving problems posed by the instructor and students. Students will normally be graded S/U, and sections will be strictly limited in size to facilitate active participation of all students.

PHYS 389, Pilot Course, topic, hrs, and cr to be arranged

PHYS 391, Directed Study, hrs and cr to be arranged

PHYS 408, Cooperative Education

On-the-job training to supplement the academic program. Students alternate periods (usually six months long) of full-time semiprofessional employment in their chosen field with periods of full-time academic study.

PHYS 411, Thermodynamics and Statistical Physics, 3 cr, 3 cl hrs

Prerequisite: PHYS 1320 or PHYS 2251; PHYS 340

A course dealing with the effects of heat and work on gases, liquids, and solids. The equations of state and the first and second laws of thermodynamics are presented with applications to heat engines and chemical processes. An introduction is given to kinetic theory and statistical mechanics.

PHYS 425, Astrophysics III: Plasma Astrophysics, 3 cr, 3 cl hrs

Prerequisites: PHYS 325, 326, 334, or graduate standing

Plasma and fluid physics govern most of the luminous matter in the universe. This course surveys the many aspects of plasma physics, from microphysics (single particle motions, waves and oscillations, collisions) to macrophysics (the fluid description and magnetohydrodynamic effects). Applications will include a wide variety of astrophysical objects, from the earth's magnetosphere and the solar wind, to accretion disks and radio jets.

PHYS 426, Astrophysics IV: High Energy Astrophysics, 3 cr, 3 cl hrs

Prerequisites: PHYS 334 and 425, or graduate standing

This course continues the application of fluid and plasma physics to astrophysics. Radiation processes and diagnostics, shock physics, high energy plasmas, and cosmic ray acceleration. Many applications will come from our galaxy, including the interstellar medium, star formation, supernovae, black holes, and pulsars. We will go beyond the boundaries of our galaxy to study active galactic nuclei and their connection to galaxy formation.

PHYS 427, Atmospheric Physics, 3 cr, 3 cl hrs

Prerequisites: PHYS 1320 or 222; or consent of instructor and advisor

Offered alternate years

Covers dry and moist thermodynamics, radiative transfer, some microphysics, and dynamics (including hydrostatic balance, geostrophic balance, and thermal wind equation).

PHYS 428, Climate Physics, 3 cr, 3 cl hrs

Prerequisites: PHYS 427; MATH 332 and 335

Offered alternate years

This course, a continuation of PHYS 427, includes the dynamics needed to understand general circulation (e.g. Rossby waves), also covers basics in climate modeling and observations.

PHYS 432, Atmospheric Remote Sensing, 3 cr, 3 cl hrs

Prerequisite: PHYS 1320 or 222

This course will examine the physics of atmospheric remote sensing using radio, microwave, infrared, visible, and ultraviolet instruments. Topics will include both active and passive systems for measuring atmospheric temperature, composition (such as water vapor and ozone), and dynamics.

PHYS 433, Special Problems in Atmospheric Physics, 3 cr, 3 cl hrs

Prerequisite: Consent of Instructor

Offered spring semesters

Project in which student works with a member of the atmospheric physics group on current research. This project is expected to lead to a report, conference presentation, or contribution to a published paper. The student should contact an appropriate faculty member within the first two weeks of the fall semester to organize a project.

PHYS 443, Atomic and Nuclear Physics, 3 cr, 3 cl hrs

Prerequisite: PHYS 340

Continuation of PHYS 340. Further topics in atomic and molecular structure, including fine/hyperfine structure, atomic/molecular spectroscopy, many electron systems and quantum statistics. Further topics in nuclear physics including radioactivity, elements of nuclear structure, and nuclear energy sources.

PHYS 444, Solid-State Physics, 3 cr, 3 cl hrs

Prerequisite: PHYS 340 or consent of instructor and advisor

Offered on demand

Crystalline structure and reciprocal lattices; binding in molecules and crystals; energy bands; electrons in metals; imperfections in solids; electrical, thermal, and magnetic properties of solids; semi-conductor theory and superconductivity.

PHYS 448, Introduction to Particle Physics, 3 cr, 3 cl hrs

Prerequisite: PHYS 2251 and PHYS 340, or consent of instructor and advisor

Corequisite: PHYS 443

This course provides an introduction to elementary particles and their interactions, at a level that does not require quantum field theory. Covered topics include particle phenomenology and conservation laws, relativistic kinematics, symmetries, Feynman diagrams, gauge theories, and the Higgs mechanism. Shares lecture with PHYS 548, with additional expectations for graduation credit.

PHYS 449, Astrobiology, 3 cr, 3 cl hrs

Prerequisite: CHEM 1215 & 1225, PHYS 1310 & 1320, one other science course and consent of instructor.

An in-depth and interdisciplinary study of astrobiology, including interactions between living and non-living systems at multiple scales: stellar, planetary, meso-, and microscopic. Addresses fundamental questions regarding the origin of life, and the possible extent and distribution of life in the universe. Combines principles of astrophysics, geosciences, planetary science, chemistry, and biology. Innovative interactive exercises and projects working in interdisciplinary groups and individually. Shares lecture with PHYS 549, with additional expectations for graduate credit. **(Same as BIOL 449 and GEOL 449)**

PHYS 451, Senior Laboratory, 1 or 2 cr, 3 or 6 lab hrs

Prerequisites: Senior status or consent of instructor and advisor

Experiments in atomic, nuclear, and solid-state physics.

PHYS 489, 489D, Pilot course, topic, hrs. and cr to be arranged**PHYS 491, Directed Study, hrs. and cr to be arranged****PHYS 500, Directed Research, cr to be arranged**

This course may not be used to fulfill graduate degree requirements.

Research under the guidance of a faculty member.

PHYS 501, 502, Introduction to Research and Scientific Communication, 2 cr, 3 lab hrs each semester

This course involves beginning graduate students in a modest project, usually related to ongoing research in the department, and provides a background in scientific communication. The research portion emphasizes independent work by the student, but is supervised by a faculty member. Possible projects include data analysis, software development, theoretical modeling, a literature survey, and design and/or construction of research or teaching equipment. The communication portion

incorporates the research topic into several written and oral assignments, including conference abstracts, proposals, oral and poster presentations, and peer-reviewed research papers.

PHYS 505, Advanced Dynamics, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Offered Fall 2014 and alternate years

Introduction to classical mechanics: Lagrangian and Hamiltonian formalism, rigid body motion, normal modes. Hamilton-Jacobi Theory, and problems in relativistic mechanics.

PHYS 508, Statistical Mechanics, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Offered Spring 2010 and alternate years

Entropy, randomness, the Boltzmann distribution, and the chemical potential. Translational, rotational, vibrational, and electronic contributions to the partition function. Calculation of mean energies, heat capacities, and equilibrium constants. Stability. The influence of wave function symmetry: Bose-Einstein and Fermi-Dirac statistics. The quantum statistical operator. Coherence and the Pauli principle. (Same as CHEM 524)

PHYS 509, Methods of Theoretical Physics, 3 cr, 3 cl hrs

(Note: MATH 535, 536 is Methods of Mathematical Physics)

Prerequisite: MATH 2420, 332, and 336 or equivalent, or graduate standing.

Offered Fall semesters

Covers mathematics essential for PHYS 510 and 518, including Dirac delta functions, vector spaces, operators and eigenvalues, Dirac notation, Fourier series and transforms, orthogonal polynomials, complex variables, and tensor notation.

PHYS 510, Electromagnetism, 3 cr, 3 cl hrs

Prerequisite: PHYS 509

Offered Spring and alternate years

Electrostatic and magneto static boundary-value problems, electromagnetic radiation generation, wave propagation in Materials and at interfaces, polarization characteristics of radiative processes, and the relativistic covariance of electromagnetism will be covered.

PHYS 511, Advanced Electromagnetism, 3 cr, 3 cl hrs

Prerequisite: PHYS 510

Offered on demand

Selected topics taken from advanced electromagnetism: optical fiber propagation, plasma waves and instabilities, scattering of radiation, optical coherence, and other topics based upon interests of the class.

PHYS 518, Quantum Mechanics, 3 cr, 3 cl hrs

Prerequisites: PHYS 505 and 509

Offered Spring 2015 and alternate years

Review of experiments leading to quantum theory: Schroedinger's Equation, applications of simple physical systems, perturbation theory, theory of angular momentum, and Dirac Theory.

PHYS 519, Advanced Quantum Mechanics, 3 cr, 3 cl hrs

Prerequisites: PHYS 518

Offered on demand

Advanced topics in quantum mechanics, including scattering theory, Feynman path integrals, an introduction to quantum field theory, and other topics based upon interests of the class.

PHYS 521, Continuum Mechanics, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Offered Fall 2015 and alternate years

Stress, strain, rate of strain, and applications of these ideas in fluid dynamics and elastic body mechanics. Statics of elastic bodies and elastic waves. Navier-Stokes equation, vorticity dynamics, flows at low and high Reynolds number. Examples taken from a broad variety of areas.

PHYS 526, Fluid Dynamics, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Offered 2010 and alternate years

Basic equations, potential and viscous flow, scaling. Compressible flow including characteristics and shock waves. Magnetohydrodynamics, including MHD waves, shocks, and confinement. Fluid and MHD instabilities. Turbulence.

PHYS 527, Geophysical Fluid Dynamics, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Dynamics of stratified, rotating fluids; governing equations of the ocean and atmosphere, inertia-gravity waves, quasi-geostrophic theory, Rossby waves, instabilities, and jets, diabatic and frictional effects, tropical atmospheric dynamics.

PHYS 532, Atmospheric Remote Sensing, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Physics of remote sensing using radio, microwave, infrared, visible, and ultraviolet instruments. Topics will include both passive and active systems for measuring atmospheric temperature, composition, and dynamics. Shares lectures with PHYS 432, but is graded separately and additional graduate-level work is required.

PHYS 533, Advanced Topics in Atmospheric Physics, 1–3 cr, 1–3 cl hrs

Specialized coursework in the student's areas of interest. Advanced topics in the area of atmospheric physics. Selection of topics changes from semester to semester. Current faculty interests can be found at the department web site: www.physics.nmt.edu. This course may be repeated for credit if the material covered in each instance is different.

PHYS 535, Physics of Lightning, 3 cr, 3 cl hrs

Prerequisite: Graduate standing, PHYS 333/334, or consent of instructor and advisor

Offered Spring 2016 and alternate years

Theory and experimental techniques concerning cloud charging mechanisms. Remote and in-situ sensing of lightning. Lightning phases and properties. Properties of the long spark and leaders in the lab and in the sky. Simple numerical models of cloud charging, lightning initiation, and propagation.

PHYS 536, Atmospheric Convection, 3 cr, 3 cl hrs

Prerequisite: Graduate standing and PHYS 427 or PHYS 428 or consent of instructor and advisor

Governing equations, turbulence, thermodynamics, and microphysics of moist convection. Models for convection ranging from plumes and thermals through numerical simulations are discussed, as well as interactions of convection with the atmospheric environment.

Physics 545 -- Technology of Laboratory Instrumentation, 3 cr, 3 cl hrs

This course provides familiarity with multiple tools used in instrumentation work, developing some applied approaches, and learning best practices for researchers using these tools. Tools and techniques to be covered will be adjusted based on the class but may include: Mechanical design and Solid works, PCB layout and design, data acquisition systems, cryogenics techniques, vacuum techniques, theory of operation of common sensors, other topics. Offered approximately every 2 years or upon request.

PHYS 546L, Electrical and Magnetic Measurements Graduate Lab, 1 cr, 3 lab hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Experiments in electricity and magnetism, emphasizing applications to measurements in physics and geophysics. Topics include DC and AC circuits, complex impedance, transformers, magnetic hysteresis, transistors, operational amplifiers, superconductivity, and student selected projects. Shares lab with Physics 336L but graduate students will face a higher standard on lab reports and be required to do some additional formal study of electronics. The course is recommended for graduate students lacking practical electronics experience.

PHYS 548, Introduction to Particle Physics, 3 cr, 3 cl hrs

Prerequisite: PHYS 2251 and PHYS 340, or consent of instructor and advisor

This course provides an introduction to elementary particles and their interactions, at a level that does not require quantum field theory. Covered topics include particle phenomenology and conservation laws, relativistic kinematics, symmetries, Feynman diagrams, gauge theories, and the Higgs mechanism. Shares lecture with PHYS 448, with additional expectations for graduation credit.

PHYS 549, Astrobiology, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor and advisor. Offered on demand.

An in-depth and interdisciplinary study of astrobiology, including interactions between living and non-living systems at multiple scales: stellar, planetary, meso, and microscopic. Addresses fundamental questions regarding the origin of life, and the possible extent and distribution of life in the universe. Combines principles of astrophysics, geosciences, planetary science, chemistry, and biology. Innovative interactive exercises and projects working in interdisciplinary groups and individually. Shares lecture with PHYS 449, with additional expectations for graduate credit. **(Same as BIOL 549 and GEOL 549)**

PHYS 562, Stellar Astrophysics, 3 cr, 3 cl hrs

Prerequisites: PHYS 425, 426 or equivalent or consent of the instructor.

Offered Spring 2015 and alternate years.

This course covers in-depth the physics of stars, their structure and evolution. Topics include energy generation and transport, nucleosynthesis, equations of state, stellar modeling, asteroseismology, and stellar pulsation and rotation — all studied in the context of the evolution of a star. There are detailed discussions and derivations of the various stages in star formation and evolution, and the end states of stars (e.g. white dwarfs, planetary nebulae, black holes). The course stresses current refereed literature and has occasional guest speakers on various topics.

PHYS 563, Extragalactic Astrophysics, 3 cr, 3 cl hrs

Prerequisites: PHYS 425, 426 or equivalent or consent of instructor and advisor

Offered Fall 2014 and alternate years

The structure and dynamics of galaxies. Distribution of galaxy types. Potential and orbit theory. Spheroidal galaxies as self-gravitating systems. Instabilities in disk galaxies. Constraints on dark matter and on galaxy formation.

PHYS 564, Relativity and Cosmology, 3 cr, 3 cl hrs

Prerequisites: PHYS 425, 426 or equivalent or consent of instructor and advisor

Offered Spring 2013 and alternate years

General relativity with application to cosmology. Basic principles of relativity. Applications to orbits, gravitational radiation, and black holes. Relativistic cosmography and cosmology. The early universe, galaxy formation, and active galaxies.

PHYS 565, Astronomical Techniques, 3 cr, 3 cl hrs

Offered on demand

Optical, IR, X-ray and gamma-ray astronomical telescopes and detectors. Throughput, detector quantum efficiency, the modulation transfer function, noise and estimation error. Photometers and photometric systems, CCD imaging, slit and objective grating spectrometry, Fourier spectroscopy. Astrometry, orbit determination. Computer analysis and astronomical databases. Class work will be augmented by extensive optical observing using local facilities.

PHYS 566, Advanced Radio Astronomy, 3 cr, 3 cl hrs*Offered Fall 2015 and alternate years*

The design and operational characteristics of radio telescopes and interferometers. Properties of antennas, telescope optics, feeds, waveguides, receivers, and amplifiers. Spectrometers and spectroscopy. Sensitivity and noise. Amplitude and phase calibration, faint signal detection, astrometry, and mapping. Factors that affect radio data, including instrumental characteristics, atmospheric limitations, and propagation phenomena. The VLA and VLBA and the techniques of radio imaging by aperture synthesis. Hands-on astrophysical exercises to be solved by imaging.

PHYS 567, Advanced Topics in Astrophysics, 2–3 cr, 2–3 cl hrs*Offered on demand*

A one-semester tutorial may be selected from any one of the following: our solar system, comets, solar and stellar activity, galactic structure and kinematics, active galaxies and quasars, astrophysical plasmas, accretion disks, black holes, stellar spectroscopy, stellar photometry and astrometry.

PHYS 571, Advanced Topics in Physics, 3 cr, 3 cl hrs*Offered on demand*

Study of a special topic not otherwise treated, normally one related to a field of research interest at NMT.

PHYS 579, Graduate-Faculty Seminar, 1 cr, 1 cl hr*Offered every semester*

A seminar in which current research topics are discussed by faculty, students, and outside speakers. Graded S/U, where satisfactory performance consists of regular attendance and participation. Credit earned may not be applied towards the 30 credits required for the M.S. degree.

PHYS 580, Graduate Internship, 4 crs, 4 cl hrs*Prerequisites: Passage of preliminary examination*

Internship to be conducted at a national lab, technical company, or observatory/research center (including those on campus) working on instrumentation design, integration and testing on a project NOT associated with the student's dissertation project. The internship can occur in the US or an international lab/business. The purpose is to increase the student's breadth of experience, work in a team environment on topics outside their project area, and potentially develop new professional contacts. The internship needs to be approved by the student's committee before it begins. It is suggested that roughly two credits be offered per month of internship duration.

PHYS 581, Directed Study, cr to be arranged

Study under the guidance of a member of the graduate faculty. In general, subject matter will supplement that available in other graduate course offerings.

PHYS 590, Independent Study, cr to be arranged**PHYS 591, Thesis (master's program), cr to be arranged****PHYS 595, Dissertation (doctoral degree program), cr to be arranged**

Prerequisite: Successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.

Faculty Research Interests

Arendt — Physics in Strong Magnetic Fields, Neutron Star Magnetospheres, Mathematical Physics

Avramidi — Mathematical Physics, Analysis on Manifolds, Quantum Field Theory

Buscher - Optical/IR Interferometry, Atmospheric Seeing Measurement, Adaptive Optics, Early and Late Stages of Stellar Evolution

Creech-Eakman — Stellar Astrophysics, Mass-loss, Optical/IR Interferometry, IR Instrumentation, Exoplanets

Da Silva — Atmospheric and Space Electricity, Lightning and Lab Discharges, Geospace Plasmas

Eack — Production of Energetic Particles and Gamma Rays in Thunderstorms

Edens — Lightning Physics, Mapping and Imaging, Storm Electrification, Instrumentation

Eilek — Plasma Astrophysics, Quasars, Radio Galaxies, Pulsars

Elvis – Quasars and Active Galactic Nuclei, X-ray Astronomy

Fuchs – Atmospheric Dynamics

Goss — Radio Astronomy, Interstellar Medium

Haertel — Atmospheric Physics/Tropical Dynamics

Haniff — Spatial Interferometry at Optical and Near-Infrared Wavelengths, Atmospheric Turbulence, Imaging Theory, Evolved Stars

Hankins — Radio Astronomy of Pulsars, Instrumentation, Signal Processing

Hofner — Star Formation, Interstellar Medium, X-ray Astronomy, Extragalactic Interstellar

Klinglesmith — Asteroids, Robotic Telescope Operations

Krehbiel — Lightning studies; radar meteorology; thunderstorm electrification

Lopez Carrillo – Doppler Radar and Data Analysis, Tropical Dynamics

Manney — Atmospheric Science, Stratospheric Dynamics/Transport, Stratospheric Polar Processes and Ozone Loss

Meier – Radio/Submm Studies of Galaxies, Astrochemistry

Myers – Cosmology, Extragalactic Radio Astronomy, Interferometric Imaging Algorithms

Minschwaner—Radiative Transfer and Climate, Physics of the Middle and Upper Atmosphere

Morales-Juberias — Outer Planets Observations and Atmospheric Dynamics

Raymond — Geophysical Fluid Dynamics, Cloud Physics, Clouds and Climate

Rison — Atmospheric Electricity, Radar Meteorology, Instrumentation.

Romero — Energetic Materials, Shock Phenomena, High Energy Physics.

Sessions — Field Theoretic Approaches to Atmospheric Physics.

Sonnenfeld — Lightning Physics and Effects, Atmospheric Instrumentation.

Teare — Experimental Adaptive Optics, Radiation Effects and Directed Energy.

Thomas — Atmospheric Physics, Instrumentation

Wells — Nuclear and Medical Physics.

Westpfahl — Dynamics of Spiral and Dwarf Galaxies

Winn — Atmospheric physics; electrical discharges in gases; instrumentation.

Young — Star Formation and the Interstellar Medium, Dwarf and Elliptical Galaxies.

Preprofessional Programs

Specific requirements for admission to professional schools vary. With the help of an advisor, each preprofessional student should plan a course of study that will meet the specific entrance requirements of the school in which the student is interested. The following statements outline the usual requirements for programs which may be completed with course offerings available at Tech.

Preprofessional students who complete the requirements for the Bachelor of Science degree in Basic Sciences with appropriate selection of electives will qualify for admission to most professional schools.

Preprofessional training in the biological and medical allied sciences consists of a thorough background in basic sciences. Hence, the first two years will be essentially the same for all specialties. Courses during the first two years should include ENGL (two semesters); BIOL 2110, 2610, 331, 333; CHEM 1215, 1225, 333, 334; MATH 1510, 1520; PHYS 1310, 1320; PSY 1110; and social science (two semesters).

Premedical Program

Students interested in preparing for admission to medical school should meet frequently with their advisors, beginning with their first semester at New Mexico Tech. Accredited medical schools require a minimum of three years of college work, with a minimum grade-point average of 3.0. However, most students complete a bachelor's degree before entering medical school.

Students are advised to consult the requirements of individual medical schools in choosing coursework. Upper division courses in New Mexico Tech's curriculum that may aid in medical school preparation include BIOL 311, 341, 351, 352, 355, and 437; CHEM 311, 331, 332, 441, and 442; PSY 309, 311, 314, 330, 409, and 410. Most premedical students major in biology, but, any bachelor's degree is acceptable. Premedical students should be aware that the Medical College Admissions Test is required for admission to medical school.

Premedical Technology Program

Students interested in preparing for admission to veterinary school should meet frequently with their advisors, beginning with their first semester at New Mexico Tech. Schools of medical technology require a minimum of three years of undergraduate study; however, the degreed student has a distinct advantage because of the extra year of preprofessional training. Recommended courses in addition to those described above for the first two years include BIOL 311, 341, 351, 355; and CHEM 311.

Prenursing Program

An increasing number of schools of nursing now require one year of general liberal arts courses for admission. Courses recommended for such nursing curricula are English (two semesters); BIOL 2110, 2610, 341; general chemistry; general psychology; and general physics (one semester each).

Prepharmacy Program

Most accredited colleges of pharmacy offer a five-year program, including prepharmacy training, leading to a Bachelor of Science in Pharmacy degree. All such colleges of pharmacy require at least one year of prepharmacy study and some colleges will accept two years. The University of New Mexico has an accredited College of Pharmacy which accepts one year of prepharmacy study. Recommended courses in the prepharmacy curriculum are ENGL 1110 and 1120; CHEM 1215 and 1225; BIOL 2110; and MATH 1510

Master of Science for Teachers (MST)

Interdepartmental Program

(Megha Khandelwal, Director Teacher Education Program)

Advisory Committee: Chair of Chemistry or designee, Chair of Mineral Engineering or designee, Chair of Communication, Liberal Arts, and Social Sciences or designee, Chair of Physics or designee, Chair of Earth and Environmental Science or designee, Chair of Computer Science or designee, Chair of Biology or designee, Chair of Mathematics or designee, Engineering Departments designee; *Ex-Officio:* Graduate Dean, Dean of Arts and Sciences, Dean of Engineering, Director of the Academic Center for Technology, Registrar, Vice President for Academic Affairs, Associate Vice President for Academic Affairs.

Degree Offered: Master of Science for Teachers

Program Description

The MST program provides graduate-level classroom and laboratory instruction for teachers or going into science, mathematics, engineering, and/or technology. The emphasis of the courses is on content, rather than pedagogy. MST students are encouraged to adapt activities, demonstrations, laboratory exercises and methods of teaching and apply these as projects in their own classrooms during the academic year. Courses for the participants are offered in a variety of disciplines and are led by New Mexico Tech faculty. Classes build on fundamental principles and offer new concepts and novel teaching methods. Courses are offered throughout the year via distance education with in-person course option in summer on the New Mexico Tech campus and around the state.

Program Prerequisites

An individual with at least one year of K–12 teaching and a bachelors' degree may apply for admittance into the MST program. The program encourages individuals to hold a valid teaching license when appropriate. To be accepted into the MST program, an individual must pass the Introductory Courses (ST 523, ST 524, ST 525, ST 526, ST 550A and ST 527) or their respective Placement Exam.

Transfer Credit Policy

A maximum of 12 credit hours of course work with grade B or better, earned at another accredited institution, may be approved by the student's advisory committee for transfer to the MST program. To be approved, credits must not have been used to satisfy the requirements for a previous degree. Transfer credits can include upper-division undergraduate or graduate credit in science, mathematics, engineering, and/or technology. Transferred credits may include up to six credit hours of professional education courses in areas generally appropriate to this program. Requests for evaluation of transfer credit hours must be made in writing to the program coordinator and must include the transfer credit form and official transcripts.

MST Fellowships

The MST Office maintains a list of available fellowships.

Endorsement Policy

Information regarding licensure endorsements may be obtained from the New Mexico Public Education Department, Santa Fe, New Mexico.

Placement Exams

MST students may take placement exams for ST: 523, 524, 525, 526, 550, or 527. Upon successful completion of the exam(s), this requisite for the program will be waived and the student will not be required to take the course(s). The exams consist of questions covering basic concepts of science and mathematics.

Use of Tech Facilities

If an MST student is utilizing New Mexico Tech facilities or faculty (i.e., computer center, advisor, or graduate committee), the student must be registered for at least one Tech upper-division or graduate course.

Graduate MST Advisory Committee

Each MST student will be assigned a temporary advisor at the time of their initial first registration. The temporary advisor will assist the student in identifying potential faculty members for their formalized committee. Once admitted to the MST program and considered a regular part-time graduate student, an advisor and advisory committee must be formalized by the completion of 12 credits introductory courses (listed in section 1A of program requirements) are not included in this count). The advisor should be a faculty member whose specialty and interests coincide with the student's. The academic advisor must be a regular faculty member of New Mexico Tech and will serve as chair of the advisory committee. The advisory committee consists of at least the academic advisor and at least two other members with regular faculty members not being a minority. Because the MST program is a transdisciplinary program, some academic advisory functions will continue to be handled by the MST program staff. To formalize the advisory committee, students must fill out the *MS Committee Form*, select the Thesis or Independent Study option, have each member of their advisory committee sign the form, and file it with the Graduate Office. The *MS Committee Form* (aka: Masters Degree Advisory Committee form) can be found online at the Center for Graduate Studies, under the *Forms* menu (https://www.nmt.edu/gradstudies/Student_Forms.php). It is the responsibility of the student to have contact with their advisory committee **at least** once a year.

Course Program

Courses to be used towards each of the graduate degrees at New Mexico Tech must meet with the prior approval of the student's advisory committee. These courses constitute the student's Course Program. For regular part-time graduate students their formalized Course Program must be approved and signed by their advisory committee and filed with the Graduate Office by the time they complete 12 credits (introductory courses are not included in this count). The report of the Master's Degree Advisory Committee (MS Course Program) form can be found online at the Center for Graduate Studies under the *Forms* menu (http://www.nmt.edu/gradstudies/Student_Forms.php). At the

time of graduation, the courses listed in the formalized Course Program must match exactly the courses listed on their transcript. If a change needs to be made to the Course Program it is the student's responsibility to get approval of their advisory committee and to file these changes with the Graduate Office.

Thesis or Independent Study Requirement

MST students must select either a thesis or a non-thesis program under the guidance of the student's advisor and advisory committee. The thesis program involves the preparation of a thesis through experimental, theoretical, or applied research (ST 591), under the supervision of a faculty member serving as their research advisor (often the same faculty as their academic advisor). The candidate must satisfy the thesis requirements of the department of his/her research advisor. Six credit hours will be allowed for the thesis. The Independent Study (IS) provides the candidate with an opportunity to engage in a plan of study under the supervision of their research advisor to (a) explore in more depth or detail an area to which the student has been introduced in previous courses or in the field of science-based education and (b) contribute to the knowledge content and/or application of the knowledge content of the selected area. An Independent Study is intended to be a project initiated by the student and designed in conjunction with his/her advisory committee. Three credit hours will be allowed for the IS (ST 590). For more details see the Independent Study Guidelines.

Program Requirements

1. All incoming MST students are typically enrolled as Special (non-degree) students and must demonstrate competence in science and mathematics by either:

A. Completing the introductory courses:

- ST 523, Survey of Biology (1)
- ST 524, Survey of Chemistry (1)
- ST 525, Survey of Geology (1)
- ST 526, Survey of Physics (1)
- ST 550, Mathematics for Teachers I (1)
- ST 527, Survey of Computer Science (1)

Credits are awarded for these courses but these credits DO NOT count towards the 30 credits needed for a MST Degree.

B. Passing the equivalent placement exams or receiving a waiver based upon previous course work. No credits are awarded for passing a placement exam.

These courses or the appropriate placement exams/waivers are prerequisites for admission into the MST program as a regular part-time graduate student as well as a majority of other courses within the MST program.

2. Master of Science for Teacher students must take the following core of 18 credit hours that will give breadth and depth to the program:

1. All incoming students must take two technical communication courses and a computer literacy course.
 - ST 529, Research and Documentation (2)
 - ST 530, Technical Communication for Teachers (2)
 - ST 556, Mobile Computing and Science Teaching (1)
2. For comprehensiveness, MST students must take two credits

in each of the following distribution areas, for a total of twelve credit hours:

- Math (2)
- Physics (2)
- Chemistry (2)
- Geology (2)
- Biology (2)
- Engineering/Computer Science/Economics (2)

3. For concentration, MST students must take an additional six credit hours within one of the above distribution areas of the student's choice.

In addition to the core requirements above, MST students must complete:

- ST 590, Independent Study (3),
- ST 591, Thesis (6)
- Additional courses to complete 30 credit hours. These courses may be chosen from MST courses or other Tech courses numbered 300 or above.

MST Courses:

All MST courses that satisfy a distribution area requirement have at least one survey course as a prerequisite. MST courses that do not apply to a distribution area require competence in basic courses in subject matter area or consent of instructor and advisor.

MST courses may not be used to fulfill the requirements of any other undergraduate or graduate degree offered by New Mexico Tech without prior approval by the chair of the department offering the degree.

Students may receive an additional credit of directed study for each course with the submission of an accepted project and paper to the professor of the respective course.

Departmental Waiver of Prerequisites and/or Distribution Area Requirement:

The MST Department Chair and the Department Chair (or his/her designee) representing a distribution area on the MST Advisory Committee must approve a request to waive a prerequisite or distribution area requirement. This request is submitted by the student and must be recommended by the advisor and have the consent of the instructor before consideration.

ST 523D Survey of Biology, 1 cr

Biology is the study of living systems. A comprehensive understanding of organisms, their structure, function, evolution, environments and how life is interconnected is important for every citizen of earth! This course is designed to provide an overview of the current scope of biology that will help teachers and, in turn, their students interpret biologically related events that will impact their world for the rest of their lives. The field of biology is very active and new discoveries are made all the time. This course will cover the basics of biology by presenting both established concepts as well as current research with details on how scientists investigate life.

ST 524D Survey of Chemistry, 1 cr

This course is an introduction to basic chemical terminology and nomenclature, modern atomic and

molecular theory, periodicities of chemical behavior, and the physical characteristics and isotopic stability of the elements. The student will learn how to read and write properly balanced chemical equations, make meaningful predictions based on stoichiometric relationships, identify and quantify the participants in electron and proton transfer reactions and establish a foundation for pursuing more advanced studies in the chemical, physical, material, life, earth and environmental sciences.

ST 525 Survey of Geology, 1 cr

This course covers the fundamentals of geosciences, including field-based training in how and why geology “works.” Mandatory field trips will introduce participants to the essentials of the study of Earth Materials, with classroom sessions discussing the origin of the Earth, its landforms, and Materials.

ST 526 Survey of Physics, 1 cr

Explore Newton’s three Laws of Motion in this laboratory course. Hands-on, class time experiments are supplemented with assigned readings. This course is not mathematically intensive.

ST 527D, Survey of Computer Science, 1 cr

This course provides an introductory overview of the discipline of computer science. Topics include the history of computer hardware/software, computer architecture, operating systems and networks, programming languages, algorithms, and applications of computer science such as computer security.

ST 529/529D Research and Documentation, 2 cr

Prerequisites: departmental approval

This course covers the various kinds of research (both primary and secondary) and documentation, particularly in the fields of science, including gathering and analyzing data, writing (literature reviews, reports, articles, bibliographies), and documenting correctly.

ST 530/530D Technical Communication for Teachers, 2 cr

Prerequisites: ST 529 or departmental waiver

The theory and practice of writing for technology and science: lab reports, proposals, abstracts, and scientific articles. Emphasis will be on audience awareness, editing, writing, and documenting information.

ST 531D Intro to Unmanned Aerial Systems, 2 cr

Prerequisites: ST 526 and ST 550 or departmental waiver

Introduction to Unmanned Aerial Systems (UAS) will present design, fundamentals, and analysis of different types of drones. This course introduces basic of aerospace engineering, classification and applications of the drones, and techniques and approaches to design and manufacturing of drones, including fixed-wing unmanned and micro air vehicles (UAV & MAV). An open source software called XFLR5 will be introduced and used for CAD modeling, aerodynamic analysis, and simulation of a small fixed wing micro air vehicle. Comprehensive/ concentration area: Engineering.

ST 534D Intro to Web & Mobile App Development, 2cr

Prerequisites: ST 527 or departmental waiver

This course will teach the skills in creating web application and mobile applications. The students will learn the basic web technologies including HTML, CSS

and Javascript and the cross-platform mobile app development using jQuery Mobile and Adobe Phone gap. Comprehensive/ concentration area: Computer Science

ST 535D Cryptography & Computer Security, 2cr

Prerequisites: ST 527 or departmental waiver

This course provides an introductory overview of cryptography and computer security mainly focusing on their application into security and privacy protection for online activities such as emailing, social networking, banking and so on. Topics include basic cryptography authentication access control firewall network security threats, risks and attacks such as phishing and malware. Course work include quizzes, homework, midterm and final exam. Comprehensive/ concentration area: Computer Science

ST 536D Fundamentals of Information Technology, 2cr

Prerequisites: ST 556 or departmental waiver

This is an introductory course aimed at presenting state-of-the art information on technology and technological issues in a broad rather than detailed manner. Major issues affecting all of us and specifically the Information Technology Professionals will be discussed. Although this course is not intended to make us all experts in Information Technology (IT) it will help us understand why IT works the way it does, and give us the groundwork to be more useful IT users and partners. This course will give the student the basic understanding of IT which will help them be more comfortable with the technology around us and use it more efficiently. The student will also have a basic proficiency in an operating system and basic software applications (e.g. word processing, spreadsheets, presentation graphics, and databases). Comprehensive/ concentration area: Computer Science

ST 540 Rocking’ Around New Mexico, 1 cr

Prerequisite: ST 525 or departmental waiver

Explore local geology, including volcanic rocks and hazards, seismic hazards, mountain-building processes, and mineral resources. Two days of the three-day course will be spent in the field, following an introductory day comprising geologic exercises and lecture presentations. Each year, a different New Mexico community hosts this course, co-sponsored by the New Mexico Bureau of Geology. Comprehensive/ concentration area: Geology

ST 541 Geology and Mining Engineering for Teachers I, 2 cr

Prerequisites: ST 525 and ST 550B; or departmental waiver

This course is a study of the principles and technology of mineral occurrence, extraction, and refining. Field trips complement lectures and laboratory experiments. Emphasis is on New Mexico base metal deposits.

ST 542 D, Cell Biology, 2 cr

Prerequisites: ST 523 or departmental waiver

This course provides an introduction to the principles governing the existence of life at the cellular level. Topics considered include the function of intracellular organelles and structures, the macromolecular building blocks of cells, cellular metabolism, and replication, and intra/ intercellular signaling. Current research areas applying to human health issues will be emphasized. Comprehensive/ concentration area: Biology

ST 543 Genetics, 2 cr

Prerequisites: ST 523 or departmental waiver

An overview of the storage, transmission and expression of biological information. This course introduces basic concepts in prokaryotic and eukaryotic genetics, including genome organization, DNA replication, recombination, repair, and regulation of gene expression. Topics considered include the genetic basis of heredity, the fundamental role of DNA recombination, repair, and mutagenesis in creating genetic variability within populations, and the importance of genetic

variability and natural selection in the ongoing process of evolution. Comprehensive/ concentration area: Biology

ST 544D Bioengineering, 2cr

Prerequisites: ST 523 or departmental waiver

Bioengineering is an exciting, engaging and complex discipline that first emerged as a field in the 1960's. Traditionally it was considered to be the application of engineering principles to solve biological problems, like artificial hearts. But over time, it has grown to be any number of combinations and blending of biological and engineering principles ranging from 3D printing of

biomaterials, to robotic biomechanics to biomimicry. This course is designed to provide students with hands-on experience to plan and construct their own bioengineering solutions to problems using common materials. Through a series of 4 modules, students will be introduced to engineering design and then apply these principles to 4 different challenges. The challenges include: 1) Developing a prosthetic device for an animal, 2) Looking at living organisms for inspiration for new materials, 3) Improving the design of a bicycle safety helmet and 4) Responding to a pandemic. The curriculum is based on the Engineering Is Elementary (EiE) platform, which was designed by the Science Museum at Boston. Comprehensive/ concentration area: Biology

ST 545D, Microscopy for Science Classroom, 2 cr

Prerequisites: ST 523 and ST 526 or departmental waiver.

Science Teachers will gain practical experience in the laboratory with single lens microscopes, compound light microscopes (dissecting, bright field, dark field, phase contrast) and confocal microscopes that will give them the confidence to utilize these tools in the classroom. They will use a microscope as a tool to conduct an experiment on a biological system. Teachers will also participate in hands-on demonstrations of other microscope and imaging techniques such as the scanning electron microscope (SEM), energy dispersive X-ray spectrometry, atomic force microscopy, microprobes and digital light microscopy. Teachers will create a lens for their own personal smart phone or tablet and become familiar with accessories, apps and software available for these devices. A collaboration with Hitachi High Technologies will allow students in this course to learn the operation of the portable SEM that could be implemented in the classroom. Science teachers will create sample lesson plans for each activity which will be shared as a daily report with the class for constructive feedback. In

addition, teachers will write a lab report, give a research project presentation and take a final exam. Comprehensive/ concentration area: Biology

ST 546D, Genetic Engineering, 2 cr

Prerequisites: ST 523 or departmental waiver

Genetic Engineering is hands-on, research-based course that will introduce students to the concepts and practice of recombinant DNA technology. Through lectures and labs, students will learn the skills and techniques that are used in genetic engineering and will use these techniques to design and carry out their own synthesis of a recombinant using IGEM components. Comprehensive/ concentration area: Biology

ST 547D Field Techniques in Geology for Teachers, 2 cr

Prerequisites: ST 525 and ST 550B; or departmental waiver

This field-based course shows how geologic mapping and maps are prepared, with in-the-field exercises showing participants how geologic information is collected and plotted on geologic maps. Students will perform rock identification, review faulting and folding of rocks, and the methods used to record geologic data. Field work will be in the Socorro area, with both in-class and in-the-field assignments. Comprehensive/ concentration area: Geology

ST 548D Geology of the Southwest—National Parks and Natural Resources, 2 cr

Prerequisites: ST 525 and ST 550B; or departmental waiver

This is a field-based course that involves camping, limited hiking, and visits to national parks and mine sites in the western U.S. Students will camp in areas of spectacular geologic settings. In-the-field assignments will comprise the basis for grading. The regional and local geologic settings of national parks and mineral deposits are reviewed, and the clash between minerals utilization and natural resources occurrence are discussed.

Comprehensive/ concentration area: Geology

ST 549D Petroleum Geology, 2 cr

Prerequisites: ST 525 or departmental waiver

Material covered will focus on the conventional and unconventional petroleum systems, from the formation of kerogen to expulsion and migration into the reservoir rock. Topics include subsurface mapping, geophysical exploration methods, chemistry of petroleum, reservoir and cap rocks, sedimentary basins and basin analysis, temperature in basins, environmental issues, and unconventional systems.

ST 550D Mathematics for Teachers, 2 cr

This course is a basic survey of the principles of contemporary mathematics. The course will emphasize the algebra of sets and numbers, exponentials and logarithms, complex numbers, vectors and matrices, and applications in science for each.

ST 552AD Calculus on a Computer, 1 cr

Prerequisites: ST 550 or departmental waiver

Students learn to use computer software to do single variable calculus. Applications and geometric understanding are emphasized. No previous calculus is required. Student versions of the software are available for

purchase.

ST 552BD Calculus on a Computer, 1 cr

Prerequisites: ST 552A or departmental waiver

Students learn to use computer software to do single variable calculus. Applications and geometric understanding are emphasized. No previous calculus is required. Student versions of the software are available for purchase.

ST 555D, Computational Thinking, 2 cr

Prerequisites: ST 527 Survey of Computer Science or departmental waiver

This course provides an introduction to a new approach to learning about computation. Viewed as a creative activity based on reason and logic, computational thinking is expected to benefit students interested in mathematics, science, engineering, and many aspects of the humanities. Topics include problem representation and decomposition, the role of abstraction, the articulation of algorithms, Python program development, the execution of those programs to enable the creation of information and knowledge, and related ethical aspects. Comprehensive/ concentration area: Computer Science

ST 556 Mobile Computing and Science Teaching, 1 cr

This is a course about how to teach science and math with a mobile computer - a tablet - and what can happen when the teacher and students all have mobile computers. Topics covered include connecting to a projector or large-screen display, evaluating additional hardware, evaluating teaching apps, sharing files, and automated grading. Students make daily presentations to the class.

ST 557D Understanding Statistics, 2 cr

Prerequisites: ST 550 or departmental waiver

This is an introductory statistics course. The framework of the course is designed to develop in the student an understanding of summarized data (ungrouped and grouped) in both descriptive and inferential statistical applications through the use of frequency distributions, measures of central tendency and measures of dispersion; outcome probabilities and the various concepts related to discrete and continuous probability distributions; the concepts surrounding random sampling and interval estimating for populations and large & small samples; classical hypothesis testing and with one-tailed & two-tailed testing; comparisons involving means and regression analysis and the application to math & sciences teachers data analysis. Comprehensive/ concentration area: Mathematics

ST 558D Probability and Statistics, 2 cr

Prerequisites: ST 550B and basic knowledge of Calculus and departmental waiver

This course covers techniques for the visual presentation of numerical data; descriptive statistics; introduction of sampling and statistical inference, illustrated by examples from a variety of fields. Comprehensive/ concentration area: Mathematics

ST 559D Discrete Math, 2 cr

Prerequisites: ST 550 or departmental waiver

This is an introductory course in discrete mathematics, a subject that describes discrete structures such as sets,

integers, permutations, relations, and graphs. This is in contrast to the continuous structures studied in calculus. Discrete math distinguishes itself from other lower division courses in its emphasis on mathematical reasoning, algorithmic thinking, and constructing logical arguments, skills necessary for any higher division math course and a variety of other subjects. These skills will be developed along side the presentation of the specific mathematical content. The topics of discrete math have important applications to subjects such as computer science and cryptography. Comprehensive/ concentration area: Mathematics

ST 560D Space Science: Hazardous Asteroids, 2 cr

Prerequisites: ST 526 and ST 550B; or departmental waiver

This course introduces concepts relevant to understanding small bodies in the Solar System and their effect on the near-Earth space environment. The emphasis is on processes that can threaten life on Earth, specifically, a potential asteroid collision. The goal is to expose the student to some of the basic principles of space science (gravity, kinetic energy, astronomical measurement) while using hazardous asteroids as a fun and non-intimidating context for refreshing simple math skills. The format will include lectures, laboratory exercises, and hands-on use of an optical telescope.

ST 561D Intro to Linear Algebra, 2 cr

Prerequisites: ST 550 or departmental waiver

This is an introductory course to linear algebra. The topics covered will include: linear systems of equations, linear transformations, matrix algebra, subspaces of n-dimensional space, determinants, and eigenvalues and eigenvectors. Comprehensive/ concentration area: Mathematics

ST 564/564D Great Concepts in Physics, 2 cr

Prerequisites: ST 526 and ST 550B; or departmental waiver

This course covers the concepts of physics from the Greeks to the present, the triumphs and questionable philosophical assumptions of the scientific method, revolutions of relativity and quantum theory. Extensive mathematical background and laboratory work are not required. Comprehensive/ concentration area: Physics

ST 565D Physics of Aviation, 2 cr

Prerequisites: ST 526 and ST 550; or departmental waiver

This course is a basic survey of aerodynamics with emphasis on the principles of physics that apply to flight. There is a limited use of mathematics, but nothing beyond basic algebra. The course uses the method of discovery learning to introduce the principles of physics to flight. The course is a combination of lecture, in-class exercises and take-home activities. There is one short in-class examination and a required in class presentation. Comprehensive/ concentration area: Mathematics

ST 567D Computational Mechanics, 2 cr

Prerequisites: ST 526 and ST 550 or departmental waiver

The course deals with the nature of matter and its interactions and it focuses on a small number of

fundamental mechanics principles (the momentum principle, the energy principle, and the angular momentum principle), all of which can be applied to a very broad range of systems, over a large range of scales. The main goal of the course is to engage you in a process that is central to science: constructing and applying physical models based on a small set of powerful fundamental principles. Comprehensive/ concentration area: Physics

ST 568D Physics of the Solar System, 2 cr

Prerequisites: ST 526 or departmental waiver

The course will provide an overview of the Solar System. Fundamental astrophysics and physics concepts will be reviewed. The students will develop problem-solving, writing and oral presentation skills. Comprehensive/ concentration area: Physics

ST 573/573D, The Science of Weather, 2 cr

Prerequisites: ST 550A and ST550B or departmental waiver

The Science of Weather class gives a basic overview of atmospheric processes, weather forecasts, and climate. It then expands on those basics by introducing current topics such as: extreme events (hurricanes, tornados, floods, droughts...) and their impact on our society, the World Meteorological Organization (WMO) and the numerical models in its network, the way the data gets collected and sent using special codes (SYNOP/SHIP) within the WMO, field projects (special way of collecting data), climate change, etc. The mornings consist of lessons, while the afternoons are used to do experiments that the teachers can repeat in their classrooms (low cost experiments), demonstrations, simulations, learning how to tell clouds apart, learning how to see from data that there will be clouds (emagrams), working with data, learning the codes SYNOP/SHIP and discussing climate change. An added value to the class is that through the lessons and afternoon practical work, the students will be able to connect the basics, conventionally taught from meteorological books, with current research. Comprehensive/ concentration area: Physics

ST 577D Medicinal Chemistry, 2 cr

Prerequisites: ST 524 or departmental waiver

This course is intended to serve as an introduction to concepts and strategies for drug design, synthesis of pharmaceuticals and overall developments in medicinal chemistry. Students taking this course are expected to already have familiarity with general chemistry, organic chemistry and some exposure to introductory biochemistry. Comprehensive/ concentration area: Chemistry

ST 578D The Chemistry of Natural Products, 2cr

Prerequisites: ST 524 or departmental waiver

This course begins with an overview of organic compounds; examining each of the major functional groups. A number of different classes of naturally derived organic compounds are then considered. These include the sugars, alkaloids (opiates, nicotine, etc.), essential oils, taxanes and

cannabinoids. Sulfur based compounds are also discussed. In particular, we are interested in understanding the natural sources for these compounds and methods of isolation. Additionally, we would like to understand their physiological effects, mode of action and metabolism. Comprehensive/ concentration area: Chemistry

ST 579D Concepts in Chemistry: Development of Atomic Theory, 2cr

Prerequisites: ST 524 or departmental waiver

This course examines the classic experiments in chemistry and physics that underpin our current understanding of atomic structure. We begin by examining the classification of matter, the fundamental laws of chemical combination and the development of a workable atomic theory. Then, we consider the discovery and characterization of the subatomic particles; the electron, proton and neutron. The structure of the atom is next discussed. We look at the experimental evidence for quantum physics and how it can be used to understand the electronic structure of the atom. Finally, simple bonding theories are presented. Comprehensive/ concentration area: Chemistry

ST 580D Introduction to Biochemistry, 2 cr.

Prerequisites: ST 523 and ST 524 or departmental waiver

This course will focus on structure-function of biological macromolecules, basic enzymology, vertebrate biochemistry and the study of vitamins, hormones, biochemical genetics, and nutrition. It will provide an overview of basic biochemistry and will emphasize on structure, nomenclature, and reactions of biologically active compounds such as carbohydrates, lipids, proteins, nucleic acids and enzymes, detailed examination of major pathways of cellular metabolism, regulation, underlying mechanisms and driving forces. The material is valuable for promoting informed and creative approaches to biomedical challenges. Comprehensive/ concentration area: Chemistry

ST 581, Directed Study, cr to be arranged

Study under the guidance of a member of the graduate faculty. In general, subject matter will supplement that available in other graduate course offerings. Comprehensive/ concentration area: Chemistry

ST 590, Independent Study, 3 cr

An IS provides the student with an opportunity to engage in a plan of study under the supervision of NMT Faculty to (a) explore in more depth or detail an area to which the student has been introduced in previous courses or in the field of science-based education and (b) contribute to the knowledge content and/or the application of the knowledge content of the selected area. An IS is intended to be a project initiated by the student and designed in conjunction with his/her advisory committee.

ST 591, Thesis (master's program), 6 cr

A Thesis is similar to an IS except that it normally involves research over an extended period of time and follows the guidelines of the Academic Advisor's or Research Advisor's Department. In general, the

requirements for a Master of Science for Teachers student completing a thesis are no different from the requirements for any other graduate student completing a thesis within the same department.

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Engineering Programs

Engineering

Accreditation

The Bachelor of Science (BS) programs in Chemical Engineering, Civil Engineering, Electrical Engineering, Environmental Engineering, Materials Engineering, Mechanical Engineering, Mineral Engineering, and Petroleum and Natural Gas Engineering are accredited by the Engineering Accreditation Commission of ABET, www.abet.org.

The Bachelor of Science program in Computer Science is accredited by the Computing Accreditation Commission of ABET, www.abet.org.

Professional Examinations

Undergraduate engineering majors in Chemical Engineering, Civil Engineering, Environmental Engineering, Mineral Engineering and Mechanical Engineering are required to take the Fundamentals of Engineering (FE) exam as a requirement for graduation. All engineering students are encouraged to take this exam, as it is the entry-level requirement for those individuals who intend to attain status as a professional engineer. The FE exam is a national, computer-based test; therefore, the results are transferable to any state or territory of the United States. See the NCEES website (<http://www.ncees.org>) for details.

Minors

- Aerospace Engineering
- Biomedical Engineering
- Chemical Engineering
- Civil Engineering
- Computer Science
- Computer Engineering
- Electrical Engineering
- Environmental Engineering
- Explosives Engineering
- Materials Engineering
- Mechanical Engineering
- Mineral Engineering
- Optical Science and Engineering
- Petroleum Engineering
- Polymer Science

Engineering Science

Courses in Engineering Science deliver fundamental topics that are common across engineering programs. No specific degree is offered. For further information, contact the Dean of Engineering.

Engineering Science Courses:

ES 110, Introduction to Engineering, 2 cr, 1 cl hr, 3 lab hrs

Corequisite: MATH 1230

Students will be introduced to the profession of engineering and gain fundamental engineering skills with an emphasis on engineering design and problem solving. Topics include problem definition, presentation of a solution, the engineering design process, working in a team environment, engineering graphics by hand and in SolidWorks, graphical solutions, and simple modeling in Microsoft Excel. Students will learn the process of designing, building, modeling, and optimizing a system through a semester-long project.

ES 111, Computer Programming for Engineers, 3 cr, 2 cl hrs, 3 lab hrs

Corequisite: MATH 1510

Engineering computer problem solving using a high-level programming language. Algorithm and program development and documentation. Emphasis is placed on programming logical and concise solutions to a variety of problems drawing from engineering disciplines of mechanics, civil, electrical, industrial, and economics.

ES 201, Statics, 3 cr, 3 cl hrs

Prerequisite: PHYS 1310

Corequisite: MATH 2532

Forces and moments acting on rigid bodies in equilibrium, distributed forces including hydrostatic forces, friction, moment of inertia, and problem solution by computer.

ES 216, Engineering Fluid Mechanics, 3 cr, 3 cl hrs

Prerequisite: PHYS 1310

Corequisite: MATH 2532

Fundamentals of fluid mechanics including fluid statics, velocity of continuous media, continuity, and momentum balance. Introduction of laminar and turbulent flows, similitude, dimensionless analysis, Bernoulli's equation, friction factor, introduction to pump and compressor selection.

ES 302, Mechanics of Materials, 3 cr, 3 cl hrs

Prerequisites: ES 201; MATH 2532

Relationships between external forces acting on deformable bodies and the stresses and strains produced; tension, compression, torsion, shear, bending, and problem solution by computer. Failure criteria. Design of members and systems.

ES 303, Engineering Dynamics, 3 cr, 3 cl hrs*Prerequisites: ES 201; MATH 2532*

Kinematics and kinetics of particles, systems of particles, and rigid bodies; and momentum and energy methods.

ES 305, Engineering Analysis, 3 cr, 3 cl hrs*Prerequisites: ES 216, ES 302; MATH 335; or consent of instructor and advisor*

Solution of linear systems of equations using Gaussian elimination and matrix methods. Scalar and vector fields; gradient; divergence; curl; line, surface and volume integrals; Green's theorem and Stokes' theorem. Solutions to partial differential equations from heat transfer, mechanical vibrations, and fluid mechanics using separation of variables, series and Laplace transforms.

ES 316, Engineering Economics, 3 cr, 3 cl hrs*Prerequisite: MATH 1520*

Professional ethics. Economic decision-making for engineering alternatives. Use of compound interest and depreciation calculations to compare the relative economy of investments and procedures. The application of economic principles such as return on investment, leverage, and present worth to engineering problems. Use of PC computer programs. This course is not available for social science credit.

ES 332, Electrical Engineering, 3 cr, 3 cl hrs*Prerequisites: PHYS 1320; MATH 1520*

Introduction to the fundamentals of electronics and circuits for applications (e.g., instrumentation, control systems and power systems) encountered by engineers. Techniques for analysis to determine voltages, currents and power are based on Kirchhoff's Laws, and include mesh and nodal analysis. Devices considered are resistors, inductors, capacitors, independent sources, dependent sources, diodes, operational amplifiers, digital-to-analog converters and analog-to-digital converters. Circuits addressed will contain constant (DC) sources, switched sources and sinusoidal (AC) sources, for which appropriate techniques will be developed and applied to determine responses in voltage, current and power.

ES 347, Thermodynamics, 3 cr, 3 cl hrs*Prerequisites: CHEM 1225; MATH 1520; PHYS 1310*

Introduction of the first and second laws of thermodynamics and their applications to engineering power cycles. Carnot cycle, Rankine cycle, refrigeration cycle, Otto cycle, and Diesel cycle.

ES 350, Heat and Mass Transfer, 3 cr, 3 cl hrs*Prerequisites: ES 216; ES 347; MATH 335*

Fundamentals of heat transfer, steady- and unsteady-state conduction, convection and radiation. Fundamentals of mass transfer, steady and unsteady state, diffusion, and convection. Dimensionless analysis, equipment.

ES 405L, Instrumentation, Measurement, and Process Control Laboratory, 1 cr, 3 lab hrs*Prerequisites: ES 111 or CHE 327; PHYS 1320*

Laboratory exercises involving instrumentation and design of basic control systems.

ES 489, 489D, Special Topics in Engineering Science, 3 cr, 3 cl hrs**ES 491, Directed Study, cr to be arranged**

Chemical Engineering

(www.nmt.edu/~cheme)

Professor - Leclerc (Dean of Engineering)

*Associate Professors—Choudhury, Chowdhury, Tartis
(Chair of the Department)*

Assistant Professor - Lee, Shin

Adjunct Faculty - Bickel, Guilette, McCoy

Laboratory Associate - Price

Emeritus Professor Bretz

Degree Offered: B.S. in Chemical Engineering

M.S. in Chemical Engineering with specialization in Surface Engineering, M.Eng. in Chemical Engineering with specialization in Surface Engineering, Ph.D. in Chemical Engineering with dissertation in Surface Engineering

Chemical engineering is considered one of the base engineering disciplines with applications in nearly every facet of life. The development and production of food, pharmaceuticals, fuels, semiconductors, detergents, fertilizers, plastics, and paper have all been driven by the ingenuity of chemical engineers. Current frontiers being explored by chemical engineers include biofuels, renewable energy, new batteries, nanotechnology, fuel cells, microsensors, explosives, and other critical technologies important to the 21st century. Chemical engineering graduates find challenging careers in a broad spectrum of fields including petroleum, chemical, plastics, paper, semiconductor, pharmaceutical, and biotechnology. At the same time, the breadth of a chemical engineering background helps graduates flourish in careers such as medicine, patent law, and technical marketing.

Throughout the Chemical Engineering curriculum, we focus on the development of complete engineers who can foster innovation through know-how and champion ideas through effective communication. We deliver a thorough education with insightful teaching, an innovative curriculum, research opportunities, summer job experiences, and channels for permanent, successful careers. Each year, our program is reviewed by an outside advisory board of professionals, who help ensure that our graduates are well prepared for lifelong successful careers in the exciting array of fields open to chemical engineers.

An important part of the chemical engineering experience at New Mexico Tech is the abundance of opportunities to participate in cutting edge research projects of our faculty and staff. Virtually all of our graduates engage in significant research projects and/or internships while working toward B.S. degrees in Chemical Engineering. Examples of areas of research open to Tech chemical engineering undergraduates include energetic materials, fuel cells, nano-composite materials, membrane separations, computer simulation, bioenergy, and thin film plasma processing. Numerous opportunities exist for summer research internships, including employment at the nearby Sandia and Los Alamos national labs as well as the research divisions on campus.

To learn more, the Student Handbook section of the Chemical Engineering website (www.nmt.edu/~cheme) is an excellent resource with quick links and great insights to taking advantage of the outstanding educational opportunities at New Mexico Tech.

Program Educational Objectives

The following objectives have been established by the program faculty in conjunction with our students and advisors from industry. They describe the characteristics and expected accomplishments of our future alumni.

1. Our graduates will be engaged in careers covering the spectrum of fields, which require a command of the principles of Chemical Engineering, or in pursuit of/complete post graduate degrees in fields such as engineering, the sciences, business, law, or medicine.
2. Our graduates will be active in the professional community by participating in professional societies, obtaining licensure, and other related activities.

Student Outcomes for Undergraduate Program

Graduates of the Bachelor of Science in Chemical Engineering program will have demonstrated:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Undergraduate Program

Bachelor of Science in Chemical Engineering

Minimum credit hours required—136

In addition to the General Education and Institute Core Curriculum (page 80), the following courses are required:

- ChE 110 (2), 326 (3), 327 (3), 345L (1), 349 (3), 351 (3), 352 (3), 371 (3), 443 & 443L (3), 445L (1), 461 (3), 462 (3), 485 (1)
- CHEM 311 & 311L (4), 331 & 331L (4), 333 & 333L (4)
- ES 201 (3), 216 (3), 302 (3), 347 (3), 350 (3), 405L (1)
- EE 211 (3) or ES 332 (3)
- MATH 2532 (4), 335 (3)
- MTLs 202 & 202L or 235 & 235L (4)
- Engineering/Technical Electives (9) Upper-division engineering or other approved courses. These electives should be Chemical Engineering, other engineering, chemistry, biology, mathematics, physics or computer science courses at the 300-, 400-, or 500-level.

Chemical engineering majors must maintain a minimum GPA of 2.0 in required courses in order to graduate. Courses used for degree, including general degree requirements, may not be taken on an S/U basis.

Chemical engineering majors are required to take the Fundamentals in Engineering (FE) exam as a requirement for graduation.

Sample Curriculum for the Bachelor of Science in Chemical Engineering

To help plan your course of study, be sure to use the degree flowchart found in the Student Handbook at www.nmt.edu/~cheme

Semester 1

- 2 ChE 110 (Intro to chemical engineering)
- 3 ENGL 1110 (college English)
- 4 MATH 1510 (calculus I)
- 4 CHEM 1215 & 1215L (general)
- 3 Social Science
- 16 Total credit hours

Semester 2

- 3 ENGL 1120 (college English II)
- 4 MATH 1520 (calculus II)
- 4 CHEM 1225 & 1225L (general)
- 5 PHYS 1310 & 1310L (general)
- 16 Total credit hours

Semester 3

- 3 ChE 326 (principles of chemical engineering I)
- 4 MATH 2532 (calculus III)
- 3 ES 201 (statics)
- 4 CHEM 311 & 311L (analytical)
- 3 Social Science
- 17 Total credit hours

Semester 4

- 3 ES 216 (fluid mechanics)
- 3 ES 347 (engineering thermodynamics)
- 3 MATH 335 (ordinary differential equations)
- 5 PHYS 1320 & 1320L (general)
- 3 ChE 327 (principles of chemical engineering II)
- 17 Total credit hours

Semester 5

- 3 ChE 349 (ChE thermodynamics)
- 3 ES 302 (strength of materials)
- 3 ES 350 (heat and mass transfer)
- 1 ES 405L (instrumentation)
- 4 CHEM 331 & 331L (physical)
- 3 Social Science
- 17 Total credit hours

Semester 6

- 1 ChE 345L (junior design)
- 3 ChE 351 (kinetics)
- 3 ChE 352 (separation processes)
- 3 Engineering/Technical Elective
- 3 ENGL 341 (technical writing)
- 4 MTLs 202&202L or 235&235L (materials engineering)
- 17 Total credit hours

Semester 7

- 1 ChE 445L (unit operations lab)
- 3 ChE 461 (plant design I)
- 1 ChE 485 (senior seminar)
- 3 Engineering/ Technical Electives
- 3 ChE 371 (chemical engineering analysis)
- 4 CHEM 333 & 333L (organic)
- 3 Humanities/Social Science/Fine & Creative Arts
- 18 Total credit hours

Semester 8

- 3 ChE 462 (plant design II)
- 3 ChE 443 & 443L (process control & lab)
- 3 ES 332 (electrical engineering)
- 3 Engineering/Technical Elective
- 3 Humanities
- 3 Social Science
- 18 Total credit hours

Minor in Chemical Engineering

Minimum credit hours required—22

The following courses are required:

- ChE 326 (3), ES 216 (3), ES 374 (3), ES 350 (3), ChE 349 (3)
- One of: ChE 351 (3), ChE 352 (3), ChE 477 (3)
- One of: CHEM 311 & L (4), CHEM 331 & L (4), CHEM 333 & L (4)

Minor in Polymer Science

Minimum credit hours required—19

The following courses are required:

- CHEM 334 (3), 446 (3)

- MTLs 202 & 202L (4) or 235 & 235L (4)
- MTLs 351 (3)
- Approved Technical Electives (6)

Graduate Programs

The chemical engineering department offers Masters of Science, Masters of Engineering and Ph.d in chemical engineering with specialization in surface engineering

Students in the graduate program in chemical engineering with specialization in surface engineering will be required to take a significant course load in surface engineering fundamentals where they will advance knowledge from science and basic engineering to surface engineering. Students will also have the opportunity to explore applications in surface engineering through coursework and research.

Upon completion of a graduate degree in chemical engineering with specialization in surface engineering, students will demonstrate:

The ability to apply experimental and/or calculation based techniques in order to solve a research question in the field of surface engineering

The ability to apply science and basic engineering to the field of surface engineering in order to solve upper level problems

The ability to effectively present their research visually and orally through oral presentations, posters, and research publications

Accelerated Masters

Qualified undergraduate students may apply for admission to the Accelerated Masters program in Chemical Engineering. In fulfillment of the requirements for both B.S and M.S. degrees, as outlined in their respective sections, accepted students may apply nine credits of 500-level courses to both degrees.

Masters of Science in Chemical Engineering with specialization in surface engineering.

The M.S. Program has the following requirements: The student must select a committee of at least three faculty with the majority of the faculty members being from inside the department. The committee must include the student's research advisor and academic advisor, which may be the same faculty member.

The MS degree requires 30 credit hours beyond the B.S. with the following requirements:

- a minimum of 6 hours of thesis
 - a maximum of 3 hours of directed study
 - a minimum of 12 hours of 500-level or above, which must include at least 9 hours of core courses
 - a minimum of 6 hours outside of chemical engineering
- 3) The student's graduate committee, the department chair, and the graduate dean must approve the course

work used for the degree.

4) The student must write and successfully defend a thesis of their research in an oral public defense before their graduate committee.

Masters of Engineering in Chemical Engineering with specialization in surface engineering.

The M. Eng. Program has the following requirements:

The MEng degree requires 30 credit hours beyond the B.S. with the following requirements:

- a maximum of 3 hours of directed study
- a minimum of 12 hours of 500-level or above, which must include at least 9 hours of core courses
- a minimum of 6 hours outside of chemical engineering

Doctor of Philosophy in Chemical Engineering with Dissertation in Surface Engineering.

The Ph.D. requirements include the following:

1) Select a graduate committee that shall consist of a minimum of four members: (a) an academic advisor from the Chemical Engineering department, and (b) at least three other members, one of which must be from outside the department assigned. The research advisor may be the academic advisor or another member of the committee.

2) The PhD degree requires 48 credit hours beyond the M.S. degree with the following requirements:

- a minimum of 24 hours of dissertation
- a maximum of 6 hours of directed study
- a minimum of 12 hours of 500-level courses, which must include 9 hours of core courses
- a minimum of 6 hours outside of chemical engineering
- passing a written examination of chemical engineering fundamentals as well as a proposal defense prior to the end of their 2nd year of residency

3) 72 credit hours beyond the B.S. degree with the following requirements:

- a minimum of 24 hours of dissertation
- a maximum of 9 hours of directed study
- a minimum of 6 hours outside of chemical engineering
- a minimum of 24 hours of 500-level courses, which must include 18 hours of core courses
- passing a written examination of chemical engineering fundamentals as well as a proposal defense prior to the end of their 2nd year of residency

4) All course work must be approved by the student's graduate committee, the Chemical Engineering Department Chair, and the Dean of Graduate Studies.

5) Pass a preliminary exam composed of 3 written exams covering core areas of surface engineering. The exam must be taken by the end of the third semester. The student must pass all three exams individually. If the student fails one of the three exams, they may retake that exam the following semester and they must pass it to move on.

6) After passing the preliminary exam, the student must present a proposal of their research to their committee in a public forum and satisfactorily, to the committee, answer questions regarding their research. The research proposal must be attempted before the end of the semester after passing the preliminary exam. If a student fails, they may have one attempt to pass the exam taken the semester after the first attempt. If the student fails the exam, they may appeal to the department chair and/or graduate dean.

7) The admission to candidacy to the Ph.D. degree requires that the qualifying and candidacy examinations be passed and approved by the graduate committee; after which the student may enroll in CHE 5xx: Dissertation.

8) The student must write a final dissertation and defend it in an oral public defense before the student's graduate committee. Additional requirements include the New Mexico Institute of Mining and Technology Graduate Program requirements.

Chemical Engineering Courses:

ChE 110, Introduction to Chemical Engineering, 2 cr, 1 cl hr, 3 lab hrs

Students will gain fundamental engineering skills that apply to all engineering disciplines through problem and cooperative based learning exercises and attain a clear understanding of what chemical engineers practice versus other engineering disciplines, in both traditional and contemporary work environments and careers. This course will introduce engineering calculations such as material and energy balances, cost analysis, and engineering software programs. The lab focuses on firsthand experience of engineering design, calculations, and simulations using ChemCAD, Lab VIEW, and Excel. Additionally, data acquisition and analysis will be introduced. Small teams will design, build, and test a system, resulting in a written report, oral presentation, and design competition.

ChE 326, Principles of Chemical Engineering I, 3 cr, 3 cl hrs

Prerequisite: CHEM 1215

Corequisite: MATH 1520

Offered fall semester

Introduction to stoichiometric computations.
Calculations of energy and material balance.
Elementary process analysis and reactor design. Single and multi-phase systems.

ChE 327, Principles of Chemical Engineering II, 3 cr, 3 cl hrs

Prerequisite: ChE 326

Corequisite: MATH 2532

Offered spring semester

Introduction to non-steady state, transient material and energy balances. Solution methods using logic programming, spreadsheets, and process simulation software. Statistical process analysis.

ChE 345L, Chemical Engineering Design Lab, 1 cr, 3 lab hrs

Prerequisites: ES 347, ChE 326

Corequisite: ES 350

Offered spring semester

Team-oriented project design. Introduction to design fundamentals and creative problem-solving techniques. Written and oral presentations summarizing team progress.

ChE 349, Chemical Engineering Thermodynamics, 3 cr, 3 cl hrs

Prerequisites: MATH 2532; CHEM 1215, PHYS 1310; ES 347 is recommended

Offered fall semester

The theory and engineering applications of the properties of mixtures, phase and chemical reaction equilibria. (Same as MTLS 350)

ChE 351, Chemical Process Kinetics, 3 cr, 3 cl hrs

Prerequisites: ChE 326, 349, MATH 335

Corequisite: ES 350

Offered spring semester

Fundamentals of chemical reaction kinetics and chemical reactor design. Development of rate equations for both homogeneous and heterogeneous reactions, catalysis, diffusion-controlled reactions, and transport processes. (Previously offered as ChE 451)

ChE 352, Separation Processes, 3 cr, 3 cl hrs

Prerequisites: ChE 326, 349

Corequisite: ES 350

Offered spring semester

The process approach to solving problems that involve equilibrium in binary and multicomponent mixtures. Phase equilibrium, absorption, distillation (binary and multicomponent), liquid-liquid extraction, leaching. Design of staged operations for separating gas-liquid, liquid-liquid, solid-liquid, and gas-solid mixtures. (Previously offered as ChE 442)

ChE 371, Solution Methods for Chemical Engineers, 3 cr, 3 cl hrs

Prerequisites: ChE 327, ChE 351, ChE 352

Offered fall semester

Application of analytic and numeric solution techniques to problems in chemical engineering thermodynamics, fluid transport, heat transfer, mass transfer, kinetics and process control. Topics covered include solution of sets of linear and nonlinear algebraic equations, ordinary differential equations, and partial differential equations. Emphasis will be on solving problems the student will encounter in the field of chemical engineering.

ChE 443, Process Dynamics and Control, 2 cr, 2 cl hrs

Prerequisites: MATH 335

Corequisites: ChE 371

Offered Fall Semester

Process dynamics and control theory applied to chemical, mechanical, and other engineering processes. Design of control systems.

ChE 443L, Chemical Process Dynamics & Control Lab, 1 cr, 3 lab hrs

Corequisite: ChE 443

Computer modeling of system dynamics. Design, implementation, and tuning of process control systems for chemical processes.

ChE 445L, Unit Operations Lab, 1 cr, 3 lab hrs

Prerequisite: ChE 351, 352

Offered fall semester

Laboratory exercises to illustrate heat exchange, fluid flow, and mass transport phenomena in common unit operations found in the chemical process industries.

ChE 461, Chemical Plant Design, Economics, and Management I, 3 cr, 1 cl hr, 6 lab hrs

Prerequisites: ChE 351 and ChE 352

Offered fall semester

A two-semester sequence of courses in which a design project is used to illustrate principles and processes of chemical plant design, economics, and management. Lecture topics include intellectual property, capital and operating cost estimation, energy conservation, design optimization and scaling of chemical processes. Use of commercially available process simulation software emphasized.

ChE 462, Chemical Plant Design, Economics, and Management II, 3 cr, 1 cl hr, 6 lab hrs

Prerequisite: ChE 461.

Offered spring semester

Continuation of ChE 461.

ChE 485, Senior Seminar, 1 cr, 3 lab hrs

Prerequisite: Senior standing or consent of instructor and advisor. Offered fall semester

Student and outside speaker presentations of topics of current interest. Peer and video review of each student's work. Career planning.

Elective Courses

ChE 463, 463D, Design and Analysis of Experiments, 3 cr, 3 cl hrs

Prerequisite: Senior standing

Methods of statistics and modeling important to many problems in materials science and engineering. Examples are chosen from a number of actual experiences. Safety considerations and experiment design including analysis of risk, how risks may be integrated, and how formal procedures should be established. The use of information sources, such as Materials safety data sheets (MSDS).

ChE 464, Natural Gas Engineering, 3 cr, 3 cl hrs

Prerequisite: PETR 245 or ChE 349

Offered fall semester

Composition and properties of natural gas. Gas

separator design. Recovery of liquefiable products from gas. Conditioning, transmission, and compression, measurement of gas, gas pipeline design, and gas storage. **(Same as PETR 464)**

ChE 465, Catalyst Characterization Techniques, 3 cr, 3 cl hrs

Prerequisite: ChE 349 or MTLs 350 or CHEM 332 or instructor's consent

The course provides an overview of techniques used to characterize catalytic materials including data analysis and linking physical and chemical properties to catalytic activity at the laboratory and process level. Topics include x-ray methods, neutron scattering methods, physical adsorption, chemical adsorption, temperature programmed techniques, photoelectron spectroscopy, vibrational spectroscopy, and electron microscopy.

ChE 468, Surfaces, Interfaces, and Colloids, 3 cr, 3 cl hrs

Prerequisites: CHE 349, MTLs 350, or CHEM 331

Kinetics and thermodynamics of nano-scale particle interactions with emphasis on colloidal phenomena, surfactants, electrostatic, London, and van der Waals interactions, gas adsorption, sedimentation and diffusion, osmotic and Donnan equilibrium, rheology, surface tension, and the electrical double layer. Relevant instrumentation will be discussed for various topics.

ChE 470, Fuel Cell Technology, 3 cr, 3 cl hrs

Prerequisite: Consent of instructor

The principles of fuel cell technology, including classification of fuel cells and operating mechanisms. Analysis of the underlying thermodynamics and physical factors which govern fuel cell performance and efficiency. Cell components and integrative cell design.

ChE 472, 472D, Advanced Transport Phenomena, 3 cr, 3 cl hrs

Prerequisite: ES 216 and 350 or MTLs 314 or consent of instructor and advisor

Advanced topics in momentum, heat, and mass transfer. Newtonian and non-Newtonian fluid behavior and laminar flow problems, elementary turbulent flow concepts, energy balance applications in incompressible fluid flow, flow and vacuum production. Fourier's law and thermal conductivity of materials, steady state and time dependent heat conduction, application in solidification, elementary convective heat transfer. Diffusivity of Materials, diffusion in gases, liquids and solids and through porous media, time dependent diffusion, and interphase mass transfer.

ChE 473, Polymer Materials Engineering, 3 cr, 3 cl hrs

Prerequisite: MTLs 202 or consent of instructor and advisor

Offered every fall semester

Introduction to classes and performance properties of polymeric materials. Methods of polymer synthesis and processing. Special emphasis on structure, viscoelasticity, and mechanical properties.

working knowledge of the instrumentation and analysis tools used in the course. These include rheometers, calorimeters, and mechanical testing. The primary analysis tool is Kaleidagraph software.

ChE 475, 475D, Explosives Surety, 3 cr, 3 cl hrs

Prerequisite: Upper-class standing or consent of instructor and advisor

Offered spring semester

An introduction to explosives and other energetic materials. The basic chemical compositions, properties and environmental effects of commercial, military, and improvised (terrorist) explosives and some pyrotechnics will be compared. The basic physics of shock waves and detonation. Explosive effects, blast detection, tagging and environmental issues. Case studies or recent bombings will be used to describe a variety of terrorist approaches. Safety in handling of explosive materials and classifications for transportation and storage. **(Same as EXPL 414.)**

ChE 476 Drug Delivery Techniques, 3 cr, 3 cl hrs

Prerequisite: Senior standing or consent of instructor and advisor

Focus is on current developments in drug delivery techniques, with only a brief discussion of common clinical techniques. The first portion of the class focuses on various delivery mechanisms and the tools needed to validate successful targeted drug delivery (both in vitro, in vivo and diagnostic tools). The second part of the course focuses on current developments in drug delivery based on published research articles.

Students will read, digest, and critically analyze scientific work from leading research laboratories. Students will also gain valuable communication tools, as each student will present an article of interest to the class. Finally, the third part of the course focuses on important Materials characterization methods such as biological sample prep, SEM, TEM, DSC, Flow Cytometry, Fluorescence Microscopy, ELISA Assays. Shares lecture with MTL5 576 with additional expectations for graduate credit.

ChE 477, Bioprocess Engineering, 3 cr, 3 cl hrs

Prerequisites: CHE 326

Fermentation processes for the production of biopolymers, biofuels, pharmaceuticals, stem cells, hormones etc. Enzyme kinetics, microbial and animal cell growth kinetics, metabolic engineering, bioreactors, separation and purification of products. Examples of industrial processes.

ChE 481, Modeling in Advanced Materials, 3 cr, 3 cl hrs

Prerequisite: Consent of instructor

Overview of several contemporary research topics pertaining to nanomaterials for energy, environment and electronics. Lectures are focused on general modeling approaches to characterize the nanomaterials, which can have a significant impact on our quality of life. Relevant physical concepts, computational methods, and simulations on parallel computers are also introduced.

Special attention are given to point out how methods learned during this course are applied in current frontier research in nanoMaterials for various applications.

Along with the lectures, the course also includes in-class implementation workshops of some of the computational methods using relevant software packages.

ChE 491, Independent Study, hrs and crs to be arranged

Prerequisite: Consent of instructor

Individual study of chemical engineering problems of special interest.

CHE 551: Advanced Mathematical Modeling 3 cr, 3 cl hrs

Prerequisites: Graduate Standing in Chemical Engineering or consent of instructor

Integrated approach to solving linear mathematical problems. Linear algebraic equations. Linear ordinary and partial differential equations using theoretical/numerical analysis based on linear operator theory. Introduction to numerical solutions to partial differential equations and non-linear systems.

CHE 552: Surface Characterization Techniques 3 cr, 3 cl hrs

Prerequisites: Graduate Standing in Chemical Engineering or consent of instructor

The course covers scientific principles behind and operating procedures for several surface characterization techniques. The techniques covered include electron microscopies (scanning electron microscopy, Auger spectroscopy, and transmission electron microscopy), x-ray spectroscopies (x-ray photoelectron spectroscopy, extended x-ray absorption fine structure), methods relying on ion detection, and scanning probe microscopies (atomic force microscopy and scanning tunneling microscopy). Associated sources, detectors, and vacuum systems will be discussed.

CHE 553: Advanced Separation Processes 3 cr, 3 cl hrs

Prerequisites: Graduate Standing in Chemical Engineering or consent of instructor

Applications of interfacial mass transfer including liquid-liquid, gas-solid, and liquid-solid separation based techniques. Processes include adsorption, crystallization, liquid-liquid extraction, chromatography, and membrane based separations.

CHE 563: Design and Analysis of Experiments 3 cr, 3 cl hrs

Prerequisites: Graduate Standing in Chemical Engineering or consent of instructor

Learn how to plan, design and conduct experiments efficiently and effectively, and data analysis to draw conclusions. Both design and statistical analysis issues are discussed. Students will learn how to utilize standard statistical software packages for design and analysis of experiments.

CHE 565: Catalyst Characterization Techniques 3 cr, 3 cl hrs

Prerequisites: Graduate Standing in Chemical Engineering

or consent of instructor

The course provides an overview of techniques used to characterize catalytic Materials including data analysis and linking physical and chemical properties to catalytic activity at the laboratory and process level. Topics include x-ray methods, neutron scattering methods, physical adsorption, chemical adsorption, temperature programmed techniques, photoelectron spectroscopy, vibrational spectroscopy, and electron microscopy. The use of information sources, such as Materials safety data sheets (MSDS). Shares lecture with ChE 465, with additional expectations for graduate credit.

CHE 566: Heterogeneous Catalysis 3 cr, 3 cl hrs

Prerequisites: Graduate Standing in Chemical Engineering or consent of instructor

Overview of properties important for catalysts, catalyst synthesis techniques, and structured catalysts. Catalytic reactor design and operation including external mass transfer, pore diffusion, and methods to determine mass transfer limitations including boundary layer models. Surface kinetic mechanisms including Langmuir-Hinshelwood and Eley-Rideal kinetics. Surface reaction thermodynamics.

CHE 568: Surfaces, Interfaces, and Colloids 3 cr, 3 cl hrs

Prerequisite: Graduate Standing in Chemical Engineering or consent of instructor

Kinetics and thermodynamics of nano-scale particle interactions with emphasis on colloidal phenomena, surfactants, electrostatic, London, and van der waals interactions, gas adsorption, sedimentation and diffusion, osmotic and Donnan equilibrium, rheology, surface tension, and the electrical double layer. Relevant instrumentation will be discussed for various topics. Shares lecture with ChE 468, with additional expectations for graduate credit.

CHE 572: Interfacial Transport Phenomena 3 cr, 3 cl hrs

Prerequisite: Graduate Standing in Chemical Engineering or consent of instructor

Advanced topics in momentum, heat, and mass transfer applied to interfacial transport processes. Newtonian and non-Newtonian fluid behavior and laminar flow problems, elementary turbulent flow concepts, energy balance applications in incompressible fluid flow, flow and vacuum production. Fourier's law and thermal conductivity of Materials, steady state and time dependent heat conduction, application in solidification, elementary convective heat transfer. Diffusivity of Materials, diffusion in gases, liquids and solids and through porous media, time dependent diffusion, and interphase mass transfer. The use of information sources, such as Materials safety data sheets (MSDS). Shares lecture with ChE 472, with additional expectations for graduate credit.

CHE 576: Drug Delivery Techniques 3 cr, 3 cl hrs

Prerequisites: Graduate Standing in Chemical Engineering or consent of instructor

Focus is on current developments in drug delivery techniques, with only a brief discussion of common clinical techniques. The first portion of the class focuses on various delivery mechanisms and the tools needed to validate successful targeted drug delivery (both in vitro, in vivo and diagnostic tools). The second part of the course focuses on current developments in drug delivery based on published research articles. Students will read, digest, and critically analyze scientific work from leading research laboratories. Students will also gain valuable communication tools, as each student will present an article of interest to the class. Finally, the third part of the course focuses on important Materials characterization methods such as biological sample prep, SEM, TEM, DSC, Flow Cytometry, Fluorescence Microscopy, ELISA Assays. The use of information sources, such as Materials safety data sheets (MSDS). Shares lecture with ChE 476, with additional expectations for graduate credit.

Faculty Research Interests

Choudhury — Computational Modeling of Materials for the Energy and Environment; Specific Research Areas include: Surface Engineering, Catalysis, Gas Sensors, Proton Transport Membranes, Sorbent, Materials and CO₂ Reduction.

Chowdhury — Optically Active Nanomaterials, Solar Energy Conversion, Single Molecule Microscopy, Plasmon Enhanced Catalysis, Plasmonic Biosensors

Leclerc — Catalysis, Reactor Design, Alternative Fuels, Biofineries, Hydrogen Production, Non- Thermal Plasma Surface Modification, biomass and plastic pyrolysis and gasification

Lee – Conjugated Polymers for Power Generation and Sensing Applications, Reversible Polymerization for Self-Healing Behavior.

Shin - Soft Matter, Surface and Colloid Science, Materials and Nanotechnology, Bioinspired Engineering, Biomimetic

Tartis—Biomedical Imaging, Targeted Drug Delivery, Lipid Prodrugs, Nanoparticles, Biomaterials, Traumatic Brain Injury

Civil Engineering

Professor Richardson (Chair of the Department)

Associate Professor Wilson, Cook

Assistant Professor Morris

Adjunct Faculty Ghosh, Kuhn, Razavi

**Degree Offered: B.S. in Civil Engineering
M.S. in Civil & Environmental Engineering**

Department Mission Statement

The primary objective of this program is to produce well-balanced civil engineers capable of entering the civil engineering profession or continuing their studies at the graduate level. Graduates will be well-prepared to solve current civil engineering problems, and they will have the ability to adapt to problems of the future.

The achievements of civil engineers are well-known to the general public, because civil engineers build the world's infrastructure. In doing so, they can shape the history of nations. Projects that civil engineers work on include: airports, bridges, buildings, dams and waterways, drainage and sewer systems, city roads, and highways.

The undergraduate program offers a balanced approach to civil engineering education. Students take a common core of civil engineering courses, and they can specialize in the areas of geotechnical, water resources, or structural engineering. The program is also designed to give students a solid foundation in engineering and science. Students take courses in chemistry, physics, and math, in addition to a core set of engineering courses common to most engineering disciplines.

The civil engineering courses teach students the fundamentals of engineering design, as well as potential applications. Students are taught how to use computer software to expedite the design process, and they are also taught how to balance engineering designs with economic constraints. During their senior year, undergraduate students work with a professor on a design project.

Program Educational Objectives

1. To develop graduates that function successfully in the fundamental areas of civil engineering, and within a specialty, such as structural, geotechnical or water resources engineering.
2. To prepare graduates for advanced education in civil engineering and related fields, and for professional licensure.

Student Outcomes for Undergraduate Program in Civil Engineering.

Graduates of the Bachelor of Science in Civil Engineering program will have demonstrated:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions

3. that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Undergraduate Program

Bachelor of Science in Civil Engineering

Minimum credit hours required—132

In addition to the General Education and Institute Core Curriculum (page 78), the following courses are required:

- CE 101 (1), 201 (3), 301 (3), 302 (3), 401 (3), 402 (3),
- CE 406 (3), CE 407 (3), 413 (3), 423(3), 481 (3)
- ES 316 (3)
- ES 110 (2), 111 (3), 201 (3), 216 (3), 302 (3)
- MATH 2532 (4), 2350 (3), 335 (3)
- ME 220 (3), 420 (3)

Basic Science Elective —3 credits from the following: BIOL 2110, GEOL 1110, GEOL 2120, GEOL 1170, GEOL 1185, GEOL 1140. Students are not required to take the accompanying lab unless it is required by the Biology/Earth Science department.

Technical Electives (12): Minimum of 12 credit hours from the list of approved civil engineering electives. Students may take approved elective courses from more than one specialty area to satisfy the B.S. degree without prior approval from their advisor or the Department Chair. Courses are grouped by specialty to assist students who may want to specialize in a particular area.

Civil engineering approved electives include:

Geotechnical (12): CE 420 (3), CE 422 (3), ME 360 (3), ME 409 (3), ME 422 (3), ME 427 (3), ME 434 (3), EXPL xxx (3)

Water Resources (12): ENVE 201 (3), ENVE 301 (3), ENVE 303(3), ENVE 304 (3), ENVE 406 (3), GEOL 440 (3), GEOL 440L (1), ES 347 (3), ES 350 (3)

Structural (12): CE 410 (3), CE 411 (3), CE 412 (3), CE 414 (3), CE 418 (3), CE 420 (3), MTLs 470 (3), MENG 304 (3), MENG 441 (3), ME 409 (3), ME 434 (3) , EXPL xxx (3)

Additional technical electives must be approved by the Department Chair

Students pursuing a B.S. in Civil Engineering must take all engineering courses for a letter grade.

Civil engineering majors must maintain a minimum GPA of 2.0 in required courses in order to graduate. Civil engineering majors are required to take the Fundamentals in Engineering (FE) exam as a requirement for graduation.

Sample Curriculum for the Bachelor of Science Degree in Civil Engineering

Semester 1

- 1 CE 101 (civil engineering seminar)
- 4 CHEM 1215 & 1215L (general)
- 3 ENGL 1110 (college English)
- 2 ES 110 (drafting)
- 4 MATH 1510 (calculus)
- 3 Basic Science*

17 Total credit hours

* Basic Science Elective from one of the following:

BIOL 2110, GEOL 1101, GEOL 2120, GEOL 1170, GEOL 1185, Geol 1140

Semester 2

- 3 ENGL 1120 (college English)
- 3 ES 111 (computer programming)
- 4 MATH 1520 (calculus)
- 5 PHYS 1310 & 1310L (general)

15 Total credit hours

Semester 3

- 4 CHEM 1225 & 1225L (general)
- 3 ES 201 (statics)
- 4 MATH 2532 (calculus)
- 5 PHYS 1320 & 1320L (general)

16 Total credit hours

Semester 4

- 3 ES 216 (fluid mechanics)
- 3 ES 302 (mechanics of Materials)
- 3 MATH 335 (ordinary differential equations)
- 3 ME 220 (surveying and map preparation)
- 6 Humanities / Social Science

18 Total credit hours

Semester 5

- 3 CE 201 (Materials, properties, and testing)
- 3 CE 302 (structures)
- 3 ME 420 (soil mechanics)
- 3 ENGL 341 (technical writing)
- 3 MATH 2350 (statistics)
- 3 Social Science

18 Total credit hours

Semester 6

- 3 CE 301 (construction engineering)
- 3 CE 401 (finite element analysis)
- 3 CE 402 (transportation)
- 3 ES 316 (engineering practice and economics)
- 3 CE Elective
- 3 Humanities

18 Total credit hours

Semester 7

- 3 CE 406 (steel)
- 3 CE 407 (concrete)
- 6 CE Electives
- 3 Humanities/Fine & Creative Arts

15 Total credit hours

Semester 8

- 3 CE 413 (foundation design & analysis)
- 3 CE 423 (open channel hydraulics)
- 3 CE 481 (senior design)
- 3 Humanities
- 3 CE Elective

15 Total credit hours

Approved Civil Engineering Electives

CE students must take a minimum of 12 elective credit hours. Students may take approved elective courses from more than one specialty area to satisfy the B.S. degree without prior approval from their advisor or the Department Chair. Courses are grouped by specialty to assist students who may want to specialize in a particular area.

Water Resources Engineering

- 3 ENVE 201 (environmental engineering)
- 3 ENVE 301 (applied principles of environmental engineering)
- 3 ENVE 303 (water treatment process design)
- 3 ENVE 304 (wastewater treatment process design)
- 3 ENVE 406 (environmental engineering unit operations)
- 4 GEOL 440 (hydrological theory and field methods)
- 3 ES 347 (engineering thermodynamics)
- 3 ES 350 (heat and mass transfer)

Geotechnical Engineering

- 3 CE 420 (pavement design)
- 3 CE 422 (geotechnical waste containment design)
- 3 ME 360 (exploration and field mapping)
- 3 ME 409 (design of structures)
- 3 ME 422 (rock mechanics)
- 3 ME 427 (site investigation)
- 3 ME 434 (drilling & blasting)
- 3 Some explosives (EXPL) courses – check with Department Chair

Structural Engineering

- 3 CE 410 (reinforced masonry and timber design)
- 3 CE 411 (minimum design loads for buildings)
- 3 CE 412 (advanced design of steel structures)
- 3 CE 414 (advanced design of concrete structures)
- 3 CE 418 (structural dynamics)
- 3 CE 420 (pavement design)
- 3 MTL 470 (corrosion phenomena)
- 3 MENG 304 (advanced strength of Materials)
- 3 MENG 441 (dynamics and vibrations in structural design)
- 3 ME 409 (design of structures)
- 3 ME 434 (drilling & blasting)
- 3 Some explosives (EXPL) courses – check with Department Chair

Additional technical electives must be approved by the Department Chair.

Minor in Civil Engineering

Minimum credit hours required – 18

The following courses are required:

- 18 total credit hours of CE courses, ME 420, or ME 422

Civil Engineering Courses:

CE 101, Civil Engineering Seminar, 1 cr, 1 cl hrs

Brief overview of civil engineering topics, including structures, water resources, geotechnical and transportation engineering in the form of seminars by faculty, and guest speakers from industry, consulting, and government.

CE 201, Construction Materials, Properties, and Testing, 3 cr, 3 cl hrs

Prerequisite: CHEM 1225

Mechanical behavior of engineering Materials, including metals, ceramics, polymers, concrete, wood, bitumens, and asphaltic concretes; explanations of macroscopic behavior in terms of phenomena at the microscopic level.

CE 301, 301D, Introduction to Construction Engineering, 3 cr, 3 cl hrs

Topics covered include: contracting and bonding, planning and scheduling, estimating, project control, and productivity models.

CE 302, 302D, Introduction to Structural Engineering, 3 cr, 3 cl hrs

Prerequisites: ES 201

Basic topics in the analysis, behavior, and design of trusses and framed structures under static loads; analysis topics include member forces in trusses, shear and moment diagrams, deflections, simple applications of the force and slope–deflection.

CE 401 – Finite Element Analysis for Civil Engineers, 3 cr, 3 cl hrs

Prerequisite: CE 302 or consent of instructor and advisor

Introduction to finite element analysis (FEA) for Civil Engineering students. Students will learn the fundamentals of FEA, and they will learn to use software packages to analyze complex structures. Topics include: 1-systems, trusses, 2-D problems, axis-symmetric solids, beams, frames, and some types of 3-D problems. **(cross-listed with CEE 501; additional course expectations for graduate credit)**

CE 402, Introduction to Transportation Engineering, 3 cr, 3 cl hrs

Overview of the field of Transportation Engineering. Topics covered include: description of transportation systems; traffic engineering studies; highway safety studies; traffic flow characteristics; transportation planning; travel demand; geometric design of highways; characteristics of drivers, pedestrians, vehicles, and roads and their applications to the determination of braking distance, stopping sight distance, passing sight distance, sign placement, and timing of change and clearance intervals. **(cross-listed with CEE 502; additional**

course expectations for graduate credit)

CE 403, Infrastructure, 3 cr, 3 cl hrs

Prerequisite: Junior standing

Infrastructure systems have been deteriorating at an alarming rate and resources available for their rehabilitation or replacement have been limited. This course considers the current challenges to managing infrastructure. It focuses on current issues and through case studies addresses: the social, economic and political importance of infrastructure, the ASCE Report Card and its purposes, planning approaches economic and other strategies for comparing infrastructure alternatives, sustainability, risk, and resilience. **(cross-listed with CEE 505; additional course expectations for graduate credit)**

CE 406, Design of Steel Structures, 3 cr, 3 cl hrs

Prerequisite: CE 302 or consent of instructor and advisor

Behavior and design of steel members subjected to tension, compression and flexural loads, according to AISC specifications. Topics covered include: elastic and inelastic design, buckling of beams and columns, and structural connections. **(cross-listed with CEE 506; additional course expectations for graduate credit)**

CE 407, Design of Concrete Structures, 3 cr, 3 cl hrs

Prerequisite: CE 302 or consent of instructor and advisor

Study of the strength, behavior and design of reinforced concrete members, including beams, columns and slabs. Topics covered will include serviceability of beams and slabs, control of deflections and cracking, shear design, and bonding. **(cross-listed with CEE 507; additional course expectations for graduate credit)**

CE 410, Reinforced Masonry and Timber Design, 3 cr, 3 cl hrs

Prerequisite: CE 302 or consent of instructor and advisor

Reinforced masonry design topics covered include: the properties and performance of masonry Materials; design criteria and methods in reinforced masonry; and design examples including reinforced masonry walls, masonry columns and pilasters, and rectangular beams. Timber topics covered include: design of beams, columns, trusses, and diaphragms in wood; design of glue laminated beams; design of wood connections; use of timber design codes and the International Building Code (IBC). **(cross-listed with CEE 5xx; additional course expectations for graduate credit)**

CE 411, Minimum Design Loads for Buildings, 3 cr, 3 cl hrs

Prerequisite: CE 302

Introduction to risk concepts, behavior and determination of design loads acting on structures. Topics covered include development of codes and laws, in-depth discussion of minimum design loads (dead, live, snow, earthquake and wind) and load combinations, risk assessment in terms of uncertainty in material properties, consequences, heuristic loading assumptions, general structural integrity, and comprehension and application of codified documents. **(cross-listed with CEE 5xx; additional course expectation for graduate credit)**

CE 412, Advanced Design of Steel Structures, 3 cr, 3 cl hrs*Prerequisite: CE 406 or consent of instructor and advisor*

Behavior and design of structural steel beams, columns, frames, and connections. Topics include: elastic and inelastic design, composite beam design, stability of beams and columns, behavior of steel frame structures, design of bolted and welded connections, metallurgical and mechanical properties of welds, braced frame and moment frame design for lateral loads. Extensive use of the current AISC-LRFD design code. **(cross-listed with CEE 5xx; additional course expectation for graduate credit)**

CE 413, Foundation Design and Analysis, 3 cr, 3 cl hrs*Prerequisite: ME 420*

Principles of soil mechanics and foundation engineering. Immediate and time dependent settlements, service loads, lateral loads, loading, approximate analysis methods, performance requirements, shallow foundations, lateral earth pressure, design of retaining walls, deep foundations, special footings, slope stability, and computer modeling of foundations. *(Same as ME 413)*. **(cross-listed with CEE 5xx)** performance requirements, shallow foundations, lateral earth pressure, design of retaining walls, deep foundations, special footings, slope stability, and computer modeling of foundations. *(Same as ME 413)*. **(cross-listed with CEE 5xx)**

CE 414, Advanced Design of Concrete Structures, 3 cr, 3 cl hrs*Prerequisite: CE 407 or consent of instructor and advisor*

Topics covered include: strut and tie models, footings, retaining walls, principles of prestressed concrete, Materials and techniques used in these systems, advantages and disadvantages of prestressing methods over regular reinforced concrete, and the design of prestressed concrete structures, such as axially loaded members, beams (for flexure and shear), and slabs.. **(cross-listed with CEE 5xx; additional course expectations for graduate credit)**

CE 418, Structural Dynamics, 3 cr, 3 cl hrs*Prerequisites: Math 335 and CE 302 or consent of instructor and advisor*

Fundamentals of structural dynamics. Analysis of single and multi-degree-of-freedom structures subjected to various types of vibrations. Topics covered will include structural responses to free, harmonic and periodic excitations, step and pulse excitations, and earthquake loads.

CE 420, Pavement Materials and Design, 3 cr, 3 cl hrs*Prerequisites: CE 201 or ES 302*

Analysis, behavior, performance, and structural design of pavements for highways, bridges and airfields. Topics include: climatic factors, maintenance strategies and life cycle design economics, traffic loadings, recycled pavement Materials, evaluation by nondestructive testing (roughness, skid resistance, structural capacity), destructive testing, and rehabilitation of pavement systems.

CE 422, Geotechnical Waste Containment Design, 3 cr, 3 cl hrs*Prerequisites: ME 420; MATH 335*

Design procedures consisting of waste disposal methods, various containment systems, and associated remediation techniques. Waste characterization and soil-waste interactions, contaminant transport in low permeability soils, geosynthetics and soil Materials use in waste containment, remedial issues of solidification and stabilization and barrier design, and landfill- and surface impoundment-related design, including liners, leachate and gas collection and removal, final covers, static and seismic slope stability, and settlement analysis. Geotechnical problem definition, application of field and laboratory test data, use of computer models for analysis and design.

CE 423, Open Channel Hydraulics, 3 cr, 3 cl hrs*Prerequisites: ES 216*

Analysis and characteristics of flow in natural and artificial open channel systems using energy, continuity, and momentum equations as applied to steady-state uniform, gradually varied, and rapidly varied flow profiles with emphasis on design of hydraulic structures. The students will use their knowledge of fluid mechanics, calculus, numerical analysis, and computer science to solve practical open channel flow problems. A variety of hydraulic conveyance and structures are covered, including rigid and flexible boundary channels, culverts, sluice gates, fumes, weirs, spillways, stilling basins, and bridges.

CE 481, Senior Engineering Design , 1 cr, 3 cl hrs*Prerequisite: Senior standing in Civil Engineering
Offered in fall semester*

Semester-long civil engineering design project organized and directed by a faculty member.

CE 482, Senior Engineering Design , 2 cr, 2 cl hrs*Prerequisite: Senior standing in Civil Engineering
Offered in spring semester*

Continuation of CE481. A semester-long civil engineering design project organized and directed by a faculty member.

CE 491, Special Topics in Civil Engineering, 2-3 cr*Prerequisite: Senior standing or consent of instructor and advisor*

New and developing areas of knowledge in civil engineering offered to augment the formal course offerings.

CEE 501 – Finite Element Analysis for Civil Engineers, 3 cr, 3 cl hrs*Prerequisite: Graduate Standing in Civil & Environmental Engineering, or consent of instructor*

Introduction to finite element analysis (FEA) for Civil Engineering students. Students will learn the fundamentals of FEA, and they will learn to use software packages to analyze complex structures. Topics include: 1-D systems, trusses, 2-D problems, axis-symmetric solids, beams, frames, and some types of 3-D problems. **(cross-listed with CE 401; additional course expectations for graduate credit)**

CEE 502, Introduction to Transportation Engineering, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing in Civil & Environmental Engineering, or consent of instructor

Overview of the field of Transportation Engineering. Topics covered include: description of transportation systems; traffic engineering studies; highway safety studies; traffic flow characteristics; transportation planning; travel demand; geometric design of highways; characteristics of drivers, pedestrians, vehicles, and roads and their applications to the determination of braking distance, stopping sight distance, passing sight distance, sign placement, and timing of change and clearance intervals. **(cross-listed with CE 402; additional course expectations for graduate credit)**

CEE 504, Reinforced Masonry and Timber Design, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing in Civil & Environmental Engineering, or consent of instructor

Reinforced masonry design topics covered include: the properties and performance of masonry Materials; design criteria and methods in reinforced masonry; and design examples including reinforced masonry walls, masonry columns and pilasters, and rectangular beams. Timber topics covered include: design of beams, columns, trusses, and diaphragms in wood; design of gluelaminated beams; design of wood connections; use of timber design codes and the International Building Code (IBC). **(cross-listed with CE 410; additional course expectations for graduate credit)**

CEE 505 Infrastructure, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing in Civil & Environmental Engineering, or consent of instructor

Infrastructure systems have been deteriorating at an alarming rate and resources available for their rehabilitation or replacement have been limited. This course considers the current challenges to managing infrastructure. It focuses on current issues and through case studies addresses: the social, economic and political importance of infrastructure, the ASCE Report Card and its purposes, planning approaches economic and other strategies for comparing infrastructure alternatives, sustainability, risk, and resilience). **(cross-listed with CE 403; additional course expectations for graduate credit)**

CEE 506, Design of Steel Structures, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing in Civil & Environmental Engineering, or consent of instructor

Behavior and design of steel members subjected to tension, compression and flexural loads, according to AISC specifications. Topics covered include: elastic and inelastic design, buckling of beams and columns, and structural connections. **(cross-listed with CE 406; additional course expectations for graduate credit)**

CEE 507, Design of Concrete Structures, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing in Civil & Environmental Engineering, or consent of instructor

Study of the strength, behavior and design of reinforced concrete members, including beams, columns and slabs.

Topics covered will include serviceability of beams and slabs, control of deflections and cracking, shear design, and bonding. **(cross-listed with CE 407; additional course expectations for graduate credit)**

CEE 508, Advanced Design of Steel Structures, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing in Civil & Environmental Engineering, or consent of instructor

Behavior and design of structural steel beams, columns, frames, and connections. Topics include: elastic and inelastic design, composite beam design, stability of beams and columns, behavior of steel frame structures, design of bolted and welded connections, metallurgical and mechanical properties of welds, braced frame and moment frame design for lateral loads. Extensive use of the current AISC-LRFD design code. **(cross-listed with CE 412; additional course expectation for graduate credit)**

CEE 509, Advanced Design of Concrete Structures, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing in Civil & Environmental Engineering, or consent of instructor

Topics covered include: strut and tie models, footings, retaining walls, principles of prestressed concrete, Materials and techniques used in these systems, advantages and disadvantages of prestressing methods over regular reinforced concrete, and the design of prestressed concrete structures, such as axially loaded members, beams (for flexure and shear), and slabs. **(cross-listed with CE 414; additional course expectations for graduate credit)**

CE 518, Structural Dynamics, 3 cr, 3 cl hrs

Prerequisite: MATH 335 and CE 302 or consent of instructor and advisor

Fundamentals of structural dynamics. Analysis of single and multi-degree-of-freedom structures subjected to various types of vibrations. Topics covered will include structural responses to free, harmonic and periodic excitations, step and pulse excitations, and earthquake loads. Graduate students complete an additional project and a classroom presentation. Graduate work is graded separately. *Lectures shared with CE 418.*

CEE 541, Minimum Design Loads for Buildings, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing in Civil & Environmental Engineering, or consent of instructor

Introduction to risk concepts, behavior and determination of design loads acting on structures. Topics covered include development of codes and laws, in-depth discussion of minimum design loads (dead, live, snow, earthquake and wind) and load combinations, risk assessment in terms of uncertainty in material properties, consequences, heuristic loading assumptions, general structural integrity, and comprehension and application of codified documents. **(cross-listed with CE 411; additional course**

expectation for graduate credit)

CEE 543, Foundation Design and Analysis, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing in Civil & Environmental Engineering, or consent of instructor

Principles of soil mechanics and foundation engineering. Immediate and time dependent settlements, service loads, lateral loads, loading, approximate analysis methods, performance requirements, shallow foundations, lateral earth pressure, design of retaining walls, deep foundations, special footings, slope stability, and computer modeling of foundations. *(Same as ME 531)*. **(cross-listed with CE 4xx; additional course expectations for graduate credit)**

Faculty Research Interests

Cook — Full-scale infrastructure destructive testing, bridge risk assessment (observed failures).

Ghosh — Macro behavior of composites, structural health monitoring and restoration

Kuhn — Geotechnical engineering

Morris — Geophysical Methods

Richardson — Environmental assessment, groundwater contamination, site remediation

Wilson — Structural vibration control, fuzzy control, earthquake engineering

Computer Science and Engineering

Professors Jeffery (Chair of Department), Liebrock, Shin, Soliman, Zheng

Associate Professors Mazumdar, Shin, Zheng

Assistant Professor Ramyaa

Instructors Knowles, Kuo, Tong

Adjunct Faculty Anselmo, Mukkamala, Clausen, Hepler

Emeritus Faculty Stavely, Sung

Degrees Offered: B.S., M.S., and Ph.D. in Computer Science

The Department of Computer Science and Engineering is focused on an exciting and rapidly growing body of knowledge with constantly changing emphasis.

The curriculum of the department includes courses in both theory and application. It prepares students to apply the principles of logic and mathematics to the design and construction of hardware and software systems using current engineering paradigms and also exposes them to major applications of computing.

The *Bachelor of Science in Computer Science* program is accredited by the Computing Accreditation Commission of ABET, <https://www.abet.org>. The program emphasizes fundamental principles while striking a careful balance between the applications of computer technology and the theory of computing. In addition to the required fundamental computer science courses, students must also take technical electives to broaden their knowledge in major computer science application areas. Graduates of this program will be well prepared for both industry employment and graduate study.

Our graduate programs provide students the opportunity to take courses, select advisory committee members, and pursue research in an area of interest to a faculty supervisor. The *Master of Science in Computer Science* program is designed for students who wish to further broaden or deepen their knowledge of computer science and applications. Master's students usually participate in faculty research projects to complete their thesis or (non-thesis) independent study report.

New Mexico Tech's Department of Computer Science and Engineering also offers a *Ph.D. in Computer Science* program. The Ph.D. program is appropriate for students with motivation for research and either a superior track record in coursework or substantial experience in industrial research and development.

The department has been certified, since 2002, by the National Security Agency and the Department of Homeland Security as a National Center of Academic Excellence in Information Assurance Education. Since 2009, the department has also been certified as a National Center of Academic Excellence in Information Assurance Research.

The department has its own network of computers and servers plus a variety of other equipment in several laboratories. The Tech Computer Center supports a larger network that is also available to the department. Computing equipment at the

research labs associated with Tech includes both symmetric multiprocessors, GPU compute servers and special purpose massively parallel computers. The department also has access to massively parallel machines at national laboratories and supercomputing centers.

Mission

Our mission is to produce computer science graduates who, trained in the design, implementation, and analysis of computational systems and skilled in technical communication, will contribute towards the advancement of computing science and technology.

Program Educational Objectives

Within a few years of graduating with a B.S. degree in Computer Science, our students should be able to demonstrate that they have:

1. the ability to design, implement, and analyze computational systems;
2. the capability to tackle complex computer science related problems in the real world;
3. contributed towards the advancement of computing science and technology;
4. the capacity to work effectively with peers in computational tasks; and
5. cognizance of ethical, social, and legal issues pertaining to computer science.

Student Outcomes

By the time of their graduation, the undergraduate academic program in Computer Science should enable our graduates to:

1. analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions;
2. design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline;
3. communicate effectively in a variety of professional contexts;
4. recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles;
5. function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline; and
6. apply computer science theory and software development fundamentals to produce computing-based solutions.

Undergraduate Program

Bachelor of Science in Computer Science

Minimum credit hours required—123

In addition to the General Education and Institute Core Curriculum (page 80), the following courses are required:

- CSE 101 (2), 113 (4), 122 (3), 213 (3), 221 (3), 222 (3), 241 (3), 324 (3), 325 (4), 326 (3), 331 (3), 342 (3), 344 (4), 353 (3), 363 (3), 382 (3), 423 (4)
- MATH 352 (3), 382 (3), 382L (1)
- Technical Electives: A sequence of 12 hours of CSE courses numbered 300 or higher, pre-approved by the student's advisor and the CSE Department, with no more than one

course numbered CSE 485. Students are encouraged to select a coherent set of courses as technical electives that will prepare them for a specific focus in their career;

- All the courses listed above must be taken for a letter grade;
- General Electives to complete 123 credit hours.

Sample Curriculum 1 for the Bachelor of Science in Computer Science program

Semester 1 (Fall)

4 MATH 1510 (calculus)
 2 CSE 101 (intro to comp science & info tech)
 4 CSE 113 & 113L (intro to programming)
 5 PHYS 1310 & 1310L (general physics I)
 15 Total credit hours

Semester 2 (Spring)

4 MATH 1520 (calculus)
 3 CSE 122 (algorithms and data structures)
 5 PHYS 1320 & 1320L (general physics II)
 3 ENGL 1110 (college English)
 15 Total credit hours

Semester 3 (Fall)

3 CSE 221 (computer systems)
 3 CSE 241 (foundations of computer science)
 4 CHEM 1215 & 1215L (general chemistry I)
 3 ENGL 1120 (college English)
 3 Humanities
 16 Total credit hours

Semester 4 (Spring)

3 CSE 213 (intro object oriented programming)
 3 CSE 222 (systems programming)
 4 Math 382 & 382L (probability and statistics)
 4 CHEM 1225 & 1225L (general chemistry II)
 3 MATH 352 (basic concepts of mathematics)
 17 Total credit hours

Semester 5 (Fall)

4 CSE 325 & 325L (operating systems)
 4 CSE 344 & 344L (design & analysis algorithms)
 3 CSE 353 (intro to computer networks)
 3 ENGL 341 (technical writing)
 14 Total credit hours *

Semester 6 (Spring)

3 CSE 326 (software engineering)
 3 CSE 342 (formal languages and automata)
 3 CSE 324 (principles programming languages)
 3 CSE 363 (secure computing)
 3 Technical Elective
 15 Total credit hours

Semester 7 (Fall)

3 Creative & Fine Arts
 3 Humanities
 3 Technical Elective
 3 Technical Elective
 3 Social Science
 15 Total credit hours

Semester 8 (Spring)

4 CSE 423 & 423L (compiler writing)
 3 CSE 331 (computer architecture)

3 CSE 382 (ethics of computing and info technologies)*
 3 Social Science
 3 Technical Elective
 16 Total credit hours

*(satisfies Area 7)

* In order to earn or retain the NM Lottery Scholarship, students must earn 15 credits each semester. Please see your advisor for details.

- In order to earn or retain the NM Lottery Scholarship, students must earn 15 credits each semester. Please see your advisor for details.

Sample Curriculum 2 for the Bachelor of Science in Computer Science program

Semester 1 (Spring)

4 MATH 1510 (calculus)
 4 CSE 113 & 113L (introduction to programming)
 3 ENGL 1110 (college English)
 4 CHEM 1215 & 1215L (general chemistry I)
 15 Total credit hours

Semester 2 (Fall)

4 MATH 1520 (calculus)
 2 CSE 101 (intro to comp science & info tech)
 3 CSE 122 (algorithms and data structures)
 4 CHEM 1225 & 1225L (general chemistry II)
 3 ENGL 1120 (college English)
 16 Total credit hours

Semester 3 (Spring)

3 CSE 213 (intro object oriented programming)
 3 CSE 222 (systems programming)
 3 CSE 324 (principles programming languages)
 5 PHYS 1310 & 1310L (general physics I)
 3 Social Science
 17 Total credit hours

Semester 4 (Fall)

3 CSE 221 (computer systems)
 3 CSE 241 (foundations of computer science)
 3 CSE 353 (intro to computer networks)
 5 PHYS 1320 & 1320L (general physics II)
 3 Humanities
 17 Total credit hours

Semester 5 (Spring)

3 CSE 326 (software engineering)
 3 ENGL 341 (technical writing)
 3 CSE 342 (formal languages and automata)
 4 MATH 382 & 382L (probability and statistics)
 3 MATH 352 (basic concepts of mathematics)
 16 Total credit hours

Semester 6 (Fall)

4 CSE 325 & 325L (operating systems)
 4 CSE 344 & 344L (design & analysis algorithms)
 3 Technical Elective
 3 Humanities
 14 Total credit hours *

Semester 7 (Spring)

4 CSE 423 & 423L (compiler writing)

| | |
|----------|--|
| 3 | CSE 331 (computer architecture) |
| 3 | CSE 363 (secure computing) |
| 3 | CSE 382 (ethics of computing and info technologies)* |
| <u>3</u> | Technical Elective |
| 16 | Total credit hours |

*(satisfies Area 7)

Semester 8 (Fall)

| | |
|----------|----------------------|
| 3 | Technical Elective |
| 3 | Technical Elective |
| 3 | Social Science |
| <u>3</u> | Creative & Fine Arts |
| 12 | Total credit hours |

* In order to earn or retain the NM Lottery Scholarship, students must earn 15 credits each semester. Please see your advisor for more information.

Minor in Computer Science

Minimum credit hours required: 28

The following courses are required:

- CSE 113 (4) and CSE 122(3)
- Any four out of CSE 324 (3), CSE 325(4), CSE 326(3), CSE 331(3), CSE 342(3), CSE 344(4), and CSE 353(3) along with their respective pre-requisites.

Minor in Computer Engineering

Minimum credit hours required: 25

The following courses are required:

- CSE 113 (4), CSE 122(3), CSE 221 (3), CSE 222 (3), EE 211 (3), EE 252 (3), and EE 351 (3)
- Any one out of CSE 325(4), CSE 326(3), CSE 331(3), CSE 353(3) along with their respective pre-requisites.

Minor in Cybersecurity

Minimum credit hours required: 22

The following courses are required:

- CSE 113 (4), CSE 122(3), CSE 221 (3), CSE 222 (3), CSE 353(3), CSE 363 (3), CSE 441 (3), CSE 461 (3), and CSE 561 (3)

Junior Standing in Computer Science:

Students are deemed to have attained *junior standing in Computer Science* when they have completed the four required 2xx courses, i.e., CSE 213, CSE 221, CSE 222, and CSE 241, each with a grade of *C* or higher.

Undergraduate Honors Thesis:

Outstanding students may pursue a *Computer Science Honors Thesis* option which involves writing a thesis based on original research, defending it before a thesis committee after enrolling first in 1 credit hour of CSE 493 *Undergraduate Thesis* and then in 2 credit hours of CSE 494 *Undergraduate Thesis* over two semesters, and presenting the research in a public colloquium. The colloquium may be a prelude to the thesis defense. CSE 493 plus 494 can substitute for only one of the required technical electives.

In order to apply, a student must

- be a CS major;
- have completed 12 credits of required core courses for the CS major at the 300 level or higher;
- have an overall CGPA of at least 3.0 and also a CGPA of at least 3.0 in the courses enumerated in the catalog in the list of required courses for the CS major that are completed at the time of application;
- have a full-time CSE faculty member as research advisor and a thesis topic;
- permission of his/her academic advisor;
- form an Undergraduate Honors Thesis Committee of three members with at least two CSE full-time faculty members including the research advisor; and
- submit a filled-out application form to the CSE Department Chair indicating approvals of the academic and research advisors.

The thesis must follow the format specified by NMT's Center for Graduate Studies. Until the defense, the student must maintain an overall CGPA of at least 3.0 and a CGPA of at least 3.0 in the courses enumerated in the catalog in the list of required courses for the CS major. In the semester the student enrolls in CSE 494, the student must defend his/her thesis. After the thesis defense, the student's Undergraduate Honors Thesis Committee will vote to either accept or reject the thesis; and the research advisor, in consultation with the committee, will assign a letter grade for CSE 494. A rejected thesis should correspond to a grade less than *C*; an accepted thesis *C* or higher. If approved, the committee will vote to decide if the thesis should be awarded a departmental certificate bestowing *High Honors* or *Highest Honors*; generally, these should correspond to *A-minus* and *A* respectively.

Graduate Program:

Graduate Certificate in Cybersecurity

The Cybersecurity Graduate Certificate offers graduate students and post-baccalaureate professionals an opportunity to build and strengthen their capabilities in cybersecurity for academic and professional work. The 12 credit hours of coursework required for the certificate include the foundational overview of cybersecurity and in addition allow the student to focus on cybersecurity courses that are of particular interest.

Requirements for the Cybersecurity Graduate Certificate are:

1. CSE 561, Foundations of Information Security
2. 9 credits from the following:
 - CSE 563, Access Control & System Security
 - CSE 570, Privacy in Mobile Environments
 - CSE 541, Advanced Cryptography
 - CSE 564, Secure System Administration
 - CSE 554, Computer Network Security
 - CSE 557, Hardware-Based Network Security
 - EMGT 509, Systems, Risk, and Decision Analysis

Master of Science

Students may earn a Master of Science degree in Computer Science or a Master of Science degree in Computer Science with Specialization in Information Technology through cooperation

with the Information Technology faculty.

Master of Science Degree in Computer Science

The M.S. program in Computer Science is based on course work as well as research (either thesis or independent study option). The student must meet the general requirements of the Graduate Program. In addition, the student must fulfill the following requirements, depending on the research option:

Without Thesis:

Course work approved by the student's advisory committee fulfilling the general requirements of 30 credit hours for the master's degree must include

- CSE 590 (Independent Study): 3 credit hours;
- CSE 585 (Graduate Seminar): 3 credit hours;
- One course on theoretical aspects of computer science: either CSE 544 or CSE 546
- One course involving substantial programming on systems aspects: either CSE 423 (not an option if already taken) or CSE 525
- 9 credit hours from computer science courses numbered higher than 500.

With Thesis:

Course work approved by the student's advisory committee fulfilling the general requirements of 30 credit hours for the master's degree must include

- CSE 591 (Thesis): 6 credit hours;
- CSE 585 (Graduate Seminar): 3 credit hours;
- One course on theoretical aspects of computer science: either CSE 544 or CSE 546
- One course on systems aspects involving substantial programming: either CSE 423 (not an option if already taken) or CSE 525
- 9 credit hours from computer science courses numbered higher than 500.

Computer Science Accelerated M.S. Option

Students who want to obtain both the *B.S. in Computer Science* and *M.S. in Computer Science* degrees may pursue an *Accelerated M.S. Degree* option. Students must apply by mid-semester of their second semester in their junior year in Computer Science to be admitted for their senior year. Accepted students may apply nine credits of CSE courses numbered above 500 to both degrees.

Doctor of Philosophy in Computer Science

Students of exceptional ability as demonstrated in previous course work are encouraged to pursue a doctor of philosophy degree; individuals with substantial experience in industrial research and development may also apply to the doctoral program. The current research programs of the department include artificial intelligence, machine learning, big data and cloud computing, computer security, privacy, computer networking, sensor networks, parallel computation, distributed

computing, mobile computing, software engineering, databases, knowledge-based systems, visualization, computational theory, and computer science education. The department also encourages interdisciplinary work with other departments and divisions at Tech and in cooperation with researchers at Los Alamos and Sandia national laboratories.

As computer science and engineering is a diverse and rapidly changing discipline, the program of study of a Ph.D. student will depend on the area of specialization and on prior experience and education. All Ph.D. students will be required to demonstrate master's-level knowledge of the core areas of computer science, as well as a thorough understanding of the intended area of specialization. The core areas include programming languages, algorithms, systems, and computational theory. In addition, all Ph.D. students are required to take three credit hours of CSE 585 (Graduate Seminar). The specific course requirements are determined with the consultation and approval of the student's advisory committee and the chair of the department.

To earn a Ph.D. degree, students must complete at least 60 post-baccalaureate credit hours. This includes at least 24 credit hours of dissertation research and at least 9 credit hours of coursework including CSE 585.

Before the degree is approved and granted, at least one paper on the subject matter from the dissertation must be accepted for publication to a reputable journal or conference proceedings acceptable to the doctoral committee of the student.

Coursework Before Candidacy Exam

In order for CS Ph.D. students to proceed to their candidacy exam, they must complete the following:

1. CSE 585 (Graduate Seminar, 3 credit hours): Students must take this and pass it with a grade of "B" or higher, unless taken before at NMT. It is recommended that they should take this in their first semester as a Ph.D. student.
2. Complete at least four courses from the CS core areas (12 credit hours):
 - CSE 524 (3) and CSE 544 (3)
 - One of CSE 525 (3) or CSE 553 (3)
 - One of CSE 546 (3) or CSE 528 (3)

For each of these four courses, either :

- Either take the class and pass it with a grade of "B" or higher, or
 - Pass the corresponding Competency Exam. Competency Exams are to be offered yearly, typically one week before the start of the semester when the corresponding course is offered.
3. Complete the required minimum credit hours as follows:
 - For students with MS in CS or closely related area: 6 credit hours of CSE graduate courses.
 - For student without MS in CS or closely related area: 21 credit hours, detailed as follows:
 - i. 15 credit hours of CSE graduate courses
 - ii. 6 credit hours of 300-level or higher courses (CSE or related/needed areas)

All students who are financially supported by the department must finish the above requirements within their first four semesters (from the time of joining the Ph.D. program); otherwise, their financial support is subject to termination without further notice.

Candidacy Exam

In order to advance to Ph.D. candidacy, the student must pass a candidacy examination (Ph.D. proposal defense) in his/her specific area of specialization. The student's advisory committee will conduct the proposal defense.

Dissertation

The doctoral dissertation demonstrates the candidate's capacity for independent research. The student may register for dissertation hours only after successfully completing the candidacy exam. A minimum of 24 credit hours must be devoted to the dissertation. The student is encouraged to explore the various current research projects in his or her field of interest before choosing a dissertation subject. The dissertation must be defended before the Tech faculty under the supervision of the student's advisory committee. Manuscript requirements are in the catalog. An external examiner will be included on the defense committee. The candidate must be registered during the semester in which the completed dissertation is submitted to the Graduate Office. Doctoral candidates are required to present at least one departmental or general seminar on the dissertation during their tenure as a graduate student.

Computer Science Courses:

Some courses are marked 'cannot be used towards graduation' to emphasize that they cannot be used to fulfill the requirements for the major; they *can* be used as general electives to complete the 123 credit hours.

CSE 101, Introduction to Computer Science and Information Technology, 2 cr, 2 cl hrs

Usually offered in both the Fall and Spring semesters.

Students must register for CSE 101 and CSE 101L concurrently

Brief overview of the discipline of computer science and information technology topics including computer architecture, operating systems and networks, automata and models of computation, programming languages and compilers, algorithms, databases, security and information assurance, artificial intelligence, graphics, and social/ethical issues of computing. (Same as IT 101)

CSE 107, Introduction to Computer Programming using Python, 4 cr, 3 cl hrs, 2 lab hrs

Co-requisite: Math 103 (MATH 1240)

Usually offered in the Fall semester.

Students must register for CSE 107 and CSE 107L concurrently

The course is designed to introduce programming and its applications to scientists and engineers. The first part of the class focuses on problem solving, algorithm development, top-down design, modular programming, debugging, testing, data types, flow-control, looping, iteration and recursion, fundamental data structures, and an introduction to object oriented programming. The second part of the class explores data analysis with Python. (Same as IT 107)

CSE 113, Introduction to Programming, 4 cr, 3 cl hrs, 3 lab hrs

Co-requisite: MATH 131 (MATH 1510)

Usually offered in both Fall and Spring semesters.

Students must register for CSE 113 and CSE 113L concurrently

The course is designed to introduce problem solving and programming in C to Computer Science majors and those interested in applications of the language that involve dynamic structures and memory management. Topics include algorithm development; top-down design; modular programming; debugging; testing; control structures including selection, iteration and recursion; number systems; data representation; data types including arrays, strings, pointers and dynamic structures involving memory management. Concepts implemented through extensive programming using good programming style. (Same as IT 113.)

CSE 122, Algorithms and Data Structures, 3 cr, 3 cl hrs

Prerequisite: CSE 113 with a grade of C or higher

Corequisite: MATH 132 (Math 1520)

Usually offered in both Fall and Spring semesters.

Fundamental data structures including linked lists, trees, hash tables, and graphs. Algorithms for sorting, searching, and other fundamental operations. Introduction to mathematical foundations for analysis of iterative and recursive algorithms and for basic correctness proofs. Analysis of algorithms. Implementation of selected algorithms using sound programming methodologies. (Same as IT 122.)

CSE 209, Programming Language Practicum, 1 cr, 3 lab hrs

Prerequisite: Knowledge of elementary programming and CSE 101 with a grade of C or higher.

A practical course teaching the use of a programming language of current interest. May be repeated for credit with different languages.

CSE 213, Introduction to Object Oriented Programming, 3 cr, 3 cl hrs

Prerequisite: CSE 101, 113, 122 each with a grade of C or higher

Usually offered in the Spring semester.

Introduction to programming in an object oriented language (e.g., Java): review of problem solving, algorithm development, top-down design, modular programming, debugging, testing, control structures including selection, iteration and recursion, data types including arrays, strings, pointers, and dynamic structures. Object oriented concepts will include: objects, classes, inheritance, instances, methods, interfaces, packages, encapsulation, and polymorphism. Concepts implemented through extensive programming using good programming style. (Same as IT 213.)

CSE 221, Computer System Organization, 3 cr, 3 cl hrs

Prerequisite: CSE 101, 122 each with a grade of C or higher

Usually offered in the Fall semester.

The hardware/software interface. Basic organization of hardware and operating systems. Memories, buses, interrupts, input and output, and instruction set architecture. Programming in assembly language. (Same as IT 221.)

CSE 222, Systems Programming, 3 cr, 3 cl hrs

Prerequisite: CSE 101, 122 each with a grade of C or higher

Usually offered in the Spring semester

This course provides an introductory overview of

operating systems and system programming, mainly focusing on system-level programming based on OS services and other APIs. Topics include system calls, file I/O, files and directories, memory management, process control, inter-process communication (IPC), socket-based network programming, remote procedure call (RPC) programming, and basic security mechanisms. Course work includes substantial programming homework and team-based projects.

CSE 241, Foundations of Computer Science, 3 cr, 3 cl hrs

Prerequisite: MATH 1520 each with a grade of C or higher

Usually offered in the Fall semester

Students must register for CSE 241 and CSE 241L concurrently

Propositional and predicate logic. Analytic reasoning and mathematical proofs. Abstraction, iteration, recursion, and induction. Fundamental discrete structures. Basic concepts of algorithms, formal languages, and computation.

CSE 321, Internet and Web Programming, 3 cr, 3 cl hrs

Prerequisite: CSE 122 and CSE 213 each with a grade of C or higher

This course has a practical emphasis on the design and techniques for developing internet-based applications, mainly focusing on web programming. Topics include HTML, client-side scripting language (JavaScript), server-side programming (e.g., Servlets, JSP, and J2EE), and XML/web services (e.g., Java and .NET). This course will also cover some important topics needed for internet-based application development, such as Internet architectures, basic object-oriented programming (OOP) concepts, and web security. Course work includes substantial programming homework and team-based projects. **(Same as IT 321.)**

CSE 324, Principles of Programming Languages, 3 cr, 3 cl hrs

Prerequisite: CSE 122 with a grade of C or higher

Usually offered in the Spring semester.

Introduction to low (micro/macro) and high level languages (L/HLLs) -- features and positions within the computer system. definition of HLLs of syntax and semantics. Data types, control structures, concurrency, declarations, procedures. Recursion and recursive definitions. Procedural and data abstraction. Critique of major programming languages features and design issues (e.g., power, efficiency, security, modularity, readability, etc). Examples from major realms of current programming languages -- imperative (block structured, object oriented), declarative (function, logic) paradigms.

CSE 325, Principles of Operating Systems, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: CSE 221, 222 each with a grade of C or higher

Usually offered in the Fall semester.

Students must register for CSE 325 and CSE 325L concurrently

This course provides an introduction to the fundamentals of operating systems and their components. Topics include processes and threads, process scheduling, process synchronization, deadlocks, memory management, file

systems, storage systems, I/O systems, security and protection, and introduction to distributed systems. Each student is expected to design and implement components of a small operating system.

CSE 326, Software Engineering, 3 cr, 3 cl hrs

Prerequisites: CSE 122, 213 each with a grade of C or higher

Prerequisites/Co-requisites: ENGL 341

Usually offered in the Spring semester.

This course provides the introductory overview of software engineering, concentrating on large-scale software system design and implementation. Topics include software life cycle, UML-based design language, design tools and techniques, design documentation, software testing, secure software construction, and software project management. Course work includes a team-based project. **(Same as IT 326.)**

CSE 328, Secure Software Construction, 3 cr, 2 cl hrs, 1 lab hr

Prerequisite: CSE 222, CSE 213 each with a grade of C or higher

Formal methods and practical techniques for the specification, design, implementation, and validation of computer software. Current software engineering and management practices, with emphasis on ensuring software reliability, safety, and security. Course work includes a team project to develop a sizeable, real-world application software. **(Same as IT 328.)**

CSE 331, Computer Architecture, 3 cr, 3 cl hrs

Prerequisite: CSE 221 with a grade of C or higher

Usually offered in the Spring semester.

The course introduces the fundamentals of modern computer architecture and design. Topics include instruction set architectures, pipelining, memory hierarchies, instruction-level parallelism, introduction to distributed and parallel computing, and performance modeling and measurements.

CSE 342, Formal Languages and Automata, 3 cr, 3 cl hrs

Prerequisite: CSE 241 with a grade of C or higher

Prerequisite/Co-requisite: MATH 352

Usually offered in the Spring semester.

Regular expressions. Regular, context-free, context-sensitive and unrestricted grammars and languages. Finite and pushdown automata. Turing machines, recursive and recursively enumerable languages. Decidability and the halting problem.

CSE 344, Design and Analysis of Algorithms, 4 cr, 3 cl hrs, 1 lab hr

Prerequisites: CSE 122, CSE 241; MATH 352 each with a grade of C or higher

Usually offered in the Fall semester.

Students must register for CSE 344 and CSE 344L concurrently.

Asymptotic complexity of algorithms. Analysis of iterative and recursive algorithms; amortized analysis. Design paradigms: greedy and dynamic programming approaches. Interplay of data structures and algorithms. Graph algorithms. Introduction to the theory of complexity classes and NP-completeness.

CSE 351, Modeling and Simulation Technologies for Information Systems, 3 cr, 3cl hrs

Prerequisites: CSE 122; CSE 241 each with a grade of C or higher

Fundamentals and techniques for designing and using simulation, modeling, and optimization algorithms with applications in system performance modeling, business infrastructure modeling, and distributed and parallel computing. An introduction to advanced complex systems models. **(Same as IT 351.)**

CSE 353, Introduction to Computer Networks, 3 cr, 3 cl hrs

Prerequisites: CSE 222 with a grade of C or higher

Usually offered in the Fall semester

Introduction to computer networking, the ISOOSI protocol stack, LAN, MAN, and WAN. Physical layer: transmission media (wireline and wireless); data signaling, modulation, and coding; multiplexing. Fiber optics networking technology: protocols & examples. Data link Layer: error/flow control— protocols design issues; MAC protocols for channel access and allocation. Wireless technology and protocols standards — IEEE 802.11 physical layer and MAC sublayer protocols. Network layer: subnet switching (CS/DG/VC) & routing protocols (Non/Adaptive); Congestion Control and QoS protocols. ISO vs. (TCP-UDP)/IP the Internet protocol stacks. Internet relays and protocols, e.g., routers, gateways, etc. Introduction to network security. Application layer protocols, E.G., DNS, E-mail, etc. **(Same as IT 353.)**

CSE 363 Computer Security, 3 cr, 3 cl hrs.

Prerequisite: CSE 221 with a grade of C or higher; CSE 353

Usually offered in the Spring semester

This course provides an overview of the principles and practices of secure computing, mainly focusing on their application in security solution design and implementation. Topics include risk/threat analysis, secure coding practices, cryptographic tools, security architectures, system security, software security, and network security. Course work include quizzes, homework, midterm and final exams, and one final team-based project. **(Same as IT 363.)**

CSE 373, Introduction to Database Systems, 3 cr, 3 cl hrs

Prerequisite: CSE 122, CSE 241 each with a grade of C or higher

Conceptual modeling and database design using the entity-relationship model. The relational model; relational algebra and relational query languages. Database integrity. Physical data organization. Non-relational models such as NoSQL and graph databases. Introduction to concurrency control and recovery. Course work includes a project using SQL and the Oracle Database Management System. **(Same as IT 373.)**

CSE 382, 382D, Ethical and Social Issues of Computing Information Technology, 3 cr, 3 cl hrs

Prerequisite: CSE 326

Usually offered in the Spring semester

In this class, students will examine ethical and social questions regarding computing and information technologies. The course challenges students to think about connections among digital technologies, the responsibilities of information technology professionals, and social justice as they study topics such as social media,

military applications of digital media, gendered technologies, and access to information technologies. In addition to learning the basics of research ethics and social responsibility, students will examine real-world debates regarding subjects like big data, computer code, and digital networks, and they will analyze the legal, political, and social stakes of information technologies. **(Same as IT 382 and PHIL 382)**

This course may be used to satisfy 3 credit hours of the General Education Area 5 requirements.

CSE 391, Directed Study, cr and topics arranged

CSE 423, Compiler Writing, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: CSE 342 with a grade of C or higher; CSE 324, 326, 344

Co-requisite: CSE 331

Usually offered in the Spring semester.

Students must register for CSE 423 and CSE 423L concurrently

Implementation of compilers for higher level computer languages including: parsing, symbol table management, code emission, and code optimization. Each student implements a small compiler and designs an optimizing compiler as a substantial portion of the course grade. Individual and group projects. Practice in developing software requirement, specification, design, and test plan documents.

CSE 441, Cryptography and Applications, 3 cr, 3 cl hrs (Same as IT 441)

Prerequisites: CSE 122, CSE 241 each with a grade of C or higher

This course provides an introductory overview of modern cryptographic theory and techniques, mainly focusing on their application into real systems. Topics include number theory, probability and information theory, computational complexity, symmetric and asymmetric cryptosystems, one-way functions, block and stream ciphers, Kerberos authentication systems, public key infrastructure (PKI), secure socket layer/transport layer security (SSL/TLS), and cryptographic protocols/applications in many real systems. Shares lecture with CSE 541 with additional expectations for graduate credit. **(Same as IT 441.)**

CSE 451, 451D, Introduction to Parallel Processing, 3 cr, 3 cl hrs

Prerequisites: CSE 122 with a grade of C or higher

Introduction to supercomputers and massively-parallel machine architecture, models of parallel computation, parallel algorithms, synchronization, parallel languages, data and functional parallelism, parallel performance analysis, popular interfaces, and parallel debugging. Students will gain experience in parallelization of sequential algorithms and implementation of parallel algorithms. **(Same as IT 451.)**

CSE 452, 452D, Introduction to Sensor Networks, 4 cr, 3 cl hrs, 2 lab hrs

Prerequisites: CSE 325 and CSE 353, or consent of instructor and advisor

Introduction to sensory technology with special focus on wireless sensor networks (WSNs) applications, topologies, deployment, sensed data manipulation, mobile ad-hoc

wireless communication, security. Low power consumption and data rates WSNs protocols (e.g., ZigBee/IEEE808.15.4). Students will get familiar with sensor nodes' hardware (motes and sensor boards) and programming (TinyOS and ZigBee application objects) via a set of practical lab/field experiments that covers the design, implementation, deployment, and data collection/analysis of some actual WSNs data/vent acquisition systems (e.g., environment monitoring, remote asynchronous event detection--forest fire, border intrusion, tsunami, earthquake, volcanic activities, etc).

CSE 453, Advances in Computer Networks and the Internet, 3 cr, 3 cl hrs

Prerequisite: CSE 353

In depth coverage of layering of protocols' stacks (ISOOSI and TCP/IP) and computer networks architectures, modern examples of LANs, MANs, WANs protocols/architectures. Recent developments in Fiber optics technology — protocols and architectures. High speed “all-fiber-optics” networks. Internetworking: global addresses/names and translation, virtual networks and tunnels, routing, subnetworks switching protocols, IPv6, multicasting. Mobile IP. End-to-end protocols, TCP and UDP. Advances in congestion control and resource allocation. Client-server models & applications. The QoS mechanism integrated/differentiated), ATM QoS. Network security: information and link security, encryption, internetworking security, IPsec, firewalls, VPN, wireless security. Analysis of networks protocols. **(Same as IT 453.)**

CSE 454, Computer Graphics, 3 cr, 3 cl hrs

Prerequisites: CSE 213, 222; MATH 2420 each with a grade of C or higher

Design and implementation of visual interfaces. Graphics input and output hardware, display programming, 2-D transformations, approximation techniques for curve and surface representation. Introduction to the creation of 3-D computer-generated images, color theory, lighting and shading.

CSE 463, 463D, Information Assurance, 3 cr, 3 cl hrs

Prerequisite: Senior standing

Defense and offensive information warfare. Information system security. Computer break-ins, hacking, and other attack methods. Vulnerability and risk analysis. Theory and applications of cryptography. Intrusion detection and incident response. Security planning and management. **(Same as IT 463.)**

CSE 464, Introduction to Soft Computing, 3 cr, 3 cl hrs

Prerequisites: CSE 344; MATH 382

Major types of artificial neural networks. Fuzzy logic theory and fuzzy systems construction. Genetic algorithms and evolutionary computing. Intelligent systems and engineering applications. Comparative study of the soft computing paradigm as a problem solving methodology.

CSE 476, 476D, Visualization, 3 cr, 3 cl hrs

Prerequisite: CSE 122 with a grade of C or higher, or consent of instructor and advisor

This course presents application of graphical visualization

to current problems, with a focus on extracting and representing information in multidimensional data sets using 2D and 3D graphics. Topics include visualization tools and techniques, human vision and perception, color mapping, sound, data representation for insight extraction, time visualization, visual analytics, volume rendering, surface extraction and rendering. Students will develop visualizations of real world problems. **(Same as IT 476.)**

CSE 485, Undergraduate Seminar on Special Topics, 3 cr, 3 cl hrs

Prerequisite: Senior standing, one semester of upper division courses in computer science, and consent of the instructor

A research seminar for undergraduate students with a focus either on special topics in computer science or on the methodology and skills required for research in computer science. *Use as technical electives is limited (see requirements above), but may be taken multiple times as a general elective.*

CSE 489, 489D, Special Topics in Computer Science, 3 cr, 3 cl hrs

Prerequisites: CSE 213, 222 each with a grade of C or higher consent of instructor, and junior standing

Undergraduate special topics in computer science. For a list of recent offerings, please visit the department's website.

CSE 491, 491D, Directed Study, cr and topics arranged

Cannot be used toward graduation.

CSE 493, Undergraduate Thesis, 1cr

Prerequisite: Acceptance into the Computer Science Undergraduate Honors Thesis option.

CSE 494, Undergraduate Thesis, 2cr

Prerequisite: CSE 493

CSE 500, Directed Research, cr and topics arranged

This course may not be used to fulfill graduate degree requirements. Research under the guidance of a faculty member.

CSE 523, Advanced Compiler Writing, 3 cr, 3 cl hrs

Prerequisite: CSE 423 with a grade of C or higher

Advanced topics in compilation, such as theory of parsing, error recovery, optimization, semantics- directed translation, and hardware-independent and hardware-specific code generation.

CSE 524, 524D, Advanced Programming Languages, 3 cr, 3 cl hrs

Prerequisites: CSE 324, 344 each with a grade of C or higher, or consent of instructor and advisor

In depth coverage of High Level languages pure/hybrid Paradigms, data manipulation and coding complexity. Modern trends in the design and philosophy of languages. Formal semantics of programming languages. Selected topics from current research.

CSE 525, 525D, Advanced Operating Systems, 3 cr, 3 cl hrs

Prerequisites: CSE 325 and 331 each with a grade of C or higher or consent of instructor and advisor

Advanced topics in operating systems such as real-time, distributed systems, fault-tolerance, parallel I/O, performance, safety-critical systems, and verification.

CSE 528, 528D, Formal Methods in Software Development, 3 cr, 3 cl hrs

Prerequisites: CSE 326, 342, and 344 each with a grade of C or higher or equivalent experience

Use of mathematics, logic, and computer science theory in software development. Formal specifications; systematic development of programs from specifications. Correctness proofs and other analysis techniques.

CSE 531, Advanced Computer Architecture, 3 cr, 3 cl hrs

Prerequisite: CSE 331 with a grade of C or higher or consent of instructor and advisor

This course covers advanced topics in computer architecture which may include superscalar and superpipelined architectures, memory hierarchies, multicore systems, multiprocessor systems, vector processors, interconnection networks.

CSE 532, Fault-Tolerant Computing, 3 cr, 3 cl hrs

Prerequisite: CSE 331 with a grade of C or higher, or consent of instructor and advisor

Techniques for design of fault-tolerant digital devices with on-line self-error-detection and self-error-correction. Fault-tolerant PLAs, gate arrays, and computer memories. Fault-tolerant computer architectures. Application of error-detecting and error-correcting codes for design of reliable devices with self-error detection/correction. Design of self-checking checkers. Combining on-line and off-line error-detecting techniques. Reliability analysis of fault-tolerant devices. Self-error detection/correction for multiprocessors.

CSE 541, 541D, Advanced Cryptography, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing or consent of instructor and advisor

This course provides an overview of modern cryptographic theory and techniques, mainly focusing on their application into real systems. Topics include number theory, probability and information theory, computation complexity, symmetric and asymmetric cryptosystems, one-way functions, block and stream ciphers, Kerberos authentication systems, public key infrastructure (PKI), secure socket layer/transport layer security (SSL/TLS), and cryptographic protocols/applications in many real systems. Shares lecture with CSE 441, with additional expectations for graduate credit

CSE 542, Advanced Formal Language Theory, 3 cr, 3 cl hrs

Prerequisite: CSE 342 with a grade of C or higher

Extensive study of context-sensitive and recursively enumerable languages; closure properties, decidability, and ambiguity of various language classes. Special topics as time permits.

CSE 544, Advanced Algorithms, 3 cr, 3 cl hrs

Prerequisite: CSE 344 with a grade of C or higher, or consent of instructor and advisor

Analysis of correctness and complexity of asymptotically efficient algorithms. Hybrid data structures; Competitive algorithms; Graph algorithms including flow networks and maximum bipartite matching; Algorithms for matrix inversion and solution of linear equations; Linear Programming; Computational geometry; NP-complete problems and Approximation algorithms. Algorithms in areas of current interest.

CSE 546, Theory of Computation, 3 cr, 3 cl hrs

Prerequisite: CSE 342 with a grade of C or higher

Effective computability of functions and sets in terms of Turing machines and other computational models. Universal machines and examples of unsolvable problems. The Church-Turing thesis and formal proofs of the equivalence of Turing machines, systems of recursion equations, and other models of computation. Mathematical properties of the classes of recursive functions. Recursive and recursively enumerable sets.

CSE 551, 551D, Advanced Parallel Processing, 3 cr, 3 cl hrs

Prerequisite: CSE 451 with a grade of C or higher, or consent of instructor and advisor

This course focuses on the application of models of parallel computation, parallel algorithms, synchronization, parallel languages, parallel performance analysis, and parallel debugging to large problems and complex systems. Topics include: integrating data and shared memory parallelism, multilevel domain decompositions, portability, and scalability. Student will parallelize and analyze the performance of a complex system or application.

CSE 553, Advanced Computer Networks, 3 cr, 3 cl hrs

Prerequisite: CSE 353 with a grade of C or higher

Models of computer networks. Design and analysis issues. Abstract syntax notation, data compression, security and authentication. Recent developments in the field.

CSE 554, 554D, Computer Network Security, 3 cr, 3 cl hrs

Prerequisite: CSE 561 with a grade of C or higher, or consent of instructor and advisor

This course will explore each layer of the internet protocol stack, focusing on security deficiencies, and remedies to those security deficiencies, and will involve extensive lab exercises using the DeterLab shared testbed (accessed via the Internet to enable distance education participants). It will study computer network security architecture and security mechanisms to protect against sophisticated adversarial attacks. This course reviews cryptographic primitives that underlie most network security mechanisms, then applies this understanding to network services proving authentication for data and transaction integrity and availability, and encryption for confidentiality. It also covers the integration of security services into network applications and utilities including secure mail, secure web services, secure wireless, and investigates system security issues such as for firewalls and intrusion detections systems.

CSE 557, 557D, Hardware-Based Network Security for the Internet of Things (IoT), 3 cr, 3 cl hrs

Prerequisite: CSE 561 and CSE 554, each with a grade of C or higher, or consent of instructor and advisor

This course will cover networking protocols, cryptography, and network security from the hardware implementation perspective. Topics include security of ND, NAT, IPSEC and other specialized IPv6 protocols in support of IoT functionality. The focus will be on implementation of security policy enforcement mechanisms in IPv6 network protocols in a Field Programmable Gate Array (FPGA) platform to protect an IoT application against sophisticated adversaries. Lab exercises using a FPGA platform will enable investigation of hardware-based security technologies such as the use of Physically Unclonable Functions that are not otherwise accessible from software.

CSE 561, Foundations of Information Security, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor and advisor

This course will explore the ideas, literature, and worked examples that established the foundations of information security. The course introduces the concept of the Information Domain as the fundamental primitive that is the axis for introducing the policy requirements of Confidentiality, Integrity and Availability that motivate the need for Information Security. The concept of the reference monitor is the organizing principle for the course. The examination of foundational literature starts with appears and ideas that first appeared in the mid 1960's and spans the time of tremendous creativity up through the following four decades.

CSE 563, Access Control and System Security, 3 cr, 3 cl hrs

Prerequisites: Consent of instructor

Topics include theoretical foundations for access control, formal access control models, access control mechanisms, tools and techniques, information flow policy, trust management, security architectures, and current issues of advanced research in access control. In addition, the protection mechanisms of general-purpose operating systems, software systems, and web applications are discussed.

CSE 564, Secure Systems Administration (SSA), 3 cr, 3 cl hrs

Prerequisites: CSE 561 and CSE 554 and with grades of C or higher, or consent of instructor and advisor

This course is primarily a Laboratory based course. The intention of the course is to give the students an experience of administering an IT system for a hypothetical business with the IT system experiencing increasingly aggressively sophisticated cyber-attacks. They are expected to build a business plan for the hypothetical business, a policy-based IT protection plan that they then implement on the host machines and networks in the laboratory. Simultaneously the adversary builds an exploitation plan that attempts to defeat the business's IT protection implementation and is able to achieve his/her exploitation objectives. The adversary has access to any/all exploit technology available, but there is a moderating factor of cost associated with the exploitation technology. The defenders have access to protection technology, but again there is a mitigating cost factor associated with the protection technology. The objective of the class is to experience and learn the capabilities and effectiveness of both defensive and exploitative technology with an appreciation of the need for policy and planning that directs, supports, and constrains the actions of both sets of actors. **(This course cannot be offered via Distance Education.)**

CSE 565, 365D, Neural Nets, 3 cr, 3 cl hrs

Prerequisites: CSE 344; MATH 2420 and 382; each with a grade of C or higher, or consent of instructor and advisor

Neuron modeling. The perceptron and multilayer perceptrons. Learning algorithms. The Kohonen model, the Grossberg model, the Hopfield model. Associative memory. Applications. Recent developments in the field.

CSE 567, 567D, Soft Computing, 3 cr, 3 cl hrs

Prerequisites: MATH 2420, 382; CSE 344 each with a grade of C or higher, or consent of instructor and advisor

Artificial neural networks, with emphasis on multiplayer feedback networks, self-organizing networks, and Hopfield-

style networks. Learning algorithms. Introduction to fuzzy systems and evolutionary computing. Engineering applications of soft computing. **(Same as MENG 567: Smart Engineering Systems)**

CSE 568, 568D, Intelligent Systems, 3 cr, 3 cl hrs

Prerequisites: MATH 2420, 382; CSE 344 each with a grade of C or higher, or consent of instructor and advisor

Overview of the major paradigms of soft computing: neural networks, fuzzy systems, and evolutionary computing. In-depth coverage of selected topics in each area as relevant to intelligent systems. Recent advances in the field, and case studies of intelligent systems. Coursework includes a large-scale project. (Same as MENG 568: Smart Engineering Systems II)

CSE 570, Privacy in Mobile Environments, 3 cr, 3 cl hrs

Prerequisite: consent of instructor

The notion of privacy; privacy threat model; Anonymity through k-anonymity, l-diversity, t-closeness, etc. Approaches to protect the location, identity, and query history of mobile users. Recent developments.

CSE 572, 572D, Advanced Data Management, 3 cr, 3 cl hrs

Prerequisite: CSE 573 with a C or higher or consent of instructor and advisor

Semi-structured, unstructured, and graph data; Large data versus BigData; Relational versus NoSQL and centralized versus distributed databases; Query processing and the MapReduce model; Storage, Recovery, Concurrency, Consistency, Availability, and Scalability.

CSE 573, 573D, Database and Knowledge-base Systems, 3 cr, 3 cl hrs

Prerequisites: CSE 373, CSE 241 each with a grade of C or higher

Databases, object bases, and knowledge bases. Data models. Logical foundations of database and knowledge-base systems. Query optimization. Selected topics from current research.

CSE 576, 576D, Advanced Visualization, 3 cr, 3 cl hrs

Prerequisite: consent of instructor

This course presents application of graphical visualization to large problems and complex systems, with a focus on extracting and representing information in multidimensional data sets using 2D and 3D graphics. Topics include visualization tools and techniques, human vision and perception, color mapping, sound, data representation for insight extraction, time visualization, visual analytics, volume rendering, surface extraction and rendering. Students will perform visual analytics research for large problems and/or complex systems.

CSE 581, Directed Study, cr to be arranged**CSE 585, 585D, Graduate Seminar, 3cr, 3 cl hrs**

Prerequisite: CSE Graduate Standing

An introduction to the methodology and skills required for academic research with emphasis on computer science. Students will learn the skills involved in discussing technical ideas; articulating research problems; critiquing, writing, and defending research proposals; reading, reviewing, and presenting research articles with appropriate visual aids; and exploring ethical issues associated with research. Students are expected to attend all presentations by outside speakers in the *CS Speaker*

Series during the semester. Typically offered each fall.

CSE 589, 589D, Special Topics in Computer Science, 3 cr, 3 cl hrs

Prerequisites: Two semesters of upper division courses in computer science and consent of instructor.

Graduate special topics in computer science. For a list of recent offerings, please visit the department's website.

CSE 590, Independent Study, cr to be arranged

Under the direction of a faculty member appointed by the department, the student shall prepare a paper making use of standard reference sources on some topics not covered by other course work.

CSE 591, Thesis (master's program), cr to be arranged

CSE 595, Dissertation (doctoral degree program), cr to be arranged

Prerequisite: Successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.

Faculty Research Interests

- Anselmo—Complex Financial Technology, commercialization, Academic Entrepreneurship.
- Clausen — Software Construction, Internet via Satellite, Multimedia/Internet Technologies, Embedded Systems
- Jefferey—Programing Languages, Program monitoring and Visualization, Virtual Environments
- Liebrock—Computer Forensics, Information Assurance, Parallel Processing, Well Posedness Analysis, Visualization
- Mazumdar—Mobile Security, Integrity and Privacy Analysis and Design of Datasets, Data Science
- Mukkamala—Information Assurance, Digital Forensics, Knowledge Mining, Applied Soft Computing Techniques, Bioinformatics, Information and Network Security Practices
- Ramyaa - Theory of Computation (and Complexity) and Logic . ML (focusing on bio-inspired techniques, abstractions and theoretical developments)
- Shin— System security, Usable Security, Applied Cryptography, Software Engineering
- Soliman—Computer/ Sensor Networks — Fiber/wireless modern technologies and protocols, Sensor Networks — modern technologies, routing security protocols, Computer/Sensor Networks Security, Programming Languages, principles and designs, Neural Networks — applications in image compression, cloud computing—management security, and sensor networks—including the design of general “smart early prediction units of any asynchronous events” (e.g. System border intrusion, forest fires, tsunami, earthquake, cancer development etc)
- Stavely—Formal Methods in Software Engineering, Programming Languages, Computational Logic
- Sung—Computational Intelligence, Information Security, Bioinformatics
- Zheng—Mobile Computing, Computer and Network security, Machine Learning and its Applications

Transdisciplinary Cybersecurity

*Director of Cybersecurity Centers - Liebrock
Faculty:*

*Adjunct – Burnham, Pierson, Quist, Tietjen
CLASS – ChoGlueck, Dotson, Elliott, Kelly
Computer Science & Engineering – Jeffery, Liebrock,
Mazumdar, Ramyaa, Shin, Soliman, Tong, Zheng
Electrical Engineering – El Osery, Shao, Teare
Business & Technology Management – Wang
Materials & Metallurgical Engineering - Majumdar
Mechanical Engineering – Ghosh, Lee*

Degrees Offered: Master of Science, Professional Masters, and Doctor of Philosophy in Transdisciplinary Cybersecurity

Mission

Addressing many of the greatest challenges to society requires understanding and integration of the methods, theories, techniques, and perspectives of multiple disciplines to develop new approaches to solve complex, real-world challenges. The mission of the Transdisciplinary Cybersecurity graduate programs is to prepare students with a broad understanding of cybersecurity from the foundational documents that have guided the development of the discipline to the ethical, legal, and psychological challenges that cybersecurity professionals face. Students further engage in hands-on cybersecurity risk analysis, data analysis, and policy development. In addition, technical electives provide technical expertise that students will need to solve real-world challenges in cybersecurity.

These programs are designed to:

1. engage students with diverse backgrounds in cutting edge cybersecurity research and prepare them for high demand, high pay cybersecurity careers; and
2. enhance cybersecurity innovation leading to improvement in the cybersecurity stance of the state of New Mexico, the nation, and the world.

Graduate Programs

These programs are all available both on campus and via distance delivery. Any course not offered via distance delivery is explicitly marked as such. All courses must be taken for a letter grade to meet program requirements except for CYBS 590, CYBS 591, CYBS 595.

Educational Objectives

The transdisciplinary faculty for this program strives to improve the graduate program in transdisciplinary cybersecurity. Several years after graduation it is expected that our graduates will be:

- leaders who help address challenges to society requiring understanding and integration of the methods, theories, techniques, and perspectives of multiple disciplines; and

- lifelong learners who continue grow in their education and profession to use and/or develop new approaches to solve complex, real-world challenges.

Student Outcomes

Upon completion of a transdisciplinary cybersecurity degree program, students will be able to:

1. Communicate effectively both orally and in writing to a variety of audiences.
2. Analyze and evaluate the cybersecurity needs of an organization to conduct a cybersecurity risk assessment.
3. Design operational and strategic cybersecurity approaches and policies.
4. Understand and appreciate the legal, ethical, technical, and psychological environment impacting individuals and business organizations to determine the implications and risks associated with cybersecurity decisions. In addition, upon completion of a Master of Science in Transdisciplinary Cybersecurity or Doctor of Philosophy in Transdisciplinary Cybersecurity degree, students will be able to:
5. Carry out research that demonstrates critical thinking by analyzing situations, integrating acquired knowledge, and developing solutions to real world cybersecurity challenges.

Core Courses

These courses are required for all programs (minimum of 18 credits at the 500-level; 3-4 credits for each course):

- CYBS 561 Foundations of Cybersecurity
- CYBS 502 Cybersecurity Ethics and Law
- CYBS 503 Cybersecurity Policy
- CYBS 504 Psychology of Cyber
- CYBS 505 Data Science for Cyber
- CYBS 509 Systems Decision and Risk Analysis

Technical Electives

- CYBS 541 Advanced Cryptography
- CYBS 554 Computer Network Security
- CYBS 557 Hardware-Based Network Security for the Internet of Things
- CYBS 563 Access Control and System Security
- CYBS 564 Secure Systems Administration
- CYBS 514 Computer Security and Incident Response
- CYBS 515 Reverse Engineering Malware
- CYBS 502 Cyber Physical System Security
- EE 560 Electronic Warfare
- EE 565 Position, Navigation and Timing

Other graduate cybersecurity courses may be substituted for the approved list only with prior written approval from their advisor and the program chair, which must be filed with the Center for Graduate Studies prior to taking the course.

Cybersecurity Area Courses

Graduate credits (CYBS 589) in the following cybersecurity areas: cybersecurity policy, psychology of

cybersecurity, cybersecurity data science, or cybersecurity technical electives.

Master of Science in Transdisciplinary Cybersecurity (MS-CYBS)

The MSTC program requires a minimum of 30 graduate credits in cybersecurity including a research project.

Students in the MSTC program must take all of the required core courses listed above, a minimum three credits of technical electives from the approved list, and at least three additional credits in the following cybersecurity areas: cybersecurity policy, psychology of cybersecurity, cybersecurity data science, or cybersecurity technical electives; other cybersecurity courses may be substituted for the approved list only with prior written approval from the advisor and the program chair, which must be filed with the Center for Graduate Studies prior to taking the course.

Research projects may be either a thesis (6 credits) or an independent study (3 credits). A thesis is to be of a high quality to make a contribution to the discipline and should be submitted for publication. Students who complete an independent study must also complete an additional cybersecurity area course.

MSTC Degree Minimum Requirements Summary

- All core courses listed above (18 cr)
- 3 credits of technical electives
- 3 credits of cybersecurity area courses
- Research
 - 6 credits of thesis
 - or
 - 3 credits of independent study and
 - 3 credits of cybersecurity area courses

Professional Master in Transdisciplinary Cybersecurity (PM-CYBS)

The PMTC program requires a minimum of 30 graded graduate credits.

Students in the PMTC program must take all of the required core courses listed above, a minimum of six credits of technical electives from the approved list, and at least six additional credits in the following cybersecurity areas: cybersecurity policy, psychology of cybersecurity, cybersecurity data science, or cybersecurity technical electives; other cybersecurity courses may be substituted for the approved list only with prior written approval from the advisor and the program chair, which must be filed with the Center for Graduate Studies prior to taking the course.

PM-CYBS Degree Minimum Requirements Summary

- All core courses listed above (18 cr)
- 6 credits of technical electives
- 6 credits of cybersecurity area courses

Accelerated Masters

The combined degrees of a MS-CYBS or PM-CYBS along with a BS in an aligned field may be achieved in five years. Students must complete all of the requirements of the associated BS and the MS-CYBS or PM-CYBS degrees. Students in the accelerated program may use up to nine 500-level or above credits toward both their BS and either MS-CYBS or PM-CYBS degrees.

Doctor of Philosophy in Transdisciplinary Cybersecurity

Students of exceptional ability, as demonstrated in previous courses, in a master's degree program, or in professional research experience, may pursue a program leading to the doctoral degree.

The prospective doctoral candidate in Transdisciplinary Cybersecurity should develop a strong background in the core of cybersecurity. Additionally, students must achieve a high level of competence in the field of specialization defined by their dissertation research. Additional information is found in the Graduate Program section of the catalog.

Research fields appropriate for the transdisciplinary cybersecurity candidate include attack and defense, communications security, computer security, cyberprivacy, cybersecurity data science, cybersecurity policy, cyberspace security, electronic warfare, enterprise-wide cybersecurity, forensics, incident response, information assurance, hardware security, network security, psychology of cybersecurity, reverse engineering, threat analysis, and vulnerability analysis. Transdisciplinary projects integrating theory, metrics, and methods from multiple disciplines are strongly encouraged.

PhD Degree Minimum Requirements Summary

- A minimum of 68 credits total.
- Up to 30 graded credit hours from an appropriate master's degree, excluding research credits, may be included.
- 44 hours of graded coursework approved by the student's advisory committee must include:
 - ◊ All core courses listed above (18 cr)
 - ◊ 9 credits of technical electives
 - ◊ 12 credits of cybersecurity area courses
 - ◊ Up to 12 graded research credits (CYBS 581) may be used toward the required graded coursework credits.
- Dissertation (24 credit hours): CYBS 595

Qualifying Examination

The paper critique is the program's qualifying examination. The critique is the first examination that a PhD student must pass within 24 months of enrolling in the program. The paper for critique must be agreed on by the doctoral committee. The student must conduct a successful

written and public oral critique of a paper published in a high-quality professional journal on a cybersecurity topic. During the paper critique presentation, the student may be asked questions relating to background knowledge gained from taking regular coursework in cybersecurity subjects. The paper critique must be completed within 24 months of enrolling in the PhD program. The committee may determine that the student has a pass, a conditional pass, or a fail on the critique. Students with an unconditional pass proceed to the dissertation proposal. Students with a conditional pass, will be required to overcome deficiencies, which may require additional courses, individual reading/research, and/or a subsequent critique before advancing to the dissertation proposal. Students who fail to pass the critique will be dismissed from the program. The committee will document the outcome of the critique and the reasons for its decision with a copy sent to the student, the program chair, and the Center for Graduate Studies.

Dissertation Proposal (Candidacy Exam)

The dissertation proposal is the program's candidacy examination, which cannot be done before the qualifying exam has been passed without condition or the conditions have been met. The student must write a research proposal and defend that proposal in a public oral defense at a minimum of two full semesters before the final dissertation defense. The proposal must include the rationale for the research, the preliminary research that has been done, and the plan for completion. The committee may determine that the student has a pass, a conditional pass, or a fail on the dissertation proposal. Students with an unconditional pass will be recommended for candidacy beginning in the subsequent semester, when they may register for dissertation credits. Students with a conditional pass, will be required to overcome deficiencies, which may require additional courses, individual reading/research, and/or a subsequent dissertation proposal before advancing to candidacy. Students who fail to pass the dissertation proposal will be dismissed from the program. The committee will document the outcome of the dissertation proposal and the reasons for its decision with a copy sent to the student, the program chair, and the Center for Graduate Studies.

Dissertation

Students may proceed with dissertation research after advancing to candidacy. Students must enroll in a minimum of 24 credits of dissertation (CYBS 595). Students should be aware that research typically takes significantly longer than two semesters and should plan accordingly. During dissertation registration, the student completes the research project approved by the committee via the dissertation proposal approval process. The dissertation is the documentation of research that advances the state of the science for transdisciplinary cybersecurity.

The student must write a dissertation and defend it in a public oral defense. The committee may determine that the student has a pass, a conditional pass, or a fail on the dissertation defense. Students with an unconditional pass will graduate with the doctoral degree. Students with a conditional

pass, will be required to overcome deficiencies, which may require research and/or a subsequent public dissertation defense before graduation. Students who fail to pass the dissertation defense will be dismissed from the program. The committee will document the outcome of the dissertation defense and the reasons for its decision with a copy sent to the student, the program chair, and the Center for Graduate Studies.

Publication Requirement

Students are required to publish a minimum of three high-quality papers in reputable, refereed journals or conference proceedings. The journals and conferences selected must be approved in writing by the committee, which will be documented with a copy sent to the student, the program chair, and the Center for Graduate Studies. At least one paper must be published after the dissertation proposal defense; others may be published on work completed earlier in the program, but that work must be an integral part of the final dissertation.

Admission Requirements

Completion of a bachelor's degree in a relevant field (e.g., information technology, computer science, electrical engineering, mathematics, etc.) or the expectation of completing such a degree before the beginning of the first semester of graduate study. Students are expected to have competencies in mathematics equivalent to those required for completion of a B.S. degree at New Mexico Tech. Students who are deficient in mathematics will be required by their advisory committee to complete undergraduate coursework in the area of deficiency. Students should have an academic record that indicates a good potential for success in a graduate program. An undergraduate GPA of 3.0 or higher is used as a general guideline in New Mexico Tech's Graduate School.

Transdisciplinary Cybersecurity Courses:

The Transdisciplinary Cybersecurity Programs encourage students from other majors to take transdisciplinary cybersecurity courses. Students from other disciplines who are interested in taking these courses should inquire at the Cybersecurity Center's offices or contact any member of the program's faculty.

CYBS 500 Directed Research, cr to be arranged

Prerequisite: Graduate standing or consent of instructor and advisor

Offered both Spring and Fall semester. Credits cannot be applied towards the credit hours required for graduation. Research under the guidance of a CYBS faculty member.

CYBS 502 Cybersecurity Ethics and Law, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

A cybersecurity ethics and law course in which students learn standards of professional, ethical behavior in cybersecurity fields by examining case studies, ethical

questions, and legal debates from the history of computing and cybersecurity.

CYBS 503 Cybersecurity Policy, 3 cr, 3 cl hrs

Prerequisite: CYBS 502 (Cybersecurity Ethics and Law)

Graduate standing or consent of instructor and advisor

A cybersecurity policy course that uses laws and standards to guide organizational policy development to secure information technology resources, without needlessly limiting technical responses, and analyzes both the outcomes of and processes for establishing those laws and standards.

CYBS 504 Psychology of Cyber, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

A psychology of cybersecurity course that addresses psychology issues from how humans respond to instructions and policies and to how differently hackers and defenders think.

CYBS 505 Data Science for Cyber, 3 cr, 3 cl hrs

Prerequisite: Math 382 & 382L; Graduate standing or consent of instructor and advisor

A cybersecurity data science course to transform raw data into meaningful and useful information to identify cybersecurity threats, risks, and incidents, helping businesses become safer and less vulnerable to cyberattacks.

CYBS 509 Systems Decision and Risk Analysis, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

An advanced treatment on major topics involved in modern engineering decision-making and risk management: fundamental statistics/probability/economics theoretical prelims for decision theory; multicriteria decision-making and decision making under uncertainty; game theory and its applications; decision making processes and risk evaluation; and an introduction to Monte Carlo and Marko decision processes. **(Same as EMGT 509.)**

CYBS 506 Cyber Physical System Security, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

In this course we investigate security threats and countermeasures for cyber physical systems (CPS). Many of our critical infrastructure is built around CPS and as such they become targets for security attacks. The course will focus on attacks that target confidentiality, integrity and/or availability of CPS and how to mitigate them. Sample topics include but are not limited to network attacks, wireless/GPS exploitation, jamming and spoofing, and risk identification and management.

CYBS 514 Computer Security and Incident Response, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

This course covers what computer security incidents are and how to respond to an incident. Computer security

incident case studies serve as the backbone of the course allowing students to analyze these case studies and determine how they were handled through process and technical analysis. Topics covered are data sources for incident detection and response, incident data analysis and incident remediation. Analysis areas covered are network event analysis, malware analysis and computer forensics for computer security incidents.

CYBS 515 Reverse Engineering Malware, 3 cr, 3 cl hrs

Prerequisite: CYBS (Computer Security and Incident Response) and Graduate standing or consent of instructor and advisor

Introduction to software reverse engineering of malicious software. Quick triage, static and dynamic analysis, string analysis, and deobfuscation analysis techniques. Intel x86 assembly, covering both 32 and 64-bit, Windows and Linux OS internals, will be discussed. Safe detonation using Cuckoo Sandbox, automated unpacking techniques. Detailed analysis and investigation of nation-state malware. Ghidra, FLARE VM, and other tools will be discussed.

CYBS 541 Advanced Cryptography, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

This course provides an overview of modern cryptographic theory and techniques, mainly focusing on their application into real systems. Topics include number theory, probability and information theory, computation complexity, symmetric and asymmetric cryptosystems, one-way functions, block and stream ciphers, Kerberos authentication systems, public key infrastructure (PKI), secure socket layer/transport layer security (SSL/TLS), and cryptographic protocols/applications in many real systems. **(Same as CSE 541.)**

CYBS 554 Computer Network Security, 3 cr, 3 cl hrs

Prerequisite: CYBS 561 with a grade of C or higher, or consent of instructor and advisor

This course will explore each layer of the internet protocol stack, focusing on security deficiencies, and remedies to those security deficiencies, and will involve extensive lab exercises using the DeterLab shared testbed (accessed via the Internet to enable distance education participants). It will study computer network security architecture and security mechanisms to protect against sophisticated adversarial attacks. This course reviews cryptographic primitives that underlie most network security mechanisms, then applies this understanding to network services proving authentication for data and transaction integrity and availability, and encryption for confidentiality. It also covers the integration of security services into network applications and utilities including secure mail, secure web services, secure wireless, and investigates system security issues such as for firewalls and intrusion detections systems. **(Same as CSE 554.)**

CYBS 557 Hardware-Based Network Security for the Internet of Things (IoT), 3 cr, 3 cl hrs

Prerequisite: CYBS 561 and CYBS 554, each with a grade of C or higher, or consent of instructor and advisor

This course will cover networking protocols, cryptography, and network security from the hardware implementation perspective. Topics include security of ND, NAT, IPSEC and other specialized IPv6 protocols in support of IoT functionality. The focus will be on implementation of security policy enforcement mechanisms in IPv6 network protocols in a Field Programmable Gate Array (FPGA) platform to protect an IoT application against sophisticated adversaries. Lab exercises using a FPGA platform will enable investigation of hardware-based security technologies such as the use of Physically Unclonable Functions that are not otherwise accessible from software. **(Same as CSE 557.)**

CYBS 561 Foundations of Cybersecurity, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

This course will explore the ideas, literature, and worked examples that established the foundations of information security. The course introduces the concept of the Information Domain as the fundamental primitive that is the axis for introducing the policy requirements of Confidentiality, Integrity and Availability that motivate the need for Information Security. The concept of the 225 reference monitor is the organizing principle for the course. The examination of foundational literature starts with papers and ideas that first appeared in the mid 1960's and spans the time of tremendous creativity up through the following four decades. **(Same as CSE 561.)**

CYBS 563 Access Control and System Security, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Topics include theoretical foundations for access control, formal access control models, access control mechanisms, tools and techniques, information flow policy, trust management, security architectures, and current issues of advanced research in access control. In addition, the protection mechanisms of general-purpose operating systems, software systems, and web applications are discussed. **(Same as CSE 563.)**

CYBS 564 Secure Systems Administration, 3 cr, 3 cl hrs

Prerequisite: CYBS 561 and CYBS 554, each with a grade of C or higher, or consent of instructor and advisor

This course is primarily a Laboratory based course. The intention of the course is to give the students an experience of administering an IT system for a hypothetical business with the IT system experiencing increasingly aggressively sophisticated cyber-attacks. They are expected to build a business plan for the hypothetical business, a policy-based IT protection plan that they then implement on the host machines and networks in the laboratory.

Simultaneously the adversary builds an exploitation plan that attempts to defeat the business's IT protection implementation and is able to achieve his/her exploitation objectives. The adversary has access to any/all exploit technology available, but there is a moderating factor of cost associated with the exploitation technology. The defenders have access to protection technology, but again there is a mitigating cost factor associated with the protection technology. The objective of the class is to experience and learn the capabilities an effectiveness of both defensive and exploitative technology with an appreciation of the need for policy and planning that directs, supports, and constrains the actions of both sets of actors. This course is not offered via Distance Education. **(Same as CSE 564.)**

CYBS 581 Directed Study, cr to be arranged

Prerequisite: Consent of graduate advisor

CYBS 589 Special Topics in Cybersecurity, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Graduate special topics in computer science. For a list of offerings, please visit banweb.nmt.edu.

CYBS 590 Independent Study, cr to be arranged

Prerequisite: Consent of graduate advisor

Independent research supervised by a faculty member. It is expected that this work will culminate in a paper to be published, and an oral presentation is required.

CYBS 591 Thesis (MS Program), cr to be arranged

Prerequisite: Consent of graduate advisor

CYBS 595 Dissertation, cr to be arranged

Prerequisites: Documentation of successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.

Faculty Research Interests

B. Burnham – Foundations of Cybersecurity, Policy
 T. Dotson – Organizational High Reliability, User Experience Research Methods
 T. Elliott – User Experience Research Methods, Psycholinguistics, Perception.
 A. El Obery – Cyber Physical Systems
 A. Ghosh - Health Systems, Health Sensing, and Health Monitoring for Naval and Weapons Systems
 C. ChoGlueck - Ethics, Values and Norms Impact on Laws and Regulations, Science, Technology Policy
 N. Kelly – Hacker Culture and History, Cybersecurity History
 C. Jeffery – Program Execution Monitoring, Programming Language Support
 K. Lee – Multi-Robot Systems
 L. Liebrock – Cybersecurity, Cybersecurity Auditing, Enterprise-wide Forensics, Parallel Processing, Security Metrics, Threat Intelligence, Visualization, Well Posedness
 B. Majumdar – Additive Manufacturing
 S. Mazumdar – Data Management, Data Science, Information Privacy
 L. Pierson – Network Security, Hardware Security Design, Formal Security Methods, Cryptographic Policy Enforcement Mechanisms
 D. Quist – Malware, Reverse Engineering
 R. Ramyaa – Artificial Intelligence
 D. Shin – System Security, Software Engineering/Security, Usable Security
 S. Shao – Secured Optical Links in Heterogeneous Wireless Networks
 H. Soliman –Machine Learning
 S. Teare - Encryption, Smart Instrumentation, Cyber Physical Systems
 K. Tietjen – Incident Response and Digital Forensics, Threat Intelligence, Data Science Focused on Threat Detection and Response, Cyber Operations Process Engineering/Quality Management
 J. Tong – Network Security
 H. Wang – Risk Analysis, Agricultural Supply Chain, Financial Crime, Online Fraud
 J. Zheng – Cybersecurity, Machine Learning, Mobile Computing, Networking, Smart Grids, Intelligent Manufacturing, Smart Agriculture

Business and Technology Management

Professor Sueyoshi

Associate Professors Anselmo, Reinow

Assistant Professor Wang

Visiting Assistant Professor Ryu

Adjunct Faculty: Berl, Lentz, Mazumdar, Stephenson, Udell

Degrees offered: A.S. of Business; B.S. of Management, B.S. of Management of Technology, B.A. in Management and Master of Engineering Management (MEM), M.S. in Engineering Management

The Business and Technology Management (BTM) program provides undergraduate and graduate degree programs that draw heavily on Tech's strengths in science, engineering, technology and math (STEM). The aim of the department is to develop in students substantive decision-making and analytical skills and tools, as well as the functional knowledge required to effectively lead complex technology-based organizations in today's competitive global economy.

The program offers an additional career path that prepares students to be future technology innovators and entrepreneurs. Students will take courses in accounting, economics, human resources, finance, management, business strategy, marketing, operations research, statistics and entrepreneurship.

New Mexico Tech offers three undergraduate degree options: The B.S. Management degree provides students with the knowledge and skills required to manage complex projects and functional areas of an enterprise, i.e. accounting, finance, logistics, marketing, or human resources. In addition, the B.S. in Management prepares potential technology entrepreneurs to start their own companies.

The B.S. Management of Technology integrates management course work with study in an engineering or science field of the student's choice, providing specific knowledge and skills required to lead those organizations. Whichever degree option a student may choose, BTM students are problem solvers across disciplines, to include natural resources, energy, manufacturing, information systems, and environmental management. Students may also pursue a minor in management in addition to their major course of study. Each management student is assigned a faculty advisor who will help him or her select a degree option and recommend courses to be taken.

The BTM program also offers an A.S. degree in Business. This program is designed for students seeking to complete a two-year degree in business (potentially in addition to their major B.S. degree) and/or those who may wish to transfer to a four-year college or university. Required courses are often transferable among participating New

Mexico colleges and universities. The department also offers a Master of Engineering Management (MEM) graduate degree that prepares students with a B.S. degree in science or engineering for leadership positions in engineering, science, and technology organizations. Please see the "Engineering Management" section of this catalog for further information.

Undergraduate Program

Associate of Science in Business

Minimum credit hours required—60

The following courses are required:

- ACCT 2110 (3), 2120 (3)
 - ECON 2110 (3), 2120 (3)
 - ENGL 1110 (3), 1120 (3)
 - MGT 330 (3), MGT 331 (3)
 - ACCT 350 (3), ACCT 353 (3), ACCT 371 (3)
 - Mathematics: Six credit hours chosen from MATH 1240 (3), 1230 (3), 105 (5), 1510 (4)
 - TC 1130 (3)
 - Business and Management Electives: Nine credit hours selected in consultation with the faculty advisor
 - Humanities and Social Science Electives: Three credit hours chosen from Area 4 or Area 5 of the General Education Core Curriculum (page 80)
 - A total of eight credit hours in courses with associated laboratories from the disciplines of biology, chemistry, earth science, or physics
 - Electives to complete 60 credit hours
- Students must achieve a minimum GPA of 2.0 in required courses in order to graduate.

Sample Curriculum for the Associate of Science in Business

Summer

3 Mathematics

3 Total credit hours

Semester 1

3 ENGL 1110 (college English)

3 Mathematics

3 ACCT 2110 (fundamentals I)

3 ECON 2110 (macroeconomics)

12 Total credit hours

Semester 2

3 ENGL 1120 (college English)

4 Science with lab (biol, chem, earth science, or physics)

3 ACCT 2120 (fundamentals II)

3 ECON 2120 (microeconomics)

13 Total credit hours

Semester 3

3 MGT 330 (organization behavior)

3 ACCT 300

- 4 Science with lab (biol, chem, earth science, or physics)
- 3 TC 1130 (intro to visual communication)
- 3 Humanities/Social Science
- 16 Total credit hours

Semester 4

- 3 MGT 331 (human resource management)
- 9 Business Electives
- 4 Electives
- 16 Total credit hours

Undergraduate Certificate in Business

Certificate in Business (18 credits, all of which are part of the A.S degree in Business)

Nine credit hours chosen from the following:

- ACCT 2110 (3); or ACCT 2120 (3); ECON 2110 (3) or ECON 2120 (3); MGT 330(3) or MGT 331(3).
- ENGL 1110 (3) 1120 (3)
- Mathematics: Three credit hours chosen from Math 1240(3),1230 (3),1510 (4)
- TCOM 1130 (3)

Core Requirements for the Bachelor of Science in Management

In addition to the General Education and Institute Core Curriculum (page 78), the following core of business, management, accounting, finance, and economics courses required of all Management students:

- ACCT 2110 (3), 2120 (3)
- ACCT 371 (3)
- MATH 2350 (3)
- CSE 107 (4) or ES 111 (3)
- ENTR 1120 (1), 330 (3) 335(3), 462 (3), 472 (3), 476 (3), 481 (3), 486 (3)
- FIN 302 (3)
- ECON 2110 (3), 2120 (3). *These courses may be used to fulfill the Area 4 of the General Education Core Curriculum, page 80.*
- At least two semesters of a single approved foreign language are strongly suggested but not required.
- Electives to complete 120 credit hours to be selected in consultation with a faculty advisor.
Any required class or technical elective used toward a B.S. in Management or a B.S. in Management of Technology may not be taken on an S/U basis. Management majors must achieve a minimum GPA of 2.0 in order to graduate.

Bachelor of Science in Management

Minimum credit hours required—120

In addition to the General Education and Institute Core Curriculum (page 78) and the core business, management, accounting, finance and economics requirements (above), the following courses are required:

- Management Elective Sequence: At least nine (9) credit hours selected in consultation with and approved by the student's faculty advisor.

Sample Curriculum for the Bachelor of Science in Management**Semester 1**

- 1 ENTR 1120 (creativity and innovation)
- 3 ENGL 1110 (college English)
- 4 CHEM 1215 & 1215L (general)
- 4 MATH 1510 (calculus)
- 3 Humanities
- 15 Total credit hours

Semester 2

- 3 ENGL 1120 (college English)
- 4 CHEM 1225 & 1225L (general)
- 4 MATH 1520 (calculus)
- 4 CSE 107 OR 113/ES 111
- 15 Total credit hours

Semester 3

- 5 PHYS 1310 & 1310L (general)
- 3 ACCT 2110 (financial)
- 3 ECON 2110 (macroeconomics)
- 3 Humanities
- 3 Social Science
- 17 Total credit hours

Semester 4

- 5 PHYS 1320 & 1320L (general)
- 3 ACCT 2120 (managerial)
- 3 MATH 2350 (applied statistics)
- 3 ECON 2120 (microeconomics)
- 3 Social Science
- 17 Total credit hours

Semester 5

- 3 ACCT 300 level
- 3 MGT 331 (human resources)
- 3 MGT 330 (organizational behavior)
- 3 ENGL 341 (tech writing)
- 3 Management Elective
- 15 Total credits

Semester 6

- 3 FIN 302 (principles)
- 3 MGT 462 (decision analysis)
- 3 MGT 335 (principles)
- 3 Management Elective
- 3 Electives
- 15 Total credit hours

Semester 7

- 3 MGT 451 (tech management)
- 3 MGT 472 (production & operations)
- 6 Management Elective
- 3 Elective
- 15 Total credit hours

Semester 8

- 3 MGT 486 (business strategy)
- 3 MGT 476 (project management)
- 3 MGT 481 (senior seminar)
- 3 Elective

3 Management Elective

15 Total credit hours

Bachelor of Science in Management of Technology*Minimum credit hours required—130*

In addition to the General Education and Institute Core Curriculum (page 78) and the core business, management, finance, and economics requirements, students are required to complete six (6) credit hours of fundamentals courses in engineering or science and (9) credit hours of engineering or science courses numbered 300 or above, depending on their preferred track.

- Engineering Traces 201 (3), 216 (3), and nine (9) approved credit hours of engineering courses numbered 300 or above, ES 316 does not count toward the Management of Technology degree
- Science Track: fundamentals courses and 300 level courses will be approved in consultation with the student's faculty advisor
- MATH 2532 (4)
- At least two semesters of a single approved foreign language are strongly suggested but not required.
- Electives to complete 130 hours

Sample Curriculum for the Bachelor of Science in Management of Technology*Semester 1*

- 1 ENTR 1120 (creativity and innovation)
- 3 Humanities
- 3 ENGL 1110 (college English)
- 4 CHEM 1215 & 1215L (general)
- 4 MATH 1510 (calculus)

12 Total credit hours

Semester 2

- 3 Social Science
- 3 ENGL 1120 (college English)
- 4 CHEM 1225 & 1225L (general)
- 4 MATH 1520 (calculus)
- 3 ES 111 or CSE 107 or Science equivalent

17 or 18 Total credit hours

Semester 3

- 5 PHYS 1310 & 1310L (general)
- 3 ECON 2110 (macroeconomics)
- 4 MATH 2532 (calculus)
- 3 ACCT 2110 (financial)
- 3 ES 201 (statics)

18 Total credit hours

Semester 4

- 5 PHYS 1320 & 1320L (general)
- 3 MATH 2350 (applied statistics)
- 3 ECON 2120 (microeconomics)
- 3 ES 216 (fluid mechanics)
- 3 ACCT 2120 (managerial)

17 Total credit hours

Semester 5

- 3 ACCT 300 level
- 3 MGT 331 (human resources)
- 3 MGT 330 (organizational behavior)
- 3 ENGL 341 (technical writing)
- 3 Social Science
- 3 Engineering or science prerequisite or elective

18 Total credit hours

Semester 6

- 3 FIN 302 (principles)
- 3 MKGT 335 (principles)
- 3 Humanities
- 3 MGT 462 (decision analysis)
- 6 Engineering or Science prerequisite or Elective

18 Total credit hours

Semester 7

- 3 MGT 451 (technical management)
- 3 MGT 472 (production & operations I)
- 3 Elective
- 6 Engineering or science prerequisite or Elective

15 Total credit hours

Semester 8

- 3 MGT 476 (project mgt)
- 3 MGT 481 (senior seminar)
- 3 Engineering or science Elective
- 3 MGT 486 (strategy)
- 3 Management Elective

15 Total credit hours

Bachelor of Arts in Business Management*Minimum credit hours required – 120*

The B.A. in Business Management provides students with a broad exposure to the field and the practical knowledge and skills required to manage a functional area, project team, or department in public or private sector organizations. The program offers an additional career path for those students interested in developing their own business or becoming future entrepreneurs. Students can choose courses of interest outside the program as electives to gain a wider view and understanding of the world of business and entrepreneurship.

In addition to the General Education and Institute Core Curriculum for a B.A degree, the following courses are required:

- ACCT 2110 (3), ACCT 2120 (3), and one course chosen from ACCT 350 (3), 353 (3), and 371 (3)
- ECON 2110 (3), 2120 (3), and 201 (3) (3 credit hours may be used to fulfill Area 4 of the General Education Requirement)
- ENTR 1110 (1) and MGT 1113 (3)
- FIN 302 (3)
- 15 credit hours chosen from MGT 330 (3), 331 (3), 335 (3), 462 (3), 472 (3), and 476 (3).

- 9 additional credit hours chosen from upper-division MGT and ECON courses, ES 316, and MATH 382.
- One course chosen from CSE 107 (4) and CSE 113 (4)
- Six credit hours (additional to courses used to fulfill the General Education Requirement Area 2) in MATH chosen from MATH 1430 (3), MATH 2350, MATH 2420, and MATH 382*. *note pre-requisites of MATH classes must be satisfied.
- One course chosen from COMM 1130(3) and COMM 360 (3). The chosen course cannot be used to fulfill the General Education Requirement Area 5.
- 13-17 credit hours of electives to complete 120 credit hours. Students are recommended to take these electives as part of a minor in a program such as Computer Science, Mathematics, or Technical Communication.
- Two semesters of a foreign language are suggested.
- Required classes cannot be taken on an S/U basis. B.A. degree must achieve a minimum GPA of 2.0.

Sample Curriculum for the Bachelor of Arts in Business Management

Semester 1

- 3 MGMT 1113 (intro. Business)
- 3 ENGL 1110 (college English)
- 3-4 Science 1
- 3 MATH 1220 (algebra) or 1240 (pre-calculus)
- 3 Humanities
- 15-16 Total credit hours

Semester 2

- 3 ENGL 1120 (college English)
- 3-4 Science 2
- 3 MATH 1430 (calculus applications)
- 4 CSE 107 (programming course)
- 1 ENTR 1110 (creativity and innovation)
- 14-15 Total credit hours

Semester 3

- 3-4 Science 3
- 3 ACCT 2110 (fundamentals I)
- 3 ECON 2120 (microeconomics)
- 3 Humanities
- 3 MATH 2350 (statistics)
- 15-16 Total credit hours

Semester 4

- 3-4 Science 4
- 3 ACCT 202 (fundamentals II)
- 3 ECON 201 (Internet Econ & E-Commerce)
- 3 ECON 2110 (macroeconomics)
- 3 Elective
- 15-16 Total credit hours

Semester 5

- 3 ACCT 300 level
- 3 MGMT 331 (human resources)
- 3 MGMT 330 (organizational behavior)
- 3 ENGL 341 (tech writing)
- 3 Elective
- 15 Total credits

Semester 6

- 3 FIN 302 (financial economics)
- 3 MGMT 462 (decision analysis & risk management)
- 3 MGMT 335 (marketing principles)
- 3 Elective
- 3 Policy and Technology Course
- 15 Total credit hours

Semester 7

- 3 Management Elective
- 3 MGMT 472 (production & operations)
- 3 MATH 2420 (linear algebra)
- 3 Elective
- 3 Creative and Fine Arts
- 15 Total credit hours

Semester 8

- 3 MGMT 476 (project management)
- 3 Management Elective
- 3 Ethics and Technology Course
- 3 Elective
- 3 COMM 1130
- 15 Total credit hours

Minor in Management

Minimum credit hours required—18

The following courses are required:

- Six (6) credit hours selected from the following courses: ACCT 2110 (3), ACCT 2120 (3), ECON 2110 (3), ECON 2120 (3)
- Twelve (12) credit hours of course electives in Business and Technology Management numbered 300-level or above, to include ES 316 as a substitute for Fin 302

Accounting Courses:

ACCT 2110. Principles of Accounting I (Financial) 3 cr., 3cl.hrs

An introduction to financial accounting concepts emphasizing the analysis of business transactions in accordance with generally accepted accounting principles (GAAP), the effect of these transactions on the financial statements, financial analysis, and the interrelationships of the financial statements.
No prerequisites required

ACCT 2120. Principles of Accounting II (Managerial) 3 cr., 3 cl.hrs

Prerequisite ACCT 2110

An introduction to the use of accounting information in the management decision making processes of

planning, implementing, and controlling business activities. In addition, the course will discuss the accumulation and classification of costs as well as demonstrate the difference between costing systems.

ACCT 350, Managerial Accounting, 3 cr, 3 cl hrs

Prerequisite: ACCT 2120 or consent of instructor and advisor

Cost-benefit choices among accounting methods and systems in support of strategic decisions and operational control, including behavioral effects of accounting systems within organizations. Analysis of cost behavior patterns and how they alter cost accounting for automated manufacturing environments. Construction of budgets, forecasts, and estimates for new product/process costs.

ACCT 353, Cost Accounting, 3 cr, 3 cl hrs

Prerequisite: ACCT 2120 or consent of instructor and advisor

The development and use of cost accounting for inventory valuation, income determination, cost control including process accounting and variance analysis.

ACCT 371, Financial Accounting I, 3 cr, 3 cl hrs

Prerequisite: ACCT 2120

A detailed study of the financial recording and reporting process. Emphasis is placed on the form and content of financial statements.

ACCT 372, Financial Accounting II, 3 cr, 3 cl hrs

Prerequisite: ACCT 371

Current financial accounting theory and practice as they relate to financial statement preparation and analysis. Emphasis on special topics includes accounting for pensions and leases, accounting changes, and earnings per share presentation. Topics of current financial accounting interest are reviewed as they develop.

ACCT 403, Tax Accounting, 3 cr, 3 cl hrs

Prerequisite: ACCT 372 or consent of instructor and advisor

Federal income tax laws and the determination of taxable income for individuals, partnerships, corporations, and fiduciaries. Tax research and planning.

ACCT 405, Accounting for Non-Profit Organizations, 3 cr, 3 cl hrs

Prerequisite: ACCT 372 or consent of instructor and advisor

Control and reporting problems for government organizations and other non-profit entities. Fund accounting principles, procedures, and reports.

ACCT 490, Selected Topics, 1–3 cr, 1–3 cl hrs

Prerequisite: ACCT 2120; FIN 302; ECON 2110, 2120; MGT 330; MATH 2350; MKT 335; senior standing

Current topics in accounting.

ACCT 491, Directed Study, 1–3 cr, 1–3 cl hrs

Prerequisite: upper-class standing or consent of instructor and advisor

Individual studies directed by consenting faculty with

prior approval of the department head

Economics Courses:

These courses may be used to Area 4: Social Sciences of the General Education Core Curriculum, page 80

ECON 2110. Macroeconomic Principles 3 cr., 3cl hrs.

No prerequisites

Macroeconomics is the study of national and global economies. Topics include output, unemployment, inflation, economic and sustainable development; and how they are affected by financial systems, fiscal and monetary policies. [General Education Area IV]

ECON 2120. Microeconomic Principles 3 cr., 3cl hrs.

No prerequisites

Broad overview of microeconomics. Microeconomics is the study of issues specific to households, firms, or industries with an emphasis on the role of markets. Topics discussed will include household and firm behavior, demand and supply, government intervention, market structures and failures, and the efficient allocation of resources. [General Education Area IV]

ECON 201, Internet Economics and E-Commerce 3 cr. hr.

Corerequisite: ECON 2120 and MATH 2350

Introduction to the theoretical foundations of e-commerce and socio-economic networks, as well as the practical aspects of understanding how the online market works. Major topics include basics of graphs and networks, basic game theory, internet market structure and competition, internet pricing and auctions, and internet entrepreneurship.

ECON 362, Managerial Economics, 3 cr, 3 cl hrs

Prerequisites: ECON 2110, 252

A coordination of economic theory and managerial practice. Consumer demand, production functions, cost behavior, output determination, and pricing within various market structures.

ECON 372, Natural Resource and Environmental Economics, 3 cr, 3 cl hrs

Prerequisites: ECON 362 or ES 316 or consent of instructor and advisor

Introduction to the economic concepts and methods used in defining and analyzing natural resources and environmental quality problems.

ECON 490, Selected Topics, 1–3 cr, 1–3 cl hrs

Prerequisite: Upper-class standing or consent of instructor and advisor

Current topics in economics.

ECON 491, Directed Study, 1–3 cr, 1–3 cl hrs

Prerequisite: Upper-class standing or consent of instructor and advisor

Finance Courses:

FIN 302, Introduction to Financial Economics 3 cr, 3 cl hrs

Prerequisites: MATH 1510, MATH 1520, MATH 2350 or MATH 382, or consent of instructor and advisor

Introduction to financial systems, financial management and planning, introduction to financial investments including debt, and capital budgeting models with examples of applications.

FIN 410, Theory of Financial Decisions, 3 cr, 3 cl hrs

Prerequisites: FIN 302; MATH 2350; or consent of instructor and advisor

Detailed study of contemporary capital market and market equilibrium theories. Consideration of individual and firm risk attitudes and ways of dealing with financial risk. Discussion of firm valuation methods and firm level approaches to risky financial decision making.

FIN 480, Investments, 3 cr, 3 cl hrs

Prerequisites: MATH 2350; FIN 302 or ES 316; or consent of instructor and advisor

Portfolio theory and empirical capital market analysis. Contemporary investment theory, including option pricing models and derivatives. Active portfolio management in light of the vast array of financial investment alternatives available in today's markets.

FIN 490, Selected Topics, 1–3 cr, 1–3 cl hrs

Prerequisite: Upper-class standing or consent of instructor and advisor

Current topics in finance.

FIN 491, Directed Study, 1–3 cr, 1–3 cl hrs

Prerequisite: Upper-class standing or consent of instructor and advisor

Management Courses:

ENTR 1120, Creativity, Innovation and Entrepreneurship, 1 cr, 1 cl hr

Learn how to develop your creative ideas into opportunities working with faculty and guest speakers who will share their hands-on experience and insight into creating and commercializing innovative products and services.

MGT 301, Survey of Engineering Management, 3 cr, 3 cl hrs

Prerequisites: ES 110 and 111 or equivalent

Survey designed for engineering majors. Topics include introductions to qualitative and quantitative management models and their implementation.

MGT 330, Management and Organizational Behavior, 3 cr, 3 cl hrs

Prerequisites: ENGL 112 and upper-class standing or

consent of instructor and advisor

Classical and contemporary organization theories, interpersonal and organization behavior, motivation, communication, leadership, decision process in organizations.

MGT 331, Human Resource Management, 3 cr, 3 cl hrs

Prerequisites: MGT 330 and upper class standing or consent of the instructor

Managing human resources in technology and engineering organizations including employee recruitment and retention, leading teams, managing employee performance, analyzing organizational productivity, among other critical topics.

MGT 335, Marketing of New Products and Innovations, 3 cr, 3 cl hrs

Prerequisites: ECON 2120; MATH 2350; or upper-class standing and consent of instructor

Application of marketing theory and practice to developing new products and innovations. Focus on marketing early stage technology innovations and products from concept to implementation.

MGT 381, Strategic Market Analysis, 3 cr, 3 cl hrs

Prerequisites: MATH 2350; FIN 302; MKT 335; upper-class standing

Analysis of data derived from either survey instruments, archival sources, or both. Design and implementation of instruments designed to elicit information useful to managers. Single and multiple variable impacts on managerial decision making.

MGT 451, Technology Management Seminar, 3 cr, 3 cl hrs

Prerequisite: ECON 2110, ECON 2120, or ES 316.

Seminar focused on building new technology products or services from idea creation through commercialization, to include budgeting, financial analysis, marketing, project planning, and strategies for intellectual property protection.

MGT 462, 462D, Systems, Risk, and Decision Analysis, 3 cr, 3 cl hrs

Prerequisites: MATH 2350 or MATH 382 and upper-class standing or consent of instructor and advisor.

Analysis of systems and managerial decisions under conditions of risk or uncertainty. Optimal project evaluations and ranking of alternatives using expected value and expected utility criteria. Topics include risk sharing, Bayesian revision of probabilities, value of information, and preference assessment procedures. **(Same as IT 462)**

MGT 472, Production and Operations Management I, 3 cr, 3 cl hrs

Prerequisites: MATH 2350 and upper-class standing or consent of instructor and advisor

Application of quantitative methods to problems encountered in management. Problem solving emphasis with extensive use of applications software. Topics include linear and integer programming, forecasting, queueing theory and simulation.

MGT 473, Production and Operations Management II, 3 cr, 3 cl hrs

Prerequisites: MGT 472 and upper-class standing or consent of instructor and advisor

Application of concepts and principles related to management of the production function in manufacturing and services. Problem solving emphasis with extensive use of applications software. Topics include independent and dependent demand inventory models, facility layout, facility location; quality control; and project management.

MGT 476, 476D, Project Management, 3 cr, 3 cl hrs

Prerequisites: MATH 2350, MGT 472 or consent of instructor and advisor

Development of work breakdown structures and multi-factor project simulations to be used in dynamic resource allocations. Assessment and evaluation of project models over time.

MGT 481, Senior Seminar, Technical Management, 3 cr, 3 cl hrs

Prerequisite: MGT 486, upper-class standing and consent of instructor and advisor

Senior research project that integrates course content across the management curriculum

MGT 486, Business Policy/Corporate Strategy, 3 cr, 3 cl hrs

Prerequisites: MATH 2350, ECON 2110 or 252, and MGT 330 or 335

Integration of the basic functions of a business enterprise—e.g., marketing, finance, and production—through case analysis. From the perspective of top management, emphasis will be placed on examination of external environments, and the development of strategies for the organization's creation of proper relationships and responses to social, political, and economic conditions.

MGT 488, Technology Entrepreneur Workshop, 3 cr, 3 cl hrs

Prerequisites: FIN 302; ACCT 2120; senior standing; or consent of instructor and advisor

This workshop is designed to familiarize participants with the process of technology marketing. Assessment of new-product marketability, development of marketing and business plans, presentation of plans in a competitive environment to an evaluation panel composed of people from various business backgrounds.

MGT 403, 403D, Information Systems in Technology Organizations, 3 cr, 3cl hrs

Pre-requisite: senior standing or consent of instructor

The role of information systems in the decision processes of data- and technology-intensive organizations. Topics include methodology for database design; models for business processes and workflows; approaches for data analytics and prediction; and ethical and social impacts of information systems. The course involves some hands-on experience with Oracle or a similar industry-standard DBMS (*DataBase Management System*). *Shares the same*

lectures with EMGT 503, EMGT 503D. Additional work required at the graduate level.)

MGT 407, 407D, Technology Entrepreneurship, 3 cr, 3cl hrs

Pre-requisite: senior standing or consent of instructor

Entrepreneurs are the cornerstone of economic growth; they must be organized and armed with the tools necessary to raise capital, recruit talent and negotiate contracts. This course is an overview of the various organizational forms used by entrepreneurs, sources of capital available to growing companies, and mechanisms and methods for accessing that capital. Emphasis on practical, hands-on activities that demonstrate this process. *Shares lecture with EMGT 503, EMGT 503D. Additional work required at the graduate level.*

Faculty Research Interests

Anselmo — Decision Analysis and Risk Management, Computational Finance, Electronic Commerce
 Mazumdar—Database Systems, Massive Storage Systems, Computational Logic
 Reinow - Strategic Management, Technology Leadership, Economic Development
 Sueyoshi —Management Science, Data Envelopment Analysis, Risk and Policy Analysis
 Wang – Regional Economics, Environmental and Natural Resources Economics, Sustainability Management, Spatial Economic Analysis, Agent-based Modeling

Engineering Management

Professor Sueyoshi

Associate Professor Anselmo, Reinow

Assistant Professor Wang

Adjunct Faculty Berl, Lentz, Mazumdar, Stephenson, Udell

Degrees offered: Master of Engineering Management, Graduate Certificate in Technology Leadership

The Graduate Degree Programs in Engineering Management are specifically designed for engineers, scientists, managers, and technologists holding a bachelor's degree in their respective disciplines who seek the knowledge and practical skills required to lead project teams and technical organizations through today's competitive and fast-changing business environment. Our focus is to provide students with a challenging educational experience that builds on their background and career interests. The curriculum is innovative and rigorous, and delivered live via interactive webcasts both on campus and globally through internet streaming; students are encouraged to participate during the live course lectures, with accommodation available when work or personal schedules do not permit in class participation. The program is designed with a student's technical degree and background in mind, as few undergraduate engineering and science degree programs prepare their graduates for their transition to management and leadership roles.

The graduate programs are 30 credit hours with three options available for students depending on their career objectives and interests, as follows:

Option 1: Professional Master of Engineering Management (MEM) is a graduate degree program designed for students interested in developing their management, analytics, and leadership skills as practitioners in their respective fields. The MEM is a 100% course-based degree program consisting of 30 credit hours of 500-level courses selected from the engineering management curriculum.

Option 2: M.S. Engineering Management (MSEM) with Independent Study option is a graduate degree program designed for students interested in developing their management, analytics, and research skills working with a faculty committee on a project of the student's interest. This MSEM option consists of 21 credit hours of 500-level core courses selected from the engineering management curriculum; 6 credit hours of 500-level courses taken from outside the program, and 3 credit hours of independent study.

Option 3: M.S. Engineering Management (MSEM) with Thesis option is a graduate degree program designed for students interested in conducting independent research and potentially applying for a doctoral program in management or a related field. Students work with a faculty committee on a research project of the student's interest that meet the university's thesis requirements. This MSEM option consists of 18 credit hours of 500-level courses selected from the engineering management curriculum; 6 credit hours of 500-level courses taken from outside the program, and 6 credit hours of thesis work.

Graduate Program

Admission to the Program

Entrance into the MEM and MSEM requires competence in engineering, science and mathematics comparable to a calculus-based bachelor's degree in a management, economics, engineering or science discipline. For the MEM, preference will be given to individuals with professional work experience in engineering, technology, or science field.

The Graduate Record Examination (GRE) is required for admission, and may be waived depending on the applicant's transcript and professional experience. Engineering Management faculty will evaluate program applicants and recommend admission to the Office of Graduate Studies.

For complete information on applying to the Graduate Engineering Management Program, see the Graduate Studies website.

Graduate Advisory Committee

MSEM students need to form a three-member committee that is comprised of at least two New Mexico Tech management faculty members and one other qualified individuals with knowledge of the student's research interest. Examples of qualified individuals include faculty members at New Mexico Tech, faculty members at other higher-education institutions, workplace supervisors, and/or professional peers with a master's or doctoral degree. The student should identify a committee chair. The primary roles of the committee is to assist the student in course selection and advise and approve the final independent study project or thesis

Program Requirements

The following Engineering Management courses are available on a rotating basis, and supplemented with special topics courses depending on student interest and faculty specialty: A total of 30 credit hours, including the following courses, are required for the MEM degree:

EMGT 501 (3), 502 (3), 503 (3), 504 (3), 505 (3), 506 (3), 507 (3), 508 (3), 509 (3), 510 (3).

Electives are selected in consultation with the student's academic advisor.

MSEM degree options require either an independent study project or thesis, culminating in a formal document and presentation to the graduate advisory committee. Students will benefit from designing, supervising, and executing a project that will ideally be developed around a workplace/business problem or a practical policy issue. This experience will aid students throughout their career as they are faced with the need to resolve critical strategic questions and implement solutions

Graduate Certificate in Technology Leadership

An additional option for prospective students is the Graduate Certificate in Technology Leadership designed for those professionals who do not wish to pursue a master's degree but require the knowledge and skills to lead teams, projects and organizations through the complex environment of change. The rapid pace of technology innovation requires leaders who possess the knowledge, skills, and vision to guide their organizations through the process with an understanding of strategic and operational issues and solutions.

The certificate requires a total of 15 credit hours selected from the engineering management curriculum, to include EMGT 513 Technology Leadership Seminar. Courses completed for the certificate may be counted toward the master's degrees. It is recommended that prospective students have completed a calculus-based bachelor's degree and a semester of probability and statistics prior to entering the program.

Engineering Management Courses:

In addition to the listed prerequisites, only students admitted to the MEM program may enroll in the following classes. Engineering Management courses may not be used to fulfill the requirements of any other undergraduate or graduate degree offered by New Mexico Tech without prior approval by the chair of the other department.

EMGT 501, 501D, Management Science for Engineering Management, 3 cr, 3 cl hrs

This course will expose participants to up-to-date Management Science applications in engineering and technology organizations. Techniques include linear programming, inventory models, and Material requirements planning.

EMGT 502, 502D, Financial Management, 3 cr, 3 cl hrs This course begins with study of the interaction between financial and accounting systems and continues with a discussion of cash flow analysis. This foundation is followed by discussion of the latest in corporate financial management and capital budgeting techniques.

EMGT 503, 503D, Information Systems in Technology Organizations, 3 cr, 3cl hrs

The role of information systems in the decision processes of data- and technology-intensive organizations. Topics include methodology for database design; models for business processes and workflows; approaches for data analytics and prediction; and ethical and social impacts of information systems. The course involves some hands-on experience with Oracle or a similar industry-standard DBMS (DataBase Management System).

EMGT 504, 504D, Engineering Statistics 3 cr, 3 cl hrs

This course is designed to provide engineering managers with a basic foundation for data-driven decision making. Decisions by modern engineering managers increasingly require a range of statistical skills including gathering and describing data, designing samples and experiments, drawing statistical inferences and conclusions, evaluating the confidence of conclusions, developing regression models for anticipating future behavior and use of statistical quality control and six Sigma to drive process

improvement. All of these important capabilities must be utilized by a technical manager to make informed decisions.

EMGT 505, 505D, Marketing Technology, 3 cr, 3 cl hrs

Design, development, marketing, and sustaining of new products and technologies both inside and outside the engineering and technology organization. Market research, sampling and other data collection issues.

EMGT 506, 506D, Managing Human Resources in Technology Organizations, 3 cr, 3 cl hrs

The study of human resource management within technology and engineering organizations at the project, department, and enterprise levels. Leading project teams, managing employee performance and productivity, diagnosing organizational issues, developing strategic human resource plans, managing employee compensation, and responding to the changing legal workplace environment will be among the topics discussed in this seminar base on research and practice.

EMGT 507, 507D, Technology Entrepreneurship, 3 cr, 3 cl hrs

Entrepreneurship is important for new startups and existing companies. This course is focused on development of skills that will assist in the advancement of innovations that will help innovators gain resources to support their efforts. Topics covered include game-theory based negotiation exercises, development of the value proposition for new products and services, and design of the business model in hyper-competitive environments.

EMGT 508, 508D, Engineering Project Management, 3 cr, 3 cl hrs

Prerequisite: EMGT 501 or consent of the instructor
Develop models of project networks that can be used to plan, monitor, and control complex projects utilizing work breakdown structures, PERT, and CPM analyses. Develop probability models for cost and time-to-completion for each activity, providing a hands-on approach to project risk management.

EMGT 509, 509D, Systems Risk and Decision Analysis, 3 cr, 3 cl hrs

Prerequisite: EMGT 504 or consent of the instructor
An advanced treatment on major topics involved in modern engineering decision-making and risk management: fundamental statistics/probability/economics theoretical prelims for decision theory; multi-criteria decision-making and decision making under uncertainty; game theory and its applications; decision making processes and risk evaluation; and an introduction to Monte Carlo and Marko decision processes.

EMGT 510, 510D, Energy Markets, 3 cr, 3 cl hrs

An advanced research-oriented class that utilizes a managerial methodology (DEA: Data Envelopment Analysis) for complex energy policy and environmental assessment to include techniques used in modeling business/policy applications for understanding business strategy, and policy implications for energy and environmental problems.

EMGT 511, 511D, Financial Modeling, 3 cr, 3 cl hrs

Prerequisites: EMGT 502 and three other courses from EMGT 501-507 or consent of instructor and advisor

Portfolio optimization and other applications of Management Science techniques in a financial context. Analysis of domestic and international risky assets, including commodities, financial assets, and debt instruments. Coverage of the latest techniques in financial risk management, including hedging and other risk sharing techniques.

EMGT 512, 512D, Complex Financial Systems, 3 cr, 3 cl hrs

Prerequisite: EMGT 511 or consent of instructor and advisor

Modern financial systems are complex, interconnected, and sensitive to a variety of information from a variety of sources. This course is devoted to development and testing of valid simulation models of complex financial systems and the analysis of model outputs.

EMGT 513 Technology Leadership Seminar 3 cr. Hr.

Explore classical and modern leadership theories and their practical application to technology and engineering organizations. Apply leadership and decision tools and techniques to address issues of organizational change, employee motivation, conflict resolution, team development, and professional ethics.

EMGT 521, Advanced Management Science Applications, 3 cr, 3 cl hrs

Prerequisites: EMGT 501 and three other courses from EMGT 501-507 or consent of instructor and advisor

Use of management science techniques such as Data Envelopment Analysis (DEA) to optimally solve resource allocation problems. Management Science techniques applied to public policy issues.

EMGT 522, 522D, Engineering Management Seminar, 3 cr, 3 cl hrs

Prerequisite: EMGT 507

Study of latest research data concerning engineering management issues. Issues such as measuring performance, project management, and human resource management in technology organizations where tasks and outcomes may be ill defined.

EMGT 571, 571D, 572, 572D, Topics in Engineering Management, 2-3 cr

Study of a special topic in Engineering Management not otherwise treated.

EMGT 581, 581D, Directed Study, cr to be arranged

Study a current topic in Engineering Management with a member of the faculty. Most directed study topics will be based on and grow out of Engineering Management program coursework.

EMGT 590, Final Project, cr to be arranged; at least 3 cr required

Corequisite: At least one elective-sequence course

Each program participant will be required to complete a project to complete the MS degree. This project, which will be supervised by at least two New Mexico Tech faculty members, is open-ended with regard to context and scope. Workplace applications are preferred, but any effort that is formally designed, carried out, and analyzed will be considered. Each project will be accompanied by a formal report that will be presented to a diverse audience

in a formal setting.

MATH 585, Statistics for Technology Managers, 3 cr, 3 cl hrs

Probability and random variables; simple and multiple linear regression using least squares and other methods; experimental design; other topics including nonlinear regression; applications to decision making.

Faculty Research Interests

Anselmo — Decision Analysis and Risk Management, Computational Finance, Electronic Commerce

Mazumdar — Database Systems, Massive Storage Systems, Computational Logic

Reinow - Strategic Management, Technology Leadership, Entrepreneurship

Sueyoshi — Management Science, Data Envelopment Analysis, Risk and Policy Analysis

Wang – Regional Economics, Environmental and Natural Resources Economics, Sustainability Management, Spatial Economic Analysis, Agent-based Modeling

Electrical Engineering

Professors: El-Osery (Dean of Graduate Studies), Teare, Wedeward

Associate Professors: Arechiga (Chair of Department), Jorgensen, Senay

Assistant Professor: Shao

Emeritus Professor: Bond

Adjunct Faculty: Erives, Helmboldt, Kassim, Prager, Restaino, Smith, Wick, Xiao

Degrees Offered: B.S. in Electrical Engineering; M.S. in Electrical Engineering; Ph.D. in Electrical Engineering with Dissertation in Cyber Electronic Systems

Mission

The mission of the New Mexico Tech Electrical Engineering Department is two-fold:

1. To develop and maintain a program of excellence in teaching which ensures that our graduates have technical knowledge and professional skills they need to become effective engineers in the rapidly-changing technical environment of today's society, so that these graduates will contribute to the growth and development of New Mexico and our nation, and
2. To develop and maintain state-of-the-art research programs which are responsive to the needs of industry and government, which provide excellent educational opportunities for students, and which provide an environment for intellectual growth and excitement.

Program Educational Objectives for Undergraduate Program in Electrical Engineering

The faculty of the Department of Electrical Engineering strives to continuously improve the undergraduate program in electrical engineering. The educational objectives reflect the needs of, and have been reviewed by, among others, the Advisory Board and faculty. Several years after graduation it is expected that the program's graduates will be:

- Recognized leaders in electrical engineering-related fields or other career paths, in the public and private sectors;
- Valued leaders and participants in diverse teams who boldly discover and apply new knowledge and engineering practices;
- Adaptive learners who continue to grow professionally in their organizations, or by earning post-graduate degrees.

Student Outcomes for Undergraduate Program in Electrical Engineering

Graduates of the Bachelor of Science in Electrical Engineering program will have demonstrated

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of

engineering, science, and mathematics

2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Undergraduate Program

The Department of Electrical Engineering concentrates on a high-quality undergraduate program in electronics and design, combined with a firm intellectual foundation in the fundamentals of circuits, signals, and systems. As with other degree programs at New Mexico Tech, students are also provided with a breadth of knowledge in the basic sciences, mathematics, humanities, and social sciences.

Laboratories constitute an important part of the electrical engineering program. Computer-based instruments and software packages provide students with up-to-date engineering and design techniques.

Engineering design is the iterative process of converting a set of needs into a process, system or component. Students learn to combine the tools of basic sciences, mathematics and engineering sciences to meet requirements using a process of establishing objectives and criteria, analysis, construction, test and evaluation. Several courses are strongly focused on the fundamentals of engineering design in which students apply understanding from previous courses to solve real-world problems. Projects for the final design courses change every year, and past contributors of projects include research laboratories at New Mexico Tech such as Langmuir Laboratory for Atmospheric Research, Energetic Materials Research and Testing Center, Etscorn Observatory, and those of individual professors; national organizations such as the VLA and VLBA facilities of the National Radio Astronomy Observatory, Sandia National Laboratories, Los Alamos National Laboratory, Air Force Research Laboratory, and Naval Research Laboratory; and companies such as Microsoft and National Instruments.

Graduates of the electrical engineering program will be well equipped with the practical skills necessary for immediate employment, as well as with the intellectual base for graduate studies and lifelong learning.

Bachelor of Science in Electrical Engineering

Minimum credit hours required—120

In addition to the General Education and Institute Core

Curriculum (page 80), the following courses are required:

- **Electrical Engineering core:** EE 161 (1), EE 162 (1), EE 211 (3), EE 212 (3), EE 252 (3), EE 271 (3), EE 311 (3), 332 (3), EE 351 (3), EE 353 (3), EE 361 (2), EE 362 (1), EE 372 (3), EE 411 (3), EE 431 (3), EE 472 (4), EE 481 (3), and EE 482 (3)
- **Mathematics core:** MATH 2532 (4), 335 (3), upper-level (300-level and above) mathematics elective (3)
- **Engineering electives:** a minimum of nine engineering credit hours (200-level or above) courses, including Optical Science and Engineering (OPT), and excluding the Electrical Engineering core classes listed above, Engineering Management, and Computer Science courses, as well as ES 316 and ES 332. Students that transfer into the NMT EE program with ES332, will have EE equivalency determined on a case by case basis.

To enroll in an Electrical Engineering class, a student must have passed the prerequisites of the course. In addition, a student must be in good academic standing and have declared electrical engineering as a major to enroll in EE 481.

Students pursuing a B.S. degree in Electrical Engineering must take all Electrical Engineering courses for a letter grade.

Sample Curriculum for the Bachelor of Science in Electrical Engineering

Semester 1

- 4 MATH 1510 (calculus I)
- 5 PHYS 1310 & 1310L (general physics I)
- 1 EE 162 (basic electronics lab II)
- 3 ENGL 1120 (college Writing)*
- 3 Humanities *

16 Total credit hours

Semester 2

- 4 MATH 1520 (calculus II)
- 5 PHYS 1320 & 1320L (general physics II)*
- 1 EE 161 (basic electronics lab I)
- 3 English 1110 (college writing)*
- 3 Fine Arts*

16 Total credit hours

Semester 3

- 3 MATH 335 (differential equations)
- 4 CHEM 1215 & 1215L (general chemistry I)
- 3 EE 211 (circuits I)
- 3 EE 271 (mathematical engineering)
- 3 Social Science*

16 Total credit hours

Semester 4

- 4 MATH 2532 (calculus III)
- 3 EE 252 (digital electronics)
- 3 EE 212 (circuits II)
- 4 CHEM 1225 & 1225L (general chemistry II)*
- 3 Humanities *

17 Total credit hours

Semester 5

- 2 EE 361 (mixed electronics lab I)
- 3 EE 353 (analog electronics)
- 3 EE 351 (microcontrollers)
- 3 EE 311 (signals & systems)
- 3 ENGL 341 (technical writing) *

14 Total credit hours ««

Semester 6

- 3 EE 332 (electricity and magnetism)
- 3 EE 372 (modeling and simulation)
- 1 EE 362 (mixed electronics lab II)
- 3 Engineering Elective
- 3 MATH Elective 300 or above

13 Total credit hours««

Semester 7

- 3 EE 481 (capstone I)
- 4 EE 431 (electrodynamics)
- 3 Engineering Elective
- 3 EE 411 (stochastic processes and communication)
- 3 Humanities or Social Science *

15 Total credit hours

Semester 8

- 3 EE 482 (capstone II)
- 3 Engineering Elective
- 3 EE 472 (digital signal processing)
- 3 Social Science *

12 Total credit hours ««

- * These courses are requirements for the general education core curriculum, but are not pre- or co-requisites for courses in electrical engineering. Students are encouraged to work with their academic advisors to find suitable points of inclusion in the course program.

Note: In order to earn or retain the NM Lottery Scholarship, students must earn 15 credits each semester. Please see your advisor for more information.

Minor in Electrical Engineering

Minimum credit hours required—18

The following courses are required:

- EE 161 (1), EE 162 (1), EE 211 (3), EE 212 (3), EE 252 (3), EE 271 (3)
- Four (4) additional credit hours of upper-level (300-level or above) Electrical Engineering courses.

Graduate Program

Graduate Degrees in Electrical Engineering

The Electrical Engineering department offers both Master of Science and Doctor of Philosophy degrees accessible to students with appropriate preparatory studies. The Doctoral degree can be entered directly from an undergraduate degree or based on completing an appropriate Master's degree. These degrees can be tailored for a wide range of research and academic interests. A graduate certificate is available for students who are looking to add to their skillset without seeking a degree.

Educational Objectives for Graduate Program in Electrical Engineering

The faculty of the Department of Electrical Engineering strives to continuously improve the graduate program in electrical engineering. The educational objectives reflect the needs of, and have been reviewed by, among others, the Advisory Board and faculty. Several years after graduation it is expected that our graduates will be:

- technology leaders who fearlessly discover, apply and teach new knowledge and engineering practices;
- entrepreneurially minded innovators driving positive economic and social impact in their communities and the nation;
- adaptive learners who continue to grow educationally and professionally through advancing their education.

Student Outcomes for Graduate Program in Electrical Engineering

To achieve the general goals of the Department of Electrical Engineering, student outcomes reflect the needs of, and have been reviewed by, among others, the Advisory Board and faculty. Upon graduation with the degree of Master of Science in Electrical Engineering, students will have obtained:

- an ability to apply methods of advanced analysis appropriate for professionals to use when solving problems;
- an ability to apply an in-depth knowledge in a particular field of study that supports the use of innovative techniques to solve problems;
- an ability to demonstrate skills pertinent to the research process, including the ability to formulate problems, synthesize and integrate information, work collaboratively, communicate effectively, and publish results.

Master of Science in Electrical Engineering

The Electrical Engineering graduate program provides students with unique research opportunities, thanks to its close association with many research facilities. These facilities include Energetic Materials Research and Testing Center, Langmuir Laboratory, Magdalena Ridge Observatory, National Radio Astronomy Observatory, Incorporated Research Institutions for Seismology, and Institute for Complex Additive Systems Analysis; all easily accessible from campus. These facilities can provide opportunities for students to participate in research related to leading scientific and engineering projects and allow them to achieve highly desirable educational and research experiences.

The student's course of study must be approved by the student's advisory committee, must fulfill the general requirements for the master's degree (page 51), and must include the course EE 521, Measurement and Instrumentation.

At least 12 semester hours must be approved Electrical

Engineering courses. No more than six (6) semester hours of advanced undergraduate course work may be used to satisfy the degree requirements. Students are required to take at least six (6) credit hours from outside the Electrical Engineering department. Students may choose between an M.S. with thesis (24 credit hours of courses plus six (6) thesis hours) or an M.S. with independent study (27 credit hours of courses plus three (3) independent study hours). Students may be required to take an appropriate software course if they don't have an appropriate programming background.

Electrical Engineering Accelerated Masters

Qualified students may apply for admission to the Accelerated Masters program in Electrical Engineering. In fulfillment of the requirement for both B.S and M.S degrees as outlined in their respective sections, accepted students may apply eight credits of 500 level or above to both degrees.

Doctor of Philosophy in Electrical Engineering with Dissertation in Cyber Electronic Systems

The prospective doctoral candidate will develop a high level of competence in the specialized area of cyber electronic systems. Candidates will also develop the ability to integrate aspects of this area and apply them in cutting-edge research. The program is arranged by the prospective student and the student's graduate committee.

The Ph.D. requirements include the following:

1. Select a graduate committee that shall consist of a minimum of four members:
 - (a) An academic advisor from the Electrical Engineering department, and
 - (b) at least three other members, one of which must be from outside the department assigned or approved by the Dean of Graduate Studies. The research advisor may be the academic advisor or another member of the committee.
2. Students with only a Bachelor of Science degree in related area must complete a minimum of 72 credit hours:
 - a minimum of 24 credit hours of electrical engineering courses 500-level or above including required core courses (8 credits)
 - a) EE 560, Electronic Warfare
 - b) EE 565, Position, Navigation and Timing
 - a minimum of 6 credit hours outside electrical engineering;
 - 24 credit hours of dissertation; and
 - no more than 6 credit hours of 300- or 400- level courses.
3. Students with a Master of Science degree in related area must complete a minimum of 48 credit hours:
 - a minimum of 12 credit hours of electrical engineering courses of 500-level or above including required core courses (8 credits)

- EE 560, Electronic Warfare
 - EE 565, Position, Navigation and Timing
- a minimum of 6 credit hours outside of the Electrical Engineering department unless satisfied by the Master of Science degree;
 - 24 credit hours of dissertation; and
 - no more than 3 credit hours of 300- or 400- level courses
4. All course work must be approved by the student's graduate committee, the Electrical Engineering Department Chair, and the Dean of Graduate Studies.
 5. The graduate committee, in consultation with the student, will select a technical paper. The student must perform an in-depth study of the paper through analysis and modeling, and/or simulation. The student will present the analysis and critique of the paper in a written report and an oral presentation. The written report and the oral presentation constitute the qualifying examination. The exam is designed to test the student's ability to be successful in the Ph.D. program by demonstrating his/her ability to analyze, critique, solve technical problems, grasp fundamental concepts, solve open problems, and communicate effectively. The graduate student may only take the qualifying exam once. In case the student did not pass, he/she may appeal the decision to the Electrical Engineering Department Chair.
 6. Successfully pass the candidacy examination. The student must present a detailed review of his/her research area and hypothesis under investigation to the members of his/her graduate committee. The presentation will be open to the public. This examination may only be taken after a student has passed the qualifying examination.
 7. The admission to candidacy to the Ph.D. degree requires that the qualifying and candidacy examinations be passed and approved by the graduate committee; after which the student may enroll in EE 595: Dissertation.
 8. The student must write a final dissertation and defend it in an oral public defense before the student's graduate committee.

Additional requirements include the New Mexico Institute of Mining and Technology Graduate Program requirements.

Graduate Certificate in Electrical Engineering

The Electrical Engineering graduate certificate program is aimed at practicing engineers wanting to increase their exposure to electrical engineering at the graduate level while not being tied to a degree program. The program is designed to provide a rigorous upgrade to the student's skills in electrical engineering while focusing on topics of interest to the student.

The certificate program requires a minimum of 16 credit hours of graduate course work. The course requirements are:

- EE 521 Measurement and Instrumentation (4 credits)
- One 4 credit electrical engineering graduate course

- One 3 credit or higher electrical engineering course at either graduate or upper undergraduate level
- One 3 credit or higher graduate course in either mathematics, physics, engineering or computer science
- EE 590 Independent Study (2 credits) supervised by a member of the electrical engineering department

Electrical Engineering Courses:

The Department of Electrical Engineering encourages students from other majors to take electrical engineering courses. Students from other disciplines who are interested in taking electrical engineering courses should inquire at the department office or contact any member of the department's faculty

EE 161, Basic Electronics Laboratory I, 1 cr, 3 lab hrs

Corequisite: MATH 1240

An introduction to electronics through practical hands-on based exercises building electronic systems with emphasis on analog electronics. Topics include: basic circuit analysis, battery chargers, amplifier circuits, circuit board layout and assembly, instrumentation and measurements, introduction to computer-based tools, and related topics.

EE 162, Basic Electronics Laboratory II, 1 cr, 3 lab hrs

Corequisite: MATH 1240

An introduction to electronics through practical hands-on based exercises building electronic systems with emphasis on digital electronics. Topics include: logic circuits, applications of microcontrollers, computer-based tools, and related topics.

EE 211, Circuits and Signals I, 3 cr, 3 cl hrs

Prerequisites: MATH 1520

Normally offered fall semester

Principles of electrical circuit analysis. Kirchhoff's laws, equivalent circuits, dependent sources, node and mesh analyses, signals, RLC components. Introductory circuits and operational amplifier circuits as examples.

EE 212, Circuits and Signals II, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: EE 211 or ES 332

Normally offered spring semester

Continuation of EE 211, Laplace transform techniques, transient response, power, steady-state sinusoidal response, and frequency response of RLC circuits.

EE 252, Digital Electronics, 3 cr, 3 cl hrs

Corequisite: EE 271

Normally offered spring semester

Fundamental concepts of digital logic analysis and design. Topics include: Boolean algebra, logic gates, truth tables, simplification methods, multiplexers, decoders, registers, sequential digital design, finite state machines, hardware description language (HDL), and related topics.

EE 271, Mathematical Engineering, 3 cr, 3 cl hrs

Corequisite: MATH 1510

Normally offered both fall and spring semesters

Fundamental concepts of programming using MATLAB

and C to address problems related to electrical engineering. Topics include: programming techniques, application of linear algebra, syntax of MATLAB and C, mathematical modeling and computations, data analysis, image processing, visualization, and other topics.

EE 311, Signals and Linear Systems, 3 cr, 3 cl hrs

Prerequisites: EE 212, EE 271 and MATH 335

Normally offered fall semester

Fundamentals of continuous and discrete signals and systems. Topics include: linear time-invariant systems, convolution, Fourier series, Fourier transforms, Laplace transforms, z-transforms, sampling theory, transfer functions, poles and zeros, feedback systems, filters, convolution, application of MATLAB, and related topics.

EE 324, Semiconductor Theory and Devices, 3 cr, 3 cl hrs

Prerequisite: PHYS 1320

Fundamentals of semiconductor Materials and devices. Topics include introduction to quantum mechanics and electrical conduction in conductors, insulators, and semiconductors. The theory is applied to pn junctions, bipolar and field-effect transistors and opto-electronic devices.

EE 332, Electricity and Magnetism, 3 cr, 3 cl hrs

Prerequisites: EE 271, PHYS 1320 and MATH 2532

Normally offered spring semester

Introduction to electricity and magnetism based on Maxwell's Equations. Topics include: calculation of electric and magnetic fields produced by simple current and charge sources, effects of Materials, energy storage in fields, capacitance, inductance, electric and magnetic force calculations using virtual work, propagation of plane waves in vacuum and in Materials, reflection and refraction of plane waves at planar interfaces, magnetic circuit calculations, application of MATLAB, and related topics.

EE 351, Microcontrollers, 3 cr, 3 cl hrs

Prerequisite: EE 271

Normally offered fall semester

Introduction to microcontrollers. Topics include: programming in assembly and C, bus structures, interrupts, timing, real-time control, parallel and serial interfaces, support devices, disassemblers, and related topics.

EE 352, Microcomputer Interfacing, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: EE 351

Design of hardware and software for microcomputer interfacing. Bus signals and timing. Interrupt and direct memory access handling. Students will design, build, program, and test a simple interface card for a common microcomputer bus.

EE 353, Analog Electronics, 3 cr, 3 cl hrs

Prerequisite: EE 212

Normally offered fall semester

Fundamentals of analog electronics. Topics include:

principles and use of operational amplifiers, diodes, field effect transistors, bipolar junction transistors, basics of transistor operation in terms of semiconductor physics, and related topics.

EE 361, Mixed Electronics Lab I, 2 cr, 6 lab hrs

Prerequisite: EE 252

Corequisites: EE 351 and EE 353 Normally offered fall semester

Intensive laboratory working with analog and digital electronics, FPGAs, and microcontrollers. Project topics include: oscillators, amplifiers, filters, analog-to-digital converters, digital-to-analog converters, direct digital synthesizers, interfacing, feedback control, and related topics.

EE 362, Mixed Electronics Lab II, 1 cr, 3 lab hrs

Prerequisite: EE 361

Corequisite: EE 372

Normally offered spring semester

Advanced laboratory working with analog/digital signals and systems. Project topics include: sensor fusion, radio frequency integrated circuits, software defined radios, testing and measurement techniques, and related topics.

EE 372, Modeling and simulation 3 cr, 3 cl hrs

Corequisite: EE 362

Normally offered spring semester

Course on simulation and modeling using modern engineering tools. Topics include: state-space modeling, modeling and simulation of systems, statistical techniques for data analysis, MATLAB, SIMULINK, CAD, Pspice, and related topics.

EE 408, Cooperative Education

On-the-job training to supplement the academic program. Students alternate periods (usually six months long) of full-time semiprofessional employment in Electrical Engineering with periods of full-time academic study. A written report of the student's activities will be required at the end of the training.

EE 411, Stochastic Processes and Communications, 3 cr, 3 cl hrs

Prerequisite: EE 311

Normally offered fall semester

Principles of communication theory. Topics include: analog modulation techniques, probability theory, random signals and noise, analysis of communication systems in presence of noise, digital communication, matched filters, channel capacity, multiple access, and related topics.

EE 422, Advanced Electronics, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: EE 353 and EE 311

Advanced electronics theory with applications. Topics may include linear and switching power supplies, current feedback op-amps, electronic noise and interference, timers and oscillators, feedback systems and phase-locked loops, and active filters.

EE 431, Electrodynamics, 3 cr, 3 cl hrs*Prerequisite: EE 332**Normally offered fall semester*

Fundamentals and applications of electrodynamics. Topics include: transient and sinusoidal steady state solutions of uniform transmission line problems modeled in terms of circuit parameters, propagation characteristics of metallic and dielectric waveguides, radiation from linear wire antennas along with large and small aperture radiators, radiation patterns of antenna arrays, and related topics.

EE 443, Intermediate Control Theory, 3 cr, 3 cl hrs*Prerequisite: EE 311*

Modeling of dynamical systems via differential equations, transfer functions, and state-space methods. Performance, characterization, and behavior of linear feedback-systems. Design of various types of control schemes to meet performance specifications.

EE 443L, Intermediate Control Theory Lab, 1 cr, 3 cl hrs*Corequisite: EE 443 or MENG 405 or permission of instructor*

Use of computer-based data acquisition and control (DAC) hardware and software. Model validation and verification of physical systems. Implementation of real-time control schemes utilizing actuators and sensors.

EE 472, Digital Signal Processing, 4 cr, 3 cl hrs, 3 lab hrs*Prerequisites: EE 311 and EE 351**Normally offered spring semester*

Principles of digital signal processing. Topics include: Infinite and finite impulse response filters, discrete and fast Fourier transforms, multirate processing, spectral estimation, quantization effects, system design, and implementation of real-time DSP algorithms on state-of-the-art hardware. Principles discussed in class will be demonstrated with real applications in labs that include design and implementation of infinite and finite impulse response filters, and applications such as communication systems, sound processing, image processing, and related topics.

EE 481, Capstone Design I, 3 cr*Prerequisites: EE 311, EE 332**EE 372, and have declared electrical engineering as a major**Normally offered fall semester*

Student design teams begin an academic year long capstone design project under the supervision of a faculty advisor. Topics include: team building, design requirements and documentation, detailed planning, identification of project needs and establishment of goals leading toward the successful completion of the project, periodic design reviews and reports, applications of engineering skills, project management and formal presentations. Successful completion of the project requires the application of electronics, applied physics, numerical computation, signal processing, other electrical engineering techniques to real world engineering problems, and related topics.

EE 482, Capstone Design II, 3 cr*Prerequisite: EE 481**Normally offered spring semester*

A continuation of the capstone design projects started in EE 481. EE 482 must be taken in the semester immediately following EE 481 to maintain project continuity. The student teams provide status reports, a final presentation to faculty and reviewers, and a senior thesis, and bring their design projects to successful completion.

EE 491, Special Topics, hrs and crs to be arranged**EE 500, Directed Research, cr to be arranged***Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor*

Offered both Spring and Fall semester. Credits cannot be applied towards the 30 credit hours required for graduation. Research under the guidance of an EE faculty member.

EE 521, Measurement and Instrumentation, 4 cr, 3 cl hrs, 3 lab hrs*Prerequisites: Graduate standing in electrical engineering or consent of instructor and advisor*

Survey of various sensors and transducers for measuring physical quantities; measurement errors; analog and digital interfaces; sampling; quantization; actuators; and sensing devices in closed-loop control. Digital interfacing to the measurement devices for both experimentation and microprocessor control will be performed using a computer equipped with data acquisition hardware and software.

EE 531, Advanced Digital Design: 4 cr, 3 cl hrs, 3 lab hrs*Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor*

Advanced topics in digital design. Synchronous and asynchronous state machines. Timing issues in high-speed digital design. Design of a complex system using Verilog or VHDL programming language in a CAD environment.

EE 533, Optical/RF Engineering, 3 cr, 3 cl hrs*Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor*

Explore various topics in data links and telemetry including RF links, antennas, satellite communications, and optical fiber links. Projects will include design and fabrication of basic RF antenna and a case study of a satellite communications system.

EE 537, Photonics, 4 cr, 3 cl hrs, 3 lab hrs*Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor*

Topics include the generation, propagation, manipulation and detection of light from low to high energy. Uses and applications of optical systems: simple optics, binary and Fourier optics, electro-optics, wavefront analysis, modal decomposition, inversion techniques for wavefront reconstruction and correction and optical signal processing. Other advanced topics in optics.

EE 544, Modern Control Theory, 4 cr, 3 cl hrs, 3 lab hrs*Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor*

Treatment of modern approach to control system design primarily via state-space analysis techniques for both continuous and discrete time systems. Topics include the realization of MIMO models for real-systems, linear feedback

control, the design of observers, optimal control, and concepts in stability. The latter part of the course will address recent advanced topics of current relevance. Associated hardware and software-based lab/project(s) will include the use of computer-based data acquisition systems.

EE 545, Digital Communication I, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor

Digital communication systems; response time requirements and control of user errors. Spread spectrum modulation and the fundamental limitations dictated by information theory. Various types of modulation and multiplexing including BPSK, QAM, QPSK, OQPSK. Statistical analysis of various modulation schemes.

EE 546, Digital Communication II, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor

Spread-spectrum modulation, frequency hopping techniques, error control coding, multiple access techniques including TDMA (time division multiple access) and CDMA (code division multiple access). Various advanced case studies. Analysis of imperfections; noise and distortion line failures, data errors, delays and blocking, treatment of errors.

EE 548, Manipulator-based Robotics: 4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor

Fundamentals of the multi-disciplinary field of robotics. Emphasis is placed on understanding how to model and control robotic manipulators while providing an appreciation of the importance of providing to robotic applications. Topics include: forward, inverse, and motion kinematics; dynamic modeling; position, velocity, and force control.

EE 551, Discrete-Time Signal Processing, Filtering, and Estimation, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor

The fast-Fourier transform and its computer implementation; spectral estimation; analytic signals; multi-dimensional signal processing; digital filters. Signal detection and estimation, Kalman Filters, linear predictive coding, and adaptive filters. Project(s) include the design and implementation of a Kalman filter for GPS data processing and LPC for speech recognition.

EE 552, Image Processing and Data Compression Techniques, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor

The basics of two-dimensional digital signal processing, image representation and human vision including color models, image transformation and video compression techniques (including JPEG and MPEG). Study of relevant current applications including HDTV.

EE 554, Embedded Control Systems, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor

Microcontroller- or microcomputer-based embedded control systems. A comparative survey of currently

available embedded computers/controllers including SBC's, PICs, basic-stamps, and System on Chip (SoC) solutions. Real-time operating systems, including real-time LINUX, and hard real-time process requirements. Projects will include the implementation of an embedded real-time control solution.

EE 560, Electronic Warfare, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor

Explores the various aspects of Electronic Warfare (EW) from the standpoint of both the user and the attacker. The course begins with a definition of terms such as Electronic Support (ES), Electronic Protection (EP), Electronic Attack(EA), and Electronic Counter-Counter Measures (ECCM). The primary emphasis is on the impact of EW techniques on radar and communication systems.

EE 562, Microwave Engineering & Radar, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor

Transmission media: waveguides, micro+strip and glass fiber. Ferrite devices and cavity resonators. Equivalent circuits using scattering and transmission matrices. Active components in microwave circuits.

EE 565, Position, Navigation and Timing, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor

Covers the fundamentals of timing, terrestrial location and navigation with an emphasis on practical exposure to the technology. Key components include: GPS fundamentals; an overview of inertial navigation technology; principles of strapdown inertial navigation systems including coordinate frames, attitude representation, and mechanization in various coordinate frames; sensor technology covering a wide range of accelerometers and gyroscopes; sensor specifications and characterization; testing and calibration approaches; effects of inertial sensor error and compensation methods; introduction to unmanned systems; analysis of real sensor data and simulation and modeling using MATLAB/Simulink.

EE 569, Wireless Communications, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor

Signaling: exchange, subscriber loops, and local loops, transmission media, and multiplexing. Switching: network switching, space-division and panel switching, and various digital-switching methods. Cellular telephony, data networks and communication protocols.

EE 570, 570D, Advanced Topics in Electrical Engineering, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: Graduate standing in electrical engineering or consent of instructor and advisor

Emerging technologies and specializations in Electrical Engineering addressed from the perspective of embedded systems and advanced design.

EE 581, Directed Study, cr to be arranged

Prerequisite: Permission of graduate advisor

EE 590, Independent Study, cr to be arranged

Prerequisite: Permission of graduate advisor

Independent research supervised by a faculty member. It is

expected that this work will culminate in a paper to be published, and an oral presentation is required.

EE 591, Thesis (Master's Program), cr to be arranged

EE 592, Graduate Seminar, 1 cr, 1 cl hr

Prerequisite: Graduate standing

Offered both Spring and Fall semester. Credits cannot be applied towards the 30 credit hours required for graduation.

EE 595, Dissertation, cr to be arranged

Prerequisite: Successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.

Faculty Research Interests

- Arechiga — Speech Processing, Thunderstorms, UAVs.
- Bond — Design for Test/Manufacturability, Teaching Effectiveness.
- Edens — Lightning Detection and Mapping, Custom Instrumentation Development, Aerial Platforms for Atmospheric Research.
- El-Osery — Wireless Communications, Control Systems, Soft Computing, Cognitive Radio, Inertial Navigations
- Erives — Hyperspectral Imaging, Sound Processing, Embedded Control Systems.
- Helmholtz — Novel Applications of Radio Astronomy Instrumentation.
- Jorgensen — Spacecraft and Astronomical Instrumentation, Space Physics, Data Assimilation, Sensor Networks, Space Elevators.
- Kassim—Novel Applications of Radio Astronomy Instrumentation.
- Prager—Semiconductors.
- Restaino—Adaptive Optics, Novel Optical Systems
- Senay — Communications, Signal Processing, Control Systems.
- Shao — Visible light communications.
- Smith — Infrastructure protection and cybersecurity.
- Teare — Adaptive Optics, Smart Sensors, Ballistics, Energetic Materials.
- Wedeward—Control Systems, Robotic Systems, Electric Power Systems.
- Wick — Experimental Adaptive and Active Optics.
- Xiao — Photonic/Fiber Sensors.

Environmental Engineering

*Professors Huang, Richardson (Chair of Department)
Associate Professor Carrico
Adjunct Faculty Brady, Cal, Schlupe, Wei*

**Degrees Offered: B.S. in Environmental Engineering;
M.S. in Environmental Engineering**

Department Mission Statement

The primary objective of this program is to produce well-balanced environmental engineers capable of entering the environmental engineering profession or continuing their studies at the graduate level. Graduates will be well-prepared to solve current environmental engineering problems, and they will have the ability to adapt to problems of the future.

By providing relevant experiences and building requisite technical skills and judgment cumulatively through rigorous problem solving, the program will instill the confidence needed for students to emerge as leaders in the field of environmental engineering.

Program Educational Objectives

1. To develop graduates that function successfully in areas of environmental engineering, such as air pollution, water and wastewater treatment, and solid and hazardous waste engineering.
2. To prepare graduates for advanced education in environmental engineering and related fields, and for professional licensure.

The achievements of environmental engineers are well-known to the general public, because environmental engineers are charged with producing clean water, disposing of waste responsibly, and maintaining air quality. Projects that environmental engineers work on include: design of water and wastewater treatment facilities, landfill design, design of air pollution control devices, and environmental law and permitting. The undergraduate program offers a balanced approach to environmental engineering education.

Students take a common core of engineering science and environmental engineering courses, including courses in environmental law, water and wastewater treatment, soil mechanics, soil and hazardous waste, hydrology and air pollution control. The environmental engineering courses teach students the fundamentals of engineering design, as well as potential applications. Students are taught how to use computer software to expedite the design process, and they are also taught how to balance engineering designs with economic constraints. During their senior year, undergraduate students work with a professor on a design thesis.

Student Outcomes for Undergraduate Program in Environmental Engineering

Graduates of the Bachelor of Science in Electrical Engineering program will have demonstrated

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Undergraduate Program

Bachelor of Science in Environmental Engineering

Minimum Hours Required—132

In addition to the General Education and Institute Core Curriculum (page 80), the following courses are required:

MATH 2532 (4), 2350 (3), 335 (3)
BIOL 2110 (3), 2110L (1), 343 (3)
ERTH 440 (3), 440L (1)
ES 110 (2), 111 (3), 201 (3), 216 (3), 302 (3), 316 (3), 347 (3), 350 (3)
ENVE 101 (1), 201 (3), 301 (3), 302 (2), 303 (3), 304 (3), 406 (3), 411 (4), 413 (4), 480 (3) or 490 (1) and 492 (2) ME 420 (3)

Technical Electives (3):

Approved technical electives include

ENVE 421, 491; CE 201, 301, 302, 401, 413, 420, 422, 423; ChE 351, 352, 443; CHEM 333, 422; EE 211; ES 305, 332; MTLs 430, 460, 470; ME 220, 409, 410, 422, 427; MENG 304, 305, 421; or other electives approved by the department chair.

Students pursuing a B.S. in Environmental Engineering must take all engineering courses for a letter grade. Environmental engineering majors must maintain a minimum GPA of 2.0 in required courses in order to graduate.

Environmental engineering majors are required to take the Fundamentals in Engineering (FE) exam as a requirement for graduation.

Sample Curriculum for the Bachelor of Science Degree in Environmental Engineering

Semester 1

- 1 ENVE 101 (environmental engineering seminar)
- 3 ENGL 1110 (college English)
- 4 BIOL 2110 & 2110L (general)
- 4 CHEM 12155 & 1215L (general)
- 4 MATH 1510 (calculus)
- 2 ES 110 (intro to engineering)

18 Total credits

Semester 2

- 3 ENGL 1120 (college English)
- 3 ES 111 (computer programming for engineers)
- 4 MATH 1520 (calculus)
- 4 CHEM 1225 & 1225L (general)
- 3 Social Science

17 Total credit hours

Semester 3

- 4 MATH 2532 (calculus)
- 5 PHYS 1310 & 1310L (general)
- 3 ENVE 201 (intro to environmental engineering)
- 3 Social Science
- 3 Humanities

18 Total credits

Semester 4

- 3 ENVE 301 (applied principles)
- 3 MATH 335 (ordinary differential equations)
- 3 PHYS 1320 & 1320L (general)
- 3 BIOL 343 (microbiology)
- 3 ES 201 (statics)

17 Total credits

Semester 5

- 3 ENVE 303 (water treatment process design)
- 3 ES 216 (fluid mechanics)
- 3 ES 302 (Materials)
- 3 ES 347 (thermodynamics)
- 3 MATH 2350 (statistics)

15 Total credits

Semester 6

- 2 ENVE 302 (environmental law)
- 3 ENVE 304 (wastewater treatment process design)
- 3 ES 316 (engineering economics)
- 3 ES 350 (heat & mass transfer)
- 3 ENGL 341 (technical writing)
- 3 Humanities

17 Total credits

Semester 7

- 4 ENVE 411 (solid and hazardous waste)
- 4 ENVE 413 (air pollution engineering)
- 1 ENVE 490 (senior design thesis I)
- 4 EARTH 440 & 441L (hydrologic theory/field methods)
- 3 ME 420 Soil Mechanics

16 Total credits

Semester 8

- 3 ENVE 406 (unit operations)
- 2 ENVE 492 (senior design thesis II)
- 3 Approved Technical Elective
- 3 Social Science

- 3 Humanities/Social Science/Fine & Creative Arts
- 14 ** Total credits

** In order to earn or retain the NM Lottery Scholarship, students must earn 15 credits each semester. Please see your advisor for more information.

Summer

- 3 CEE 581

Semester 7

- 4 ENVE 411
- 4 ENVE 413
- 4 EARTH 440

- 3 Social Science

15 Total credit hours

Semester 8*

- 3 ENVE 406
- 3 ENVE 490
- 3 ENVE 510

- 3 Humanities/Social Science

12 Total credit hours

*B.S. degree is granted

Summer

- 3 CEE 591

Semester 9

- 3 CEE 501
- 3 CEE 503
- 3 CEE 512

- 3 CEE 591

12 Total credit hours

Semester 10

- 3 CEE 520
- 3 Elective
- 3 Elective

- 3 CEE 591 (optional)

12 Total credit hours

Summer

- 3 CEE 591 (optional)

Minor in Environmental Engineering

Minimum credit hours required – 18

The following courses are required:

- ENVE 201 (3), ENVE 301 (3)
- 12 additional hours of approved courses, including any ENVE courses, ME 420, or EARTH 440

Graduate Programs

Master of Science in Civil and Environmental Engineering

The Civil and Environmental Engineering graduate program at New Mexico Tech provides a unique educational and research experience in the engineering and science of the natural and the built environment and environmental protection. The plan of study and research is suited to each individual, drawing upon the strengths of the student, taking advantage of program capabilities, and complementing research activities

within and outside New Mexico. A thesis or independent study project is required to complete the degree. General requirements common to all Master of Science degree curricula also apply.

Admission to the Master of Science in Civil and Environmental Engineering program requires competence in mathematics, chemistry, physics, and engineering science comparable to the Bachelor of Science in Civil or Environmental Engineering. The department chair, or an advisory committee, will evaluate the scholastic record of every entering student to determine whether any deficiencies exist in their educational background. For example, students entering the program without an engineering degree may be required to take additional course work in such areas as fluid mechanics, heat and mass transfer, and differential equations before being granted a M.S. in Civil and Environmental Engineering. It is up to the student and his or her graduate committee to determine the specific plan of study for the student after the first semester of graduate work. Transfer credit for courses taken at another institution will be evaluated on an individual basis.

Areas of Specialization

The Civil and Environmental Engineering Master's Program will offer two areas of specialization: Environmental Engineering and Civil Engineering

The Area of Specialization in Environmental Engineering requires a minimum of 4 courses be taken from the following list of CEE courses:

CEE 501, Physicochemical and Biological Processes
 CEE 503, Environmental Risk Assessment
 CEE 510, Advanced Water Chemistry
 CEE 511, Water Quality Management and Control
 CEE 512, Industrial Water and Wastewater Treatment
 CEE 513, Air Resources Engineering
 CEE 514, Energy & Environment
 CEE 520, Hazardous Waste Site Remediation
 CEE 521, Green Engineering
 CEE 522, Geotechnical Waste Containment
 CEE 523, Open Channel Hydraulics
 CEE 571, Special Topics

The Area of Specialization in Civil Engineering requires a minimum of 4 courses be taken from the following list of CEE courses:

CEE 5xx, Finite Element Analysis for Civil Engineers
 CEE 502, Introduction to Transportation Engineering
 CEE 506, Design of Steel Structures
 CEE 507, Design of Concrete Structures
 CEE 5xx, Reinforced Masonry and Timber Design
 CEE 5xx, Infrastructure
 CEE 5xx, Minimum Design Loads for Buildings
 CEE 5xx, Foundation Design and Analysis
 CEE 5xx, Advanced Design of Steel Structures
 CEE 5xx, Advanced Design of Concrete Structures
 CEE 523, Open Channel Hydraulics
 CEE 571, Special Topics

Thesis Option

A total of 30 credit hours are required for a M.S. in Civil and Environmental Engineering, which must include a minimum of 18 credit hours of Civil and Environmental Engineering coursework, and 6 credit hours of CEE 591 (thesis). All students must take a minimum of 12 credit hours of 500-level Civil and Environmental Engineering courses.

Independent Study Option

A student may petition the department with the approval of the Department Chair to pursue a Master of Science degree with an independent study option. Candidates for the non-thesis Master of Science option must complete a minimum of 30 credit hours, of which 3 credit hours must be independent study (CEE 590). All students must take a minimum of 12 credit hours of 500-level Civil and Environmental Engineering courses, and an additional 6 credits of 400- or 500-level Civil and Environmental Engineering courses (18 credits total). The student's course of study must be approved by the student's advisory committee, and it must fulfill the other requirements of the M.S. in Civil and Environmental Engineering degree program with the exception of 6 credit hours of thesis (CEE 591).

Five Year Bachelor's/Master's Degree Program

A five-year B.S. /M.S. Civil and Environmental Engineering degree can be achieved by fulfilling the separate requirements of both the undergraduate degree and graduate degree for students in the Civil Engineering and Environmental Engineering BS programs, a combined minimum of 159 credit hours is required for the dual degree with at least 12 credit hours of 500-level CEE courses and 6 credit hours of Thesis (CEE 591). For students in affiliated BS engineering programs including chemical engineering, mechanical engineering and material engineering there are commensurate requirements. Students in the five-year program are also required to take CEE 581 (summer). A B.S. degree in Civil Environmental or Environmental Engineering will be granted after the five-year student has completed the 132 credit-hour undergraduate requirement for their respective degree. For students in affiliated BS engineering programs the B.S degree will be granted after the five-year student has completed the credit-hour undergraduate requirement for their respective degree. For the M.S. degree, the 6 credit hours of required graduate electives must be non-ENVE courses of 300-level and above. Students with a minimum GPA of 3.0 are eligible to apply for the admission to the graduate program after the first semester of their junior year. Once admitted to the graduate program, the five-year student will spend his/her senior year as a dual registered student and all rules for graduate student status apply. A sample curriculum for the five-year B.S. /M.S. Environmental Engineering degree is listed above.

Environmental Engineering Courses:

ENVE 101, Environmental Engineering Seminar, 1 cr, 1 cl hr

Seminars by faculty, and guest speakers from industry, consulting, and government provide a brief overview of environmental engineering topics, including air pollution, water quality, and solid and hazardous waste.

ENVE 201, Introduction to Environmental Science and Engineering, 3 cr, 3 cl hr

Prerequisites: CHEM 1225 & 1225L; BIOL 2110 & 2110L; MATH 1520

The fundamentals of physics, chemistry, biology, and geology applied to problem solving in science and engineering. A study of environmental phenomena and strategies to control pollution of water, air, and land. Definition of basics for water quality engineering, water treatment, wastewater treatment, solid and hazardous waste management, radioactive waste management, and air pollution. Environmental impact statements and environmental ethics.

ENVE 301, Applied Principles of Environmental Engineering, 3 cr, 3 cl hrs

Prerequisites: ENVE 201

Application of chemical and biological principles to the study of the natural environment and engineered systems related to pollution of air, water, and soil. Topics include: atmospheric chemistry, biokinetics, carbonate cycle, corrosion, complexation (coordination chemistry), redox reactions, and precipitation. Principles will be tied to specific environmental engineering applications.

ENVE 302, Environmental Law and Regulations, 2 cr, 2 cl hrs

Prerequisite: ENVE 201

An overview of the major federal and state environmental statutes and regulations. Statutory/regulatory scheme and its application to current environmental problems. Specific regulations pertaining to air, water, toxic substances and pesticides, and solid and hazardous wastes, as well as related regulatory programs. Historical and philosophical basis of environmental regulation.

ENVE 303, Water Treatment Process Design, 3 cr, 3 cl hrs

Prerequisites: ENVE 201 or consent of instructor and advisor

Physical-chemical processes encountered in the design, analysis, and operation of municipal and industrial water treatment systems. Concepts of mass balance and chemical reactor theory applied to water quality improvements. Specific topics include flocculation/coagulation, softening, sedimentation, filtration, stabilization, disinfection, ion exchange, carbon adsorption, and gas transfer. A team design project will be required as partial fulfillment of course requirements.

ENVE 304, Wastewater Treatment Process Design, 3 cr, 3 cl hrs

Prerequisites: BIOL 343; ES 216, 350; or consent of instructor and advisor; *Corequisite:* ES 350

Physical-chemical-biological processes encountered in the design, analysis, and operation of municipal and industrial wastewater treatment systems. Microbial kinetics of carbon and nutrient removal. Aerobic and anaerobic biological processes occurring in suspended growth and fixed-film reactors. Processing, management, and disposal of biosolid residuals. Specific topics include collection, pretreatment, sedimentation, trickling filters, activated sludge aerobic and anaerobic digestion. A team design project will be required as partial fulfillment of course requirements.

ENVE 406, Environmental Engineering Unit Operations, 3 cr, 2 cl, 3 lab hrs

Corerequisites: ENVE 303 or 304 or consent of instructor and advisor

Laboratory and field studies of unit operations and processes in environmental engineering. A student-designed feature will be integrated into all of the studies. Potential topics include reactor mixing and hydraulics, coagulation, flocculation, sedimentation, filtration, carbon adsorption, chemical oxidation, air stripping, etc. Emphasis on planning of studies, preparation of work plans, data collection and analysis, report writing, and technical presentation.

ENVE 411, Solid and Hazardous Waste Engineering, 4 cr, 4 cl hrs

Prerequisites: ES 350 or consent of instructor and advisor

A study of solid waste management functions: generation, transport, storage, treatment and recovery, and disposal. Emphasis on design of treatment and recovery unit operations and processes for both municipal and industrial wastes. Site selection criteria and engineering considerations for land disposal alternatives. Special consideration of hazardous waste management: treatment, storage, disposal. Uncontrolled hazardous waste sites: risk assessment and remediation design. Projects on waste management will be developed by teams as partial fulfillment of course requirements.

ENVE 413, Fundamentals of Air Pollution Engineering, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: ES 216 and 350; or consent of instructor and advisor

Sources, behavior, and fate of gaseous and particulate air pollutants. Principles of meteorology and atmospheric diffusion in relation to modeling pollutant transport and dispersion. Design of air pollution control equipment for removal of gases and particles from air streams. Unit operations examined include cyclones, electrostatic precipitators, fabric filters, wet scrubbers, incinerators, biofiltration, adsorbers, and absorbers. In the laboratory section, students will develop an air permit, and complete projects using dispersion modeling and air pollution engineering software. Shares lecture with ENVE 513, with additional expectations for graduation credit.

ENVE 414, Energy & Environment, 3 cr, 3 cl hrs

Prerequisites: MATH 1520, PHYS 1320, CHEM 1225 or consent of instructor and advisor

This course takes an engineering approach to evaluating energy systems and their environmental impacts. Particular attention is focused upon multimedia environmental impacts to land, water, air, and climate -- all energy sources. In the beginning, students review the fundamental principles of energy, heat, work, power and efficiency. The students apply these concepts of physics, chemistry, thermodynamics, heat transfer, and economics in evaluating various energy systems. Student evaluate major energy resources including advanced fossil-fuel, renewables, energy efficiency and conservation techniques, and nuclear power systems. The course also explores the full gamut of energy end uses as well -- electrical, space heating and cooling, transportation, and lighting. The course emphasizes group project work and includes a special project for

graduate credit. Shares lecture with ENVE 514, with additional expectations for graduation credit.

ENVE 421, Green Engineering, 3 cr, 3 cl hrs

Prerequisite: junior standing

Evaluating the full range of environmental effects associated with products and services from raw Materials acquisition and manufacturing to use and disposal. Industrial processes, potential waste minimization procedures, relevant regulations as well as life-cycle analysis. Shares lecture with ENVE 521, with additional expectations for graduate credit.

ENVE 480, Environmental Engineering Senior Design, 3 cr, 3 cl hrs

Prerequisite: Senior standing and consent of instructor

Design of equipment, unit processes, and systems in environmental engineering through application of scientific, technological, and economic principles. Emphasis is placed upon problem formulation and the conceptual, analytical, and decision aspects of open-ended design situations. Course integrates knowledge and skills gained in previous and concurrent courses. Students work as a team in a local, regional or national design competition. A team project report is required. Instructors may also require interim reports, an individual final report, and a final presentation.

ENVE 490, Senior Design Thesis I, 1 cr

Prerequisite: Senior standing or consent of instructor and advisor

Normally offered fall semester.

An open-ended design of equipment, unit processes, and/or systems in environmental engineering through application of scientific, technological, and economic principles. The investigative component of the Senior Design Thesis focuses on identifying feasible design topics of interest to the student. Working with a faculty advisor, a thesis topic will be selected and the thesis scope and objectives defined. A preliminary thesis outline and literature review will be completed in accordance with the semester timeline schedule posted by the department. The investigative component integrates knowledge and skills gained in previous and concurrent courses.

ENVE 491, Special Topics in Environmental Engineering, 3 cr, 3 cl hrs

Prerequisite: Senior standing or consent of instructor and advisor

ENVE 492, Senior Design Thesis II, 2 cr

Prerequisite: ENVE 490 with a grade of C or higher. This course shall be taken with in ENVE 490 in sequential semesters.

Normally offered spring semester.

An open-ended design of equipment, unit processes, and/or systems in environmental engineering through application of scientific, technological, and economic principles. The design component of the Senior Design Thesis is a continuation in content of the investigative component completed in the previous semester. This course focuses on the design and economic analysis of the selected topic outlined in the deliverable for ENVE 490. An oral presentation and completed Senior Design Thesis including, but not limited to, introduction, scope, and objectives, litera-

ture review, selection criteria, design and technical analysis, and economic analysis shall be completed in accordance with the schedule posted by the department. This capstone design component course integrates knowledge and skills gained in previous and concurrent courses.

CEE 501, Physicochemical and Biological Processes, 3 cr, 3 cl hrs

Fundamentals of physical, chemical, and microbial processes in natural and engineered remedial systems. Phase interactions, chemical transformations, transport phenomena, and separation processes in the natural and engineered systems. Characteristics of microorganisms, microbial ecology, biokinetics, and nutrient requirements. The role of microorganisms in treatment processes and the monitoring and enhancement of *in-situ* activity.

CEE 503, Environmental Risk Assessment, 3 cr, 3 cl hrs

Multi-disciplinary approaches required to develop credible risk analysis within the U.S. regulatory and social framework. Philosophical contexts, regulatory framework, and economic implications. Components of risk and performance assessments, including source term, contaminant transport, exposure, and consequences. Computer models and case studies.

CEE 505 Infrastructure, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing in Civil & Environmental Engineering, or consent of instructor

Infrastructure systems have been deteriorating at an alarming rate and resources available for their rehabilitation or replacement have been limited. This course considers the current challenges to managing infrastructure. It focuses on current issues and through case studies addresses: the social, economic and political importance of infrastructure, the ASCE Report Card and its purposes, planning approaches economic and other strategies for comparing infrastructure alternatives, sustainability, risk, and resilience). **(cross-listed with CE 403; additional course expectations for graduate credit)**

CEE 510, Advanced Water Chemistry, 3 cr, 3 cl hrs

Advanced study of physical and organic chemistry as applicable to natural water bodies and water and wastewater treatment. Chemical cycles, equilibrium chemistry, chemical thermodynamics, reaction kinetics, precipitation and dissolution, oxidation and reduction, colloidal and surface chemistry, complexation phenomena, electroneutrality, mass balances, and transport and fate of chemical species. Relevance of these topics to water quality control are discussed.

CEE 511, Water Quality Management and Control, 3 cr, 3 cl hrs

Prerequisite: MATH 335 or consent of instructor and advisor

Fundamentals of water quality, including water bodies and their natural setting, water uses and waste input, and water quality cause-effect relationships. Water quality parameters, criteria, and standards; principles of water quality systems analysis, both in the formulation and application of water quality models; engineering controls and socio-economic concepts of water quality management and control, including cost/benefit analysis and management modeling.

CEE 512, Industrial Water and Wastewater Treatment, 3 cr, 3 cl hrs

Prerequisites: ENVE 303, 304, CEE 501 or ENVE 501; or consent of instructor and advisor

Advanced study of treatment unit operations and processes within industry-specific water and wastewater situations. Process design, specifications, and costing of physical, chemical, or biological technology to meet a particular treatment objective. Subject matter is developed through references to current practice, critique of completed designs, design exercises, and field trips.

CEE 513, Air Resources Engineering, 4 cr, 3 cl, 3 lab hrs

Prerequisites: ES 216 and 350; or consent of instructor and advisor

Sources, behavior, and fate of gaseous and particulate air pollutants. Principles of meteorology and atmospheric diffusion in relation to modeling pollutant transport and dispersion. Design of air pollution control equipment for removal of gases and particles from air streams. Unit operations examined include cyclones, electrostatic precipitators, fabric filters, wet scrubbers, incinerators, biofiltration, adsorbers, and absorbers. In the laboratory section, students will develop an air permit, and complete projects using dispersion modeling and air pollution engineering software. Graduate students complete an additional project and a classroom presentation. Shares lecture with ENVE 413, with additional expectations for graduate credit.

CEE 514, Energy & Environment, 3 cr, 3 cl hrs

Prerequisites: MATH 1520, PHYS 1320, CHEM 1225 or consent of instructor and advisor

This course takes an engineering approach to evaluating energy systems and their environmental impacts. Particular attention is focused upon multimedia environmental impacts to land, water, air, and climate -- all energy sources. In the beginning, students review the fundamental principles of energy, heat, work, power and efficiency. The students apply these concepts of physics, chemistry, thermodynamics, heat transfer, and economics in evaluating various energy systems. Student evaluate major energy resources including advanced fossil-fuel, renewables, energy efficiency and conservation techniques, and nuclear power systems. The course also explores the full gamut of energy end uses as well -- electrical, space heating and cooling, transportation, and lighting. The course emphasizes group project work and includes a special project for graduate credit. Shares lecture with ENVE 414, with additional expectations for graduation credit.

CEE 520, Hazardous Waste Site Remediation, 3 cr, 3 cl hrs

Prerequisites: ENVE 411, ENVE 501 or CEE 501; or consent of instructor and advisor

Design and specification of various physical, chemical, thermal, and biological technologies commonly used in the cleanup of hazardous waste sites. Special emphasis on innovative and emerging technologies for site remediation. Proper sampling and monitoring procedures. Emergency technology in hazardous waste management.

CEE 521, Green Engineering, 3 cr, 3 cl hrs

Evaluating the full range of environmental effects associated with products and services from raw Materials acqui-

sition and manufacturing to use and disposal. Industrial processes, potential waste minimization procedures, relevant regulations as well as life-cycle analysis. Shares lecture with ENVE 421, with additional expectations for graduate credit.

CEE 522, Geotechnical Waste Containment Design, 3 cr, 3 cl hrs

Prerequisite: ME 420 or consent of instructor and advisor

Design procedures consisting of waste disposal methods, various containment systems, and associated remediation techniques. Waste characterization and soil-waste interactions, contaminant transport in low permeability soils, geosynthetics and soil Materials use in waste containment, remedial issues of solidification and stabilization and barrier design, and landfill- and surface impoundment-related design, including liners, leachate and gas collection and removal, final covers, static and seismic slope stability, and settlement analysis. Geotechnical problem definition, application of field and laboratory test data, use of computer models for analysis and design.

CEE 523, Open Channel Hydraulics, 3 cr, 3 cl hrs

Prerequisite: ES 216 or consent of instructor and advisor

Analysis and characteristics of flow in natural and artificial open channel systems using energy, continuity, and momentum equations as applied to steady-state uniform, gradually varied, and rapidly varied flow profiles with emphasis on design of hydraulic structures. The students will use their knowledge of fluid mechanics, calculus, numerical analysis, and computer science to solve practical open channel flow problems. A variety of hydraulic conveyance and structures are covered, including rigid and flexible boundary channels, culverts, sluice gates, fumes, weirs, spillways, stilling basins, and bridges. Shares lecture with CE 423, with additional expectations for graduate credit.

CEE 551, Graduate Seminar, 1 cr each semester

Seminar presentations by faculty, graduate students, and guest speakers on their interests and current research topics. Graded on S/U basis.

CEE 571, Special Topics in Environmental Engineering, 2-4 cr, 2-4 cl hrs

Prerequisite: Consent of instructor

Offered on sufficient demand

Special topics in environmental engineering.

CEE 581, Directed Study, credit to be arranged

Independent design project conducted by the student under the direction of the student's advisor. A written final report and oral presentation are required.

CEE 590, Independent Study, cr to be arranged

Independent research organized and conducted by the student under the direction of the student's advisor. A written final report is required

CEE 591, Thesis (Master's Program), credit to be arranged

Faculty Research Interests

Brady — Aquatic chemistry, global change, groundwater remediation

Carrico — Air quality engineering, aerosols, global change, energy and environmental impacts

Hendrickx — Vadose zone hydrology, water and salt balance of natural and irrigated systems, evapotranspiration, remote sensing, soil physics, electromagnetic induction

Huang — Hazardous waste management, water treatment, wastewater reuse

Richardson — Biological wastewater treatment, environmental risk assessment, groundwater contamination, site remediation

Materials and Metallurgical Engineering

Professors Burleigh (Chair of the Department), Fuierer, Kalugin, Majumdar, McCoy
Assistant Professors C. Hargather, D. Choudhuri
Professors with Joint Appointments in Chemical Engineering Choudhury, Chowdhury, Leclerc, Tartis, Y-Lee
Adjunct Faculty Boyce, Chambers, Curro, Hirschfeld, Kropka, Lowe, Marchi, Prasad, Vogel
Emeritus Professor Bond

Degrees Offered: B.S. in Materials Engineering, Materials Engineering with Metallurgical Engineering Option, Materials Engineering with BioMaterials Engineering Option; M.S., M.E., and Ph.D. in Materials Engineering

Web site: <https://www.nmt.edu/academics/mtls/index.php>

Department Mission Statement

- To educate our students so that they are prepared to obtain and succeed in the best positions in industry, government laboratories, and graduate schools.
- To advance the frontiers of Materials science and engineering.
- To serve the public of New Mexico through outreach and expanded education.

Program Educational Objective

Program educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve. The Materials Engineering program will prepare graduates who:

- 1) Establish themselves in a range of careers in industry or government or pursue post baccalaureate education in engineering, science, business, law, medicine, or other professional discipline.
- 2) Advance in their chosen profession; and
- 3) Engage in appropriate professional societies and in continuing education activities

Student Outcomes for Undergraduate Program in Material Engineering

Graduates of the Bachelor of Science in Material Engineering program will have demonstrated.

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public

- health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Undergraduate Program

Advanced technologies in for example the electronic or aerospace industries, are often initiated with innovations in new Materials. These innovations rest on a fundamental understanding of how the structure of a Material at different length scales, ranging from sub-atomic to nano, to micro and macro-scale influences material properties. The state of the Material at these length scales are probed by various characterizing methods, which provide understanding of mechanisms responsible for observed phenomenon. Thereby Material problems can be resolved and innovations made that are both efficient and based on solid scientific principles. The undergraduate Materials program provides this foundations in an academic atmosphere that fosters growth and collaboration. With a small class size, students have the opportunity to interact closely with professors and conduct research in laboratories.

Students are exposed to Materials science principles starting from their freshman year and continuing through their senior year. A number of options are available in the department so that students have the flexibility to select courses that suit a specialization. In addition to theoretical courses, students obtain an excellent experience in processing and characterization techniques during their junior and senior years, these constituting the core of most experimental research and innovations. Material probing methods include spectroscopic (e.g. X-ray, FTIR, Raman), electron microscopic, thermal, and mechanical characterization.

The processing-structure-property relations are developed and expanded upon throughout the undergraduate curriculum. Four classes in the junior year target the theories used to understand characteristics of metals, ceramics, polymers, and composites. Senior-level elective Materials courses target specialized topics such as electronic, structural, nano Materials, biomaterials, and computational Materials science. The senior design sequence emphasizes the synthesis of skills and ideas as well as providing experience in teamwork and practical design.

Research experience for the students is available and encouraged through part-time employment in the broad range

of Materials research projects that are on-going in the department and also in other in-house research entities, such as the Energetic Materials Research and Testing Center and the Petroleum Recovery Research Center. Departmental collaborations with scientists at Los Alamos and Sandia National Laboratories provide another avenue for student involvement in research projects. Many of our students pursue graduate degrees either at New Mexico Tech or elsewhere while others seek employment directly.

The department operates and maintains a broad range of instrumentation. A full list of these resources is available on the department's web site. Of particular note is the broad range of microscopy capabilities for research and instruction, including scanning electron microscopes, Auger probe and a scanning probe (atomic force) microscope.

Bachelor of Science in Materials Engineering

Minimum credit hours required—131

In addition to the General Education and Institute Core Curriculum (page 78), the following courses are required: These additional courses may not be taken on a S/U basis:

- MATH 2532 (4), 335 (3)
- ES 110 (2), 111 (3), 201 (3), 302 (3), 332 (3) or EE 211 (3)
- MTLS 101L (1), 202 & 202L (4), 235 & 235L (4), 301 (3), 310 (3), 311 (3), 314 (3), 327 (3), 350 (3), 351 (3), 410 (3), 445 (3), 481 (3), 482 (3)
- Advanced basic science (3): CHEM 311, 331, 333 or MTLS 452 are recommended; advisor approval is required.
- Technical electives (12): Approved upper level MTLS courses. Up to 3 credit hours can be completed outside the department with the consent of the department.
- Electives to complete 131 credit hours
- Credit for trigonometry or college algebra is not allowed for engineering students.

Sample Curriculum for the Bachelor of Science Degree in Materials Engineering

Semester 1

1 MTLS 101L (Intro. Materials Lab)
 3 ENGL 1110 (College English 1)
 4 MATH 1510 (Calculus 1)
 4 CHEM 12155 & 1215L (General Chemistry 1)
 3 Social Science
 2 ES 110 (Intro. to Engineering)
 17 Total credit hours

Semester 2

3 ENGL 1120 (College English 2)
 4 MATH 1520 (Calculus 2)
 4 CHEM 1225 & 1225L (General Chemistry 2)
 3 ES 111 (Computer Programming)
 3 Humanities
 17 Total credit hours

Semester 3

4 MTLS 202 & 202L (General Materials 1)
 4 MATH 2532 (Calculus 3)
 5 PHYS 1310 & 1310L (General Physics 1)
 3 Humanities
 16 Total credit hours

Semester 4

3 MATH 335 (Applied Analysis)
 5 PHYS 1320 & 1320L (General Physics 2)
 4 MTLS 235 & 235L (General Materials 2)
 3 ES 201 (Statics)
 3 Social Science
 18 Total credit hours

Semester 5

3 Humanities/Social Science
 3 ES 302 (Mechanics of Materials)
 3 MTLS 301 (Ceramics)
 3 MTLS 350 (Materials Thermodynamics)
 3 MTLS 310 (Processing and Microstructure)
 15 Total credit hours

Semester 6

3 ENGL 341 (Technical Writing)
 3 ES 332 or EE 211 (Electrical Engineering)
 3 MTLS 327 (Physical Metallurgy)
 3 MTLS 351 (Polymers)
 3 MTLS 314 (Transport Processes)
 3 MTLS 311 (Thermal and Mechanical Properties)
 18 Total credit hours

Semester 7

3 Technical Elective*
 3 Technical Elective*
 3 MTLS 445 (Composites)
 3 MTLS 481 (Senior Design 1)
 3 MTLS 410 (Microstructural Characterization)
 15 Total credit hours

Semester 8

3 Technical Elective*
 3 Technical Elective*
 3 Advanced Basic Science Elective*
 3 MTLS 482 (Senior Design 2)
 3 Humanities/Social Science/Fine & Creative Arts
 15 Total credit hours

** Electives must be approved by the student's advisor.*

Bachelor of Science Degree in Materials Engineering with Metallurgical Engineering Option

Minimum credit hours required—131

In addition to the General Education and Institute Core Curriculum (page 78), the following courses are required: These additional courses may not be taken on a S/U basis:

- MATH 2532 (4), 335 (3)
- ES 110 (2), 111 (3), 201 (3), 302 (3), 332 (3) or EE 211 (3)
- MTLS 101L (1), 202 & 202L (4), 235 & 235L (4), 310 (3), 311 (3), 314 (3), 327 (3), 350 (3), 410 (3), 435 (3), 481

- (3), 482 (3)
- Two of the following: MTLs 301(3), MTLs 351(3), MTLs 445(3)
 - Advanced basic science (3): MTLs 452 is recommended.
 - Technical electives (12): Approved upper level MTLs courses. Up to 3 credit hours can be completed outside the department.
 - Electives to complete 131 credit hours
 - Credit for trigonometry or college algebra is not allowed for engineering students.

Sample Curriculum for the Bachelor of Science Degree in Materials Engineering with Metallurgical Engineering Option

Semester 1

- 1 MTLs 101L (Intro. Materials Lab)
 3 ENGL 1110 (College English 1)
 4 MATH 1510 (Calculus 1)
 4 CHEM 12155 & 1215L (Chemistry 1)
 _____ 3 Social Science
 17 Total credit hours

Semester 2

- 3 ENGL 1120 (College English 2)
 4 MATH 1520 (Calculus 2)
 4 CHEM 1225 & 1225L (Chemistry 2)
 3 ES 111 (Computer Programming)
 _____ 3 Humanities
 17 Total credit hours

Semester 3

- 4 MTLs 202 & 202L (Materials 1)
 4 MATH 2532 (Calculus 3)
 5 PHYS 1310 & 1310L (Physics 1)
 _____ 3 Humanities
 16 Total credit hours

Semester 4

- 3 MATH 335 (Applied Analysis)
 5 PHYS 1320 & 1320L (General Physics 2)
 4 MTLs 235 & 235L (General Materials 2)
 3 ES 201 (Statics)
 _____ 3 Social Science
 18 Total credit hours

Semester 5

- 3 Humanities/Social Science
 3 ES 302 (Mechanics of Materials)
 3 MTLs 301 (Ceramics)
 3 MTLs 350 (Materials Thermodynamics)
 3 MTLs 310 (Processing and Microstructure)
 15 Total credit hours

Semester 6

- 3 MTLs 311 (Thermal and Mechanical Properties)
 3 MTLs 314 (Transport Processes)
 3 MTLs 351 (Polymers)**
 3 MTLs 327 (Physical Metallurgy)
 3 ES 332 or EE 211 (Electrical Engineering)
 _____ 3 ENGL 341 (Technical Writing)
 18 Total credit hours

Semester 7

- 3 Technical Elective*
 3 Technical Elective*
 3 MTLs 481 (Senior Design 1)
 3 MTLs 410 (Microstructural Characterization)
 _____ 3 Fine & Creative Arts
 15 Total Credit hours

Semester 8

- 3 Technical Elective*
 3 Technical Elective*
 3 Advanced Basic Science Elective*
 3 MTLs 482 (Senior Design 2)
 _____ 3 Fine & Creative Arts
 15 Total credit hours

* Electives must be approved by the student's advisor.

** Two of the following: MTLs 301 (Ceramics) (3), MTLs 351 (Polymers) (3), or MTLs 445 (Composites)(3)

Bachelor of Science Degree in Materials Engineering with BioMaterials Engineering Option

Minimum credit hours required—131

In addition to the General Education and Institute Core Curriculum (page 78), the following courses are required: These additional courses may not be taken on a S/U basis:

- MATH 2532 (4), 335 (3)
- ES 110 (2), 111 (3), 201 (3), 302 (3), 332 (3) or EE 211 (3)
- MTLs 101L (1), 202 & 202L (4), 235 & 235L (4), 301 (3), 314 (3), 327 (3), 350 (3), 351 (3), 481 (3), 482 (3)
- Two of the following: MTLs 310 (3), 311 (3), 410(3)
- BIOL 2110, 2110L (4), BIOL 331 (3), BIOL 333, 333L (4), Program-Specific Elective (3)
- Technical electives (6): Suggested electives include BIOL 341 (3), 351 (3); ChE 473 (3); CHEM 333, 333L (4), 334, 334L (4); MTLs 445 (3), 470 (3); MATH 2350 (3), 382 (3); MENG 460 (3), 465 (3), 489 (3), 576 (3). Alternative or additional technical electives must be approved by the Student, the Advisor, and the Department Chair.

Sample Curriculum for the Bachelor of Science in Materials Engineering with BioMaterials Engineering Option

Semester 1

- 1 MTLs 101L (Intro. Materials Lab)
 3 ENGL 1110 (College English 1)
 4 MATH 1510 (Calculus 1)
 4 CHEM 12155 & 1215L (Chemistry 1)
 3 Social Science
 _____ 2 ES 110 (Intro. to Engineering)
 17 Total credit hours

Semester 2

- 3 ENGL 1120 (College English 2)
 4 MATH 1520 (Calculus 2)
 4 CHEM 1225 & 1225L (Chemistry 2)
 3 ES 111 (Computer Programming)
 _____ 3 Social Science
 17 Total credit hours

Semester 3

| | |
|----------|-------------------------------|
| 4 | MTLS 202 & 202L (Materials 1) |
| 4 | MATH 2532 (Calculus 3) |
| 5 | PHYS 1310 & 1310L (Physics 1) |
| <u>4</u> | BIOL 2110 & 2110L (Biology 1) |
| 17 | Total credit hours |

Semester 4

| | |
|----------|-------------------------------|
| 3 | MATH 335 (ODE's) |
| 5 | PHYS 1320 & 1320L (Physics 2) |
| 4 | MTLS 235 & 235L (Materials 2) |
| 3 | ES 201 (Statics) |
| <u>3</u> | Humanities |
| 18 | Total credit hours |

Semester 5

| | |
|----------|-------------------------------------|
| 3 | MTLS 301 (Ceramics) |
| 3 | BIOL 331 (Cell Biology) |
| 3 | ES 302 (Mechanics of Materials) |
| 3 | MTLS 350 (Materials Thermodynamics) |
| <u>3</u> | MTLS 310/311/410 |
| 15 | Total credit hours |

Semester 6

| | |
|----------|---|
| 3 | MTLS 351 (Polymers) |
| 3 | MTLS 314 (Transport Processes) |
| 3 | MTLS 327 (Physical Metallurgy) |
| 3 | ES 332 or EE 211 (Electrical Engineering) |
| 3 | ENGL 341 (Technical Writing) |
| <u>3</u> | Humanities |
| 18 | Total credit hours |

Semester 7

| | |
|----------|----------------------------|
| 3 | Technical Elective* |
| 3 | Social Science/Humanities |
| 3 | Social Science/Humanities |
| 3 | MTLS 481 (Senior Design 1) |
| <u>3</u> | MTLS 310/311/410 |
| 15 | Total credit hours |

Semester 8

| | |
|----------|------------------------------------|
| 4 | BIOL 443, 443L (Molecular Biology) |
| 3 | Technical Elective* |
| 3 | MTLS 482 (Senior Design 2) |
| 3 | Program Specific Elective |
| <u>3</u> | Social Science/Humanities |
| 16 | Total credit hours |

* *Electives must be approved by the student's advisor.*

Minor in Materials Engineering

Minimum credit hours required—17

The following courses are required:

- MTLS 202 and MTLS 235 (6+), MTLS 327 (3).
- Approved Technical Electives (to yield total of 17).

Minor in Polymer Science

Minimum credit hours required—19

The following courses are required:

- CHEM 334 (3), 446 (3)
- MTLS 202 & 202L (4) or 235 & 235L (4)
- MTLS 327 (3), 351 (3)

- Approved Technical Electives (6)

Graduate Programs

Graduate students in the M.S. program, Ph.D. program, or accelerated B.S./M.S. program must take MTLS 592 each semester offered. The student may appeal to their advisory committee for possible exception.

The Materials Engineering Department administers both the Master of Science and the Master of Engineering degree for those students wishing to pursue an advanced degree in Materials Engineering. The Master of Science degree must be earned with a thesis. The Master of Engineering degree is a coursework-only option for students seeking a non-research-based advanced degree focused on satisfying the needs of practicing engineers. Students selecting the Master of Engineering option must complete two additional three credit elective course (total of 30 course credits vs. 24 course credits and 6 thesis credits for the Master of Science Option). Students must take MTLS 592 each semester offered (for a maximum of two times). Students may appeal to their advisory committee for possible exception.

In the case of the Master of Engineering, the student's degree program is directed by the departmental Master of Engineering Graduate Committee which sets detailed curriculum requirements. Additional classes for students with insufficient background in Materials Engineering may be required (there is the potential that these classes may not be eligible to satisfy the required 30 course credit hours and must be taken in addition to these classes)

Master of Science in Materials Engineering

The Master of Science Option prepares students for high quality research (and is often preferred for admission into PhD programs around the country). Full time graduate students must formalize an advisory committee that will consist of an academic advisor from the department and at least two additional members. The selection of an advisor must be completed by the end of the first semester while the remaining members of the committee along with thesis topic must be decided by the end of the second semester.

Department faculty must not be in the minority in the committee. Part time or DE students must formalize their advisor by the time they complete 12 credits. The student must meet with his or her committee at least once per year.

The Course Requirements include:

- At least 24 credit hours of course work that must include:
 - a minimum of 12 credit hours of 500 level courses, and
 - at least 6 hours of upper level (300+) courses outside the Materials Department, unless the student is from a non-Materials background in which case all courses may be from within the Materials Department No more than 3 hours of MTLS 581 Directed Study.

b) 6 credit hours of MTLS 591 (Thesis) that will be defended in a public oral defense. Students may take MTLS 500 (Directed Research) in multiple semesters but the credits may not count toward their degree requirements. Courses must be approved by the advisory committee, and the research should be directed toward a journal publication. Students must inform faculty advisors in advance regarding courses that they plan to take in the following semester. Students are required to write a thesis proposal and defend it in a public oral defense before the advisory committee at least one full semester (fall or spring) before the final defense. The final thesis must be successfully defended in a public oral defense before the advisory committee. Additional requirements for the MS degree include the New Mexico Tech General Graduate Program Requirements. Students must take MTLS 592 each semester offered (for a maximum of two times). Students may appeal to their advisory committee for possible exception.

Courses must be approved by the advisory committee, and the research should be directed toward a journal publication. Students must inform faculty advisors in advance regarding courses that they plan to take in the following semester.

Students are required to write a thesis proposal (or independent study proposal) and defend it in a public oral defense before the advisory committee at least one full semester (fall or spring) before the final defense.

The final thesis must be successfully defended in a public oral defense before the advisory committee.

Additional requirements for the MS degree include the New Mexico Tech General Graduate Program Requirements.

Master of Engineering in Materials Engineering

The Master of Engineering (ME) degree is a coursework-only option for students seeking a non-research-based advanced degree. The ME in Materials Engineering is professionally-oriented, focused on satisfying the needs of practicing engineers in a materials-related discipline. Degree requirements are set by the departmental Master of Engineering Graduate Committee.

The Course Requirements include:

- a. At least 30 credit hours of upper level coursework that must include: (i) a minimum of 12 credit hours of MTLS 500 level courses and (ii) the 6 credit hours of outside department coursework must be selected from EMGT 501, EMGT 502, EMGT 503, EMGT 504, EMGT 505, EMGT 506, EMGT 507, EMGT 508, EMGT 509, or EMGT 510. (iii) ME students with a BS in Materials Engineering may take an additional 6 credits of elective outside of the Materials Engineering department, for a minimum of 18 hours of MTLS coursework. ME students with a BS outside of Materials Engineering must complete 21 credit hours of MTLS coursework.
- b. Students may not use MTLS 581, Directed Study, to

satisfy the coursework requirements for a Master of Engineering degree. All coursework used towards the ME degree requirements must carry a letter grade.

- c. The student must work with his/her faculty advisor to form a course plan. Coursework to be applied towards the degree must be approved by the graduate student's advisor, chair, and the Dean of Graduate Studies
- d. Students enrolled in the Master of Engineering program are required to take two semesters of MTLS 592. MTLS 592 cannot be used towards the ME 30 credit coursework requirements.

If a student has completed their BS in Materials Engineering or affiliated field at New Mexico Tech and has at least a 3.0 GPA, the student can be accepted to the ME program without taking the GRE.

Accelerated Masters

Qualified undergraduate students may apply for admission to the Accelerated Masters program in Materials Engineering. In fulfillment of the requirements for both B.S and M.S. degrees, as outlined in their respective sections, accepted students may apply six credits of 500-level courses to both degrees.

Doctor of Philosophy in Materials Engineering

The prospective doctoral candidate should develop a good background in Materials sciences, chemistry, physics, and mathematics, in addition to achieving a high level of competence in a specialized area of Materials. Programs are arranged by the prospective student and the student's advisory committee.

The PhD requirements include the following:

1. Select an advisory committee that shall consist of a minimum of four members: (a) an academic advisor from the Materials department, (b) at least three other members out of which one must be from outside the department (not necessarily from a different field). The research advisor may be the academic advisor or other member of the committee. Materials faculty shall not be in the minority on the advisory committee. The student must select an academic advisor, who may serve as a temporary research advisor, before the second semester of study. The selection of the entire committee and dissertation topic must be completed by the end of the second semester of study for full-time in-house students, and immediately after completing 12 credit hours for DE students. The student must meet with his or her committee at least once per year, and must get courses approved by them.
2. Complete at least 24 credit hours of courses approved by the doctoral committee, including:
 - (i) at least 12 hours of 500 level courses. No more than 3 hours of MTLS 581 Directed Study may be used for fulfilling the course requirements. Students may take MTLS 500 (Directed Research) in multiple

semesters but the credits may not count towards their degree requirements.

- For students who have already received an MS degree from the Materials department, the total credit requirements for course work may be reduced below 24 credits with the approval of their committee, department chair, and the graduate dean.
3. Conduct a successful written and public oral critique of a paper published in a high quality professional journal. The paper choice shall be agreed on by the doctoral committee. The paper critique is the Materials Department's **Preliminary** (alternately called qualifying) examination. This is the first examination that a student has to pass. During the paper critique presentation, the student may be asked questions relating to background knowledge gained from taking regular coursework in Materials and related subjects. The paper critique must be completed within 18 months of enrolling into the PhD program.
 4. Write a research proposal and defend it in a public oral defense at least two full semesters before the final dissertation defense. This proposal defense is the Materials Department **Candidacy** exam, and should address the rationale for the research plan and preliminary work in progress. This examination can only be taken after a student has passed the preliminary examination.
 5. The admission to candidacy to the PhD degree requires that the preliminary and candidacy examinations be passed and approved by the advisory committee. Following this, the student must enroll in at least 24 credit hours of MTLS 595 Dissertation during which the student completes the research project approved by the advisory committee. The student cannot start taking MTLS 595 credits until both the preliminary exam (paper critique) and the candidacy exam (proposal defense) have been passed.
 6. A full-time graduate student must be enrolled in a minimum of 9 credit hours per regular semester and 6 credit hours during the summer.
 7. The student must submit at least one paper based on the dissertation to a recognized journal acceptable to the doctoral committee. A preprint must be submitted to the doctoral committee prior to defense of the PhD dissertation. It is preferable that this paper be accepted by the journal and a written copy of the acceptance or conditional acceptance with reviewer comments should be provided to the committee.
 8. The student must write the final dissertation and defend it in an oral public defense before the doctoral committee.

Additional requirements include the New Mexico Tech General Graduate Program Requirements.

Materials Engineering Courses:

MTLS 101L, Introductory Materials Engineering Laboratory, 1 cr, 3 lab hrs

Hands-on laboratory experience with some fundamental concepts in Materials engineering: classification of solids, gelation processes, particulate dispersions, nucleation and growth of crystals, phase diagrams, magnetic do-

main, (explosive) welding, and composite design. Course provides a glossary of terms and concepts used in the field of Materials science and engineering.

MTLS 202, Materials Engineering I, 3 cr, 3 cl hrs

Corequisite: CHEM 1225

The course is an introduction to the important concepts in materials science and engineering with a goal of building the foundations for all other courses related to materials. The course introduces the perspectives needed to think about materials in other areas of engineering and the physical sciences. The structure, properties, and processing of metals, ceramics, polymers, and composite materials are discussed. Topics covered include atomic bonding, crystal structures and symmetry, metal alloys, strength, microstructures, glasses, defects, diffusion, elasticity, fracture, and phase diagrams.

MTLS 202L Materials Engineering I Laboratory, 1 cr, 3 lab hrs

Corequisite: MTLS 202

Laboratory experiments addressing elementary design problems involving optimal use of Materials. Designed to reinforce principles discussed in MTLS 202.

MTLS 235 Materials Engineering II, 3 cr, 3 cl hrs

Prerequisites: CHEM 1225 and 1225L

Corequisite: Phys 1320 & 1320L

Survey of technologically important Materials including ceramics, glasses, semiconductors, polymers and composites. The objective is to understand the chemical composition, structure, processing and property relationships in material systems. The student will obtain a basic understanding of the principles of electronic transport, dielectric, thermal, optical and mechanical properties of engineered solids. Undergraduate students majoring in Materials Engineering must take MTLS 235L concurrently.

MTLS 235L Materials Engineering II Laboratory, 1 cr, 3 lab hrs

Prerequisites: CHEM 1225 and 1225L

Corequisites: MTLS 235

Laboratory experiments introducing the fabrication of technical Materials and the measurement of their properties. Designed to reinforce principles discussed in MTLS 235.

MTLS 301, Introduction to Ceramic Engineering, 3 cr, 3 cl hrs

Prerequisites: MATE or MTLS 235; or consent of instructor and advisor

Ceramic processing from raw Materials to finished products. Chemistry and structure of ceramic raw Materials. Ceramic powder preparation and characterization. Engineering ceramic suspensions. Microstructures of traditional (porcelain and glass) and advanced (modern structural and electrical) ceramics. Properties of ceramics, and their dependence on processing and microstructure.

MTLS 310 Processing and Microstructure Methods and Analysis 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: MATE or MTLs 202, MATE or MTLs 235; or consent of instructor and advisor

Emphasis on the relationship between processing and microstructure. Processing techniques used to form metals, ceramics, polymers, and composites will be studied such as extrusion, pressing, forging, rolling, casting, and joining. Elementary analysis techniques such as optical and electron microscopy will be used to illustrate the effect of processing on microstructure.

MTLS 311 Thermal and Mechanical Methods and Analysis 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: MATE or MTLs 202, 235; ES 302; or consent of instructor and advisor

Emphasis on the use of thermal and mechanical techniques to both influence and measure the properties of metals, polymers, ceramics, and composites. Thermal techniques such as DSC, DTA, TGA, TMA, and dilatometry will be described. Thermal processing and temperature measurement techniques will also be covered. Mechanical techniques such as viscometry, rheometry, strength/toughness testing, hardness testing, and fatigue will be covered. These thermal and mechanical techniques will be used to elucidate the relationship between properties and microstructure, relaxation mechanisms, lifetime predictions, phase transformations, chemical reactions, and synthesis.

MTLS 314, Transport Processes, 3 cr, 3 cl hrs

Prerequisites: MATH 1510, MATH 1520; PHYS 1310

Introduction to the concepts of fluid dynamics and mass and heat transfer.

MTLS 327 Introduction to Physical Metallurgy, 3 cr, 3 cl hrs

Prerequisite: MATE or MTLs 202

Mechanisms of deformation and fracture in metals. Binary phase diagrams. Phase transformations, age hardening, heat treatment of steels, TTT diagrams, CT diagrams, martensitic transformation, shape-memory effects. Common ferrous and non-ferrous alloys.

MTLS 350, Materials Thermodynamics, 3 cr, 3 cl hrs

Prerequisite: MATH 2532, CHEM 12155, PHYS 1310. (ES 347 is recommended.)

The mathematical structure of thermodynamics is developed and elucidated from a transport-process-based perspective. Basic quantities such as heat and temperature are carefully defined. The conserved nature of the First-Law and the non-conserved nature of the Second Law are emphasized. The consequences of the ensuing stability-conditions are explored in the area of phase equilibrium in multicomponent mixtures. **(Same as ChE 349)**

MTLS 351, Introduction to Polymeric Materials, 3 cr, 3 cl hrs

Prerequisites: (MATE or MTLs 202); or (MATE or MTLs 235); MATH 2532 or MATH 335

Basic concepts of polymer science; polymerization reactions and mechanisms, as well as kinetics involved; poly-

mer solutions, molecular-weight determinations, analysis and testing of polymers; structural properties of polymers; properties of commercial polymers; processing of polymers.

MTLS 402, Physical Ceramics, 3 cr, 3 cl hrs

Prerequisite: MATE or MTLs 301

Review of ceramic microstructures. Atomistic, microstructural, and thermodynamic origins of ceramic properties, with emphasis on the effects of atomic and structural defects and interpretation of phase diagrams.

MTLS 410 Microstructural Characterization Methods and Analysis 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: PHYS1320, MATE or MTLs 202, MATE or MTLs 235 or consent of instructor and advisor

Crystalline and non-crystalline Materials are characterized using various types of scattering, diffraction, absorption and microscopy techniques. Methodologies such as x-ray diffraction, electron diffraction and microscopy are introduced for analyzing crystallographic and other structural properties of metals, ceramics, polymers and composites.

MTLS 420 Biomedical Materials, 3 cr, 3 cl hrs

Prerequisite: (MATE or MTLs 202) or (MATE or MTLs 235) or consent of instructor and advisor

This course covers the application of Materials in medical devices. Mechanical properties of hard and soft tissues are reviewed. Applications of biomaterials in orthopedics are discussed with emphasis on problems of material-tissue interactions. Other biomedical Materials are covered with applications in skin transplants, eye surgery, pacemakers, tissue engineering, and neural prostheses. Host responses are surveyed including adaptation, inflammation, coagulation, foreign body effects, and changes in tissue and organ functions. Methods for biological and clinical testing are highlighted. Regulatory, ethical and business issues are discussed. Shares lecture with MTLs 520 with additional expectations for graduate credit.

MTLS 435, Mechanical Behavior of Materials, 3 cr, 3 cl hrs

Prerequisite: (MATE or MTLs 202) or consent of instructor and advisor

Elasticity and plasticity; flow criteria. Strengthening mechanisms. Deformation processes. Mechanical testing of Materials: tensile, hardness, fatigue, fracture, formability.

MTLS 441, 441L, X-Ray Diffraction, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: PHYS 1320, (MATE or MTLs 202) or (MATE or MTLs 235)

Properties and generation of X-rays, X-ray diffraction phenomena. Single-crystal and powder techniques for study of structure of metals and alloys, imperfections, stress, and strain.

MTLS 443, Magnetic Materials, 3 cr, 3 cl hrs

Prerequisite: (MATE or MTLs 235) or consent of instructor and advisor

The origin of magnetism, theory of magnetism, comparison of diamagnetic, paramagnetic, ferromagnetic, and ferromagnetic solids. Magnetic measurements, magnetic characterization techniques, domain theory and hysteresis. Structure-processing-property relationships in magnetic Materials. Applications of “hard” and “soft” magnetic Materials.

MTLS 445, 445D, Introduction to Composite Materials, 3 cr, 3 cl hrs

Prerequisites: ES 302 or consent of instructor and advisor

Reinforcement Materials, glass, Kevlar, polyethylene, carbon, boron, silicon carbide, alumina, metallic fibers. Interface between the matrix and fiber. Polymer matrix, metal matrix, and ceramic matrix composites. Mechanism of fiber strengthening. Micromechanics and macromechanics of composite Materials, their strength and fracture behavior.

MTLS 446, 446D, Survey of Computational Methods in Materials Science, 3 cr, 3 cl hrs

Prerequisite: MATH 2532

Computers have become a common tool in the effort to bridge the gap between atomic and macroscopic Materials properties. Examples selected from the literature are used to introduce the student to the principal techniques employed in the field. Topics covered include: polymers, metals, ceramics, magnetic Materials, water, phase equilibrium, protein folding, self-assembled monolayers, gelation, the glass transition, rheology, and dielectric relaxation.

MTLS 447, Optical Materials, 3 cr, 3 cl hrs

Prerequisite: (MATE or MTLS 235) or consent of instructor and advisor

Review of optical phenomena: reflection, transmission, absorption, color, polarization, refraction and birefringence, and their origin in Materials. Structure-processing-property relationships in optical Materials including crystals, glasses, and thin films. Applications including mirrors, filters, lenses, lasers, electro-optics, detectors and fiber optics.

MTLS 452, 452D, Solid State Physics for Engineers, 3 cr, 3 cl hrs

Prerequisite: Senior standing or consent of instructor and advisor

Discussion of physical properties of metals, semiconductors, and dielectrics from the viewpoint of solid-state theory. Electron dynamics, electronic transport, interaction of electromagnetic waves with solids, wave mechanics, quantum mechanics, free electron theory, band theory of solids. Application of semiconductor and quantum physics to modern electronic and optoelectronic devices.

MTLS 452L, Electronic Materials Laboratory, 1 cr, 3 lab hrs

Prerequisites: (MATE or MTLS 235, 235L), or consent of instructor and advisor

Use of electronic measurement equipment to characterize the behavior of common circuit components: resistors, capacitors, inductors, temperature- and voltage-

dependent resistors, diodes. Interpretation of electronic properties of Materials.

MTLS 474, Polymer Processing and Characterization, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: Consent of instructor

The basics of rheology, calorimetry and mechanical testing are covered. A specific polymer is used (e.g., an epoxy) throughout the course and the processing of this polymer is covered. Students are expected to acquire a working knowledge of the instrumentation and analysis tools used in the course. These include rheometers, calorimeters, and mechanical testing. The primary analysis tool is Kaleidagraph software.

MTLS 479, Transmission Electron Microscopy, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: MATE or MTLS 441, MATE or MTLS 410, or consent of instructor and advisor

Electron optics, design and operation of TEM; specimen preparation; electron diffraction and interpretation of diffraction patterns; imaging, dynamical theory; image interpretation for perfect crystals, crystal defects, interfaces and precipitates. Use of a TEM.

MTLS 481, 481L, Engineering Design I, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: Senior Standing, MATE or MTLS 301, MATE or MTLS 351, MATE or MTLS 327, MATE or MTLS 310, MATE or MTLS 311 (BIOL 2110/2110L may substitute for MTLS 310 or 311 for students pursuing the BioMaterials Engineering Option)

Student design teams begin a year-long capstone design project. The teams will identify project needs, establish goals, determine design requirements, produce alternate solutions, and perform detailed planning. Project initiation, periodic design reports and design reviews. Students, faculty, and distinguished visitors discuss subjects of current and/or long-range interest in various fields of Materials. Undergraduate students majoring in Materials Engineering are required to take MTL 481 and MTL 481L concurrently.

MTLS 482, 482L, Engineering Design II, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: MATE or MTL 481, MTL 481L

Continuation of the design projects initiated in MTL 481. The student design teams bring the projects to a successful conclusion. Economic analysis and detailed cost evaluation, use of engineering statistics in data analysis and design of experiments, preparation and presentation of final project report. Undergraduate students majoring in Materials Engineering are required to take MTL 482 and MTL 482L concurrently.

MTLS 483, 483L, Scanning Electron Microscopy, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: PHYS 1225 or consent of instructor and advisor

Fundamental theory and experimental techniques in scanning electron microscopy. Electron optics, electron beam interactions with solids, signal detection and processing. Chemical X-ray microanalysis. Undergraduate

students majoring in Materials Engineering are required to take MTLs 483 and MTLs 483L concurrently.

MTLS 491, Directed Study/Senior Thesis, 3 cr

Prerequisite: Senior standing or consent of instructor and advisor

MTLS 500, Directed Research, cr to be arranged

Prerequisite: Graduate standing

This course may not be used to fulfill graduate degree requirements.

MTLS 501, Foundations of Materials, 3cr

Prerequisite: Graduate standing

This course is designed for the Materials graduate students with undergraduate degrees from other disciplines. Fundamental elements of metals, ceramics, polymers and composites will be covered.

MTLS 502, Physical Ceramics, 3 cr, 3 cl hrs

Prerequisite: MATE or MTLs 301

Review of ceramic microstructures. Atomistic, microstructural, and thermodynamic origins of ceramic properties, with emphasis on the effects of atomic and structural defects and interpretation of phase diagrams. Shares lectures with MTLs 402, but is graded separately, and additional work is required at the graduate level.

MTLS 503, 503D, Crystal Chemistry and Crystal Physics, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Classification of elements and ions. Bonding and rules for building of structures in solids. Systematic review of the basic crystal structures of inorganic solids and their relationship with observed macroscopic properties. Introduction to crystal physics, relating measurable quantities to crystal symmetry.

MTLS 505, 505D, Electronic Materials, 3 cr, 3 cl hrs

Prerequisite: MATE or MTLs 235 and graduate standing; or consent of instructor and advisor

Review of electronic, atomic, and defect structures which govern electrical behavior of ceramics and metals. Bulk and printed (thick film) electronic sensors and components. Superionic conductors used in solid electrolyte batteries, and developments in new high-temperature superconducting ceramics. Polarization mechanisms and relaxation phenomena in dielectrics, with discussion of low-permittivity and microwave dielectrics.

MTLS 509, 509D, Statistical Mechanics of Simple Materials, 3 cr, 3 cl hrs

Prerequisite: (MATE or MTLs 350) or ChE 349 or Graduate Standing or consent of instructor and advisor

After a brief review of thermodynamics, the basics of Statistical Mechanics are presented and applied to a number of cases of interest. These include solid state heat capacity, the adsorption of gases on surfaces, Bose-Einstein statistics, blackbody radiation, magnetism, superfluidity, Fermi-Dirac statistics, the electron gas, theories of phase transitions, and the Monte Carlo method.

MTLS 512, 512D, Electronic Thin Films: Science and Technology, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Discussion of thin-film deposition techniques (evaporation, sputtering, molecular beam epitaxy, liquid-phase epitaxy, and chemical vapor deposition), and their applications and limitations. Thin-film growth mechanism. Stress and interdiffusion in thin films. Electrical and optical properties of thin films, heterostructures, quantum wells, and superlattices.

MTLS 514, 514D, Liquid State Theory, 3 cr, 3 cl hrs

Prerequisite: MATE or MTLs 509, Graduate Standing or consent of instructor and advisor

An introduction to the study of many-particle systems and to the techniques of computer simulation. The statistical mechanics of simple liquids and their mixtures, with particular emphasis on the atomic origin of the structure factor and the relationships between atomic-level structure and macroscopic, thermodynamic properties.

MTLS 515, Glasses and Other Complex Fluids, 3 cr, 3 cl hrs

Prerequisite: MATE or MTLs 351 or consent of instructor and advisor

Complex fluids span the range between the traditional Newtonian fluid (where shear stress is proportional to strain rate) and linear response solids (where shear stress is proportional to strain). In all cases, non-trivial relaxation mechanisms introduce a range of relaxation times and extreme temperature sensitivity in the a Materials' properties. Glasses are the most dramatic examples of this class of Materials although all polymeric Materials show complex behavior under temperature and time scales in typical applications. This course introduces the techniques used to quantify the thermal and temporal response of common complex fluids focusing primarily on rheometry and calorimetry. In addition, theories linking evolving microstructures are employed to explain the observed macroscopic responses.

MTLS 516, Biomimetic Materials, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

An overview of the field of biomimetics: the achievement of unusual Materials properties or processes by mimicry of various aspects of biological systems. Mimicry of natural structural design; biomimetic Materials processing; "artificial photosynthesis"; biomolecular electronics; and biomimetic catalysis. Interdisciplinary studies.

MTLS 520 Biomedical Materials, 3 cr, 3 cl hrs

Prerequisite: (MATE or MTLs 202) or (MATE or MTLs 235) or consent of instructor and advisor

This course covers the application of Materials in medical devices. Mechanical properties of hard and soft tissues are reviewed. Applications of bioMaterials in or-

thopedics are discussed with emphasis on problems of material-tissue interactions. Other biomedical Materials are covered with applications in skin transplants, eye surgery, pacemakers, tissue engineering, and neural prostheses. Host responses are surveyed including adaptation, inflammation, coagulation, foreign body effects, and changes in tissue and organ functions. Methods for biological and clinical testing are highlighted. Regulatory, ethical and business issues are discussed. Shares lecture with MTLs 420 with additional expectations for graduate credit.

MTLS 530, 530D, Design and Analysis of Experiments, 3 cr, 3 cl hrs

Methods of statistics and modeling important to many problems in Materials science and engineering including Six Sigma. Examples are chosen from a number of actual experiences. Safety considerations and experiment design including analysis of risk, how risks may be integrated, and how formal procedures should be established. The use of information sources, such as Materials safety data sheets (MSDS). Shares lectures with MTLs 430, but is graded separately, and additional work is required at the graduate level.

MTLS 531, 531D, Fundamentals in Manufacturing Processes of Materials, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Introduction to Materials design; flow theories and work of deformation, microstructure-property relationships for different Materials; fracture; casting and heat-flow/mass-transfer issues; bulk deformation processing with applications to rolling and extrusion; powder metallurgy and sintering of metal and ceramic powders.

MTLS 534, 534D, Phase Equilibria in Materials Systems, 3 cr, 3 cl hrs

Prerequisites: MTLs 350 and (METE or MTLs 327), or consent of instructor and advisor

The theoretical and practical aspects of phase equilibria of metal and ceramic multicomponent systems will be examined in detail. The thermodynamics and experimental methods of determining phase equilibria of these systems will be studied. Particular emphasis to Gibbs phase rule, the construction and interpretation of phase diagrams, and the importance of nonequilibrium in metals and ceramics will be investigated. Thermodynamic calculations related to phase stability and phase diagram prediction will be performed using the modeling software, Thermo-Calc.

MTLS 535, 535D – Metallurgical Phase Transformations, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in Materials Engineering, or consent of instructor

Thermodynamic considerations, phase diagrams, and atomic diffusion are reviewed. Principles of crystal interfaces and microstructure are studied, including grain boundaries, interfaces, influence of interfaces and strain energy on microstructure and kinetics. Solidification of single-component and multicomponent systems is discussed with applications to ingots, castings, and

welding. Diffusional and diffusionless phase transformations in metals and their alloys are discussed. Knowledge of the core thermodynamic concepts underlying materials behavior, as well as the structure of various engineering materials is required.

MTLS 536, 536D – Materials Applications of Density Functional Theory, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor

The course is an introduction to materials modeling using the quantum theory of materials and first-principles computational techniques. Specifically, the use of density functional theory will be explored to solve an approximated version of the Schrodinger equation in order to obtain materials properties of metals and their alloys. The course will explore theoretical aspects of density functional theory including the clamped nuclei approximation, the exclusion principles, and the mean-field approximation. The Hartree-Fock and Kohn-Sham equations are studied. All course material will be strongly coupled to hands-on computations using Vienna ab-initio Simulation Package.

MTLS 540, 540D, Electrochemical Techniques & Process, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor and advisor

This course is an overview of the growing field of electrochemistry, and the many electrochemical techniques and processes. The lectures and assignments will review the theory and the science of batteries, electroplating, fuel cells, electrocatalysis, electro-refining, corrosion, bioelectrochemistry, and organic electrosynthesis. In addition to the applications, the electrochemical techniques will also be introduced, including open circuit potentials, linear polarization, potentiodynamic polarization, cyclic voltammetry, zeta potentials, electrochemical impedance spectroscopy, and photoelectrochemistry.

MTLS 541, Advanced Physical Metallurgy, 3 cr, 3 cl hrs

Prerequisites: METE 327 or MTLs 327; or consent of the instructor

Application of thermodynamic principles to formation and stability of alloy systems. Recrystallization. Precipitation hardening. Physical metallurgy of steels, aluminum, rapidly solidified alloys, and quasi-crystals.

MTLS 542, Solid State Diffusion, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor and advisor

Fundamentals of diffusion will be studied including solutions to the diffusion equation, random walk theory, correlation effects, and diffusion mechanism. Experimental methods related to diffusion phenomena will be explored. Diffusion phenomena in metals, ionic crystals, semiconductors, and non-MTLs will be discussed with relation to thermodynamic, point-defect and defect reactions, and impurity effects.

MTLS 543, 543D, Advanced Mechanical Metallurgy, 3 cr, 3 cl hrs

Prerequisites: MATE or MTLS 435

Theory of elasticity/plasticity; dislocation theory; strengthening mechanisms; tensile testing; fracture and related failure phenomena; principal features of fatigue and creep; metalworking; related strain state- strain rate phenomena, including shock deformation and high energy rate forming.

MTLS 545, Micromechanics of Fracture, 3 cr, 3 cl hrs

Prerequisite: MATE or MTLS 435 or equivalent or consent of instructor and advisor

Analysis of criteria for crack initiation and propagation leading to structural failure; study of fracture mechanics starting with Griffith theory for ideally brittle Materials through plane strain and ultimately elastic- plastic toughness phenomena. Effects of geometry, rate, environment, and microstructure will be considered as related to micromechanisms of fracture (cleavage, ductile fracture, fatigue, stress corrosion cracking).

MTLS 550, 550D, Microstructure and Properties of Steels, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in Materials Engineering, or consent of instructor

The microstructure and mechanical properties of steels are covered in the course. Topics include the iron-carbon phase diagram, allotriomorphic transformation from austenite to ferrite, Widmanstätten ferrite, pearlite, kinetics of transformations and mechanisms that influence the microstructure and properties, effects of substitutional solutes on phase transformation and kinetics, crystallography of martensite, nucleation and growth of martensite and influence on mechanical properties, bainitic transformation and microstructure, thermomechanical treatment of steels, micro-alloyed steels, stainless steels, fracture and embrittlement.

MTLS 560, 560D, Failure Analysis, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Failure analysis is the science of unraveling why a product failed unexpectedly. The results of the failure analysis may be used to design a better product, or as evidence in litigation. This course will cover the proper methodology for investigating a failure, the common failure modes of structures and machines, fractography, the procedure for writing a failure analysis report, and the legal implications.

MTLS 564, 564D, Nano-Optics, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Review of Nano-Optics—an emerging field, rapidly developing as a part of nanoscience and nanotechnology requiring tools and techniques for fabrication, manipulation and characterization at nanoscale. The class covers theoretical foundations on propagation and focusing of optical fields; methods of nanoscale optical microscopy: near-field optical probes and nanoscale distance control; features of optical interaction in na-

noscale environments. Modern applications of nano-optics including quantum emitters, photonic crystals and resonators, surface plasmons structures and devices, will be discussed in the frames of this class.

MTLS 565, 565D, Catalyst Characterization Techniques, 3 cr, 3 cl hrs

Prerequisite: ChE 349/MATE or MTLS 350 and/or CHEM 331/332 or consent of instructor and advisor

The course provides an overview of techniques used to characterize catalytic Materials including data analysis and linking physical and chemical properties to catalytic activity at the laboratory and process level. Topics include x-ray methods, neutron scattering methods, physical adsorption, chemical adsorption, temperature programmed techniques, photoelectron spectroscopy, vibrational spectroscopy, and electron microscopy. A research project is required.

MTLS 566, Interfacial Phenomena, 3 cr, 3 cl hrs

Thermodynamics of interfaces (liquid/liquid, liquid/vapor, liquid/solid, solid/solid, solid/vapor); interfacial equilibria; interfacial free energy (surface tension measurements in liquids; specific surface free energy in solid systems); structure of solid surfaces and interfaces; properties of interfaces.

MTLS 570, 570D, Corrosion Phenomena, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing or consent of instructor and advisor

Theory of aqueous corrosion (thermodynamics and kinetics); forms of corrosion; corrosion testing and evaluation; designing to minimize corrosion; methods of corrosion prevention; corrosion in specific systems; case studies.

MTLS 572, 572D, Advanced Transport Phenomena, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Advanced topics in momentum, heat, and mass transfer. Newtonian and non-Newtonian fluid behavior and laminar flow problems, elementary turbulent flow concepts, energy balance applications in incompressible fluid flow, flow and vacuum production. Fourier's law and thermal conductivity of Materials, steady state and time dependent heat conduction, application in solidification, elementary convective heat transfer. Diffusivity of Materials, diffusion of gases, liquids and solids and through porous media, time dependent diffusion, and interphase mass transfer.

MTLS 575, 575D, Introduction to Nano Materials, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

An introduction to physical basics of nanosystems, physics and chemistry of nanostructure synthesis and fabrication. Other topics include: semiconductor nanostructures, magnetic nanostructures and spintronics, molecular nanostructures, electron transport in nanosystems, optical effects in nanosystems, na-

nomachines, nanoscale biological assemblies, nanocomposite Materials.

MTLS 576, Drug Delivery Techniques, 3 cr, 3 cl hrs

Prerequisite: Senior or graduate standing or consent of instructor and advisor

Focus is on current developments in drug delivery techniques, with only a brief discussion of common clinical techniques. The first portion of the class focuses on various delivery mechanisms and the tools needed to validate successful targeted drug delivery (both in vitro, in vivo and diagnostic tools). The second part of the course focuses on current developments in drug delivery based on published research articles. Students will read, digest, and critically analyze scientific work from leading research laboratories. Students will also gain valuable communication tools, as each student will present an article of interest to the class. Finally, the third part of the course focuses on important Materials characterization methods such as biological sample prep, SEM, TEM, DSC, Flow Cytometry, Fluorescence Microscopy, ELISA Assays. Same as BIOT 576. Shares lecture with ChE 476, with additional expectations for graduate credit

MTLS 580, Dislocation Theory, 3 cr, 3 cl hrs

Prerequisite: Graduate standing in Materials Engineering or consent of instructor and advisor

Dislocations in isotropic continua; effects of dislocations on crystal structure; point defects and physical properties; point defects and mechanical properties; dislocation-point-defect interactions and groups of dislocations; dislocation interactions.

MTLS 581, 581D, Directed Study, cr to be arranged

Study under the guidance of a member of the department. In general, subject matter will supplement that available in the other graduate course offerings in metallurgy or Materials engineering.

MTLS 590, Independent Study, cr to be arranged

The student must clearly demonstrate the ability to organize and pursue research. A written final report and public oral presentation is required.

MTLS 591, Thesis (master's program), cr to be arranged

MTLS 592, 592D, Materials Engineering Graduate Seminar, 1 cr, 1 cl hrs

Must be taken S/U

Prerequisite: Graduate standing or consent of instructor and advisor

Seminar presentations by students, faculty and outside speakers. Discussion of topics of technical interest in Materials science and engineering and related fields.

MTLS 595, Dissertation (doctoral degree program), cr to be arranged

Prerequisite: Successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.

MTLS 599, 599D, Special Topics, cr to be arranged

Lectures in new or advanced areas of Materials.

Faculty Research Interests

- T.D. Burleigh—Corrosion Mechanisms, Alloy Design, Coatings for Corrosion Prevention and Electrochemical Processes
- D. Choudhuri—Solid State Phase Transformations, Dislocation Plasticity, Atomistic Simulations, Phase-Field modeling, Computational method development, Solidification, Magnesium, Aluminum, Titanium and High entropy alloys
- P. Fuierer—Electronic/Functional Ceramics, Ionic Conductors for Fuel Cells and Sensors, Photovoltaics, Grain-Oriented Ceramics, and Aerosol Deposition of Ceramic Thick Films
- C. Z. Hargather—density functional theory, calculation of phase diagrams (CALPHAD), diffusion coefficients, thermodynamics, creep in high-entropy alloys, additive manufacturing of energetics, rocket propellants
- N. Kalugin -Optoelectronics and Nonlinear Optics, Nanostructures and Nanotechnology, TeraHz Lasers and Photodetectors, Solid State Physics of Nanostructures, and Semiconductor Materials and Devices
- B. Majumdar— Structure□Property Relations in Materials, Processing of Metals and Composites, SMAs, Fatigue, Creep, Fracture
- J. McCoy— Glass Transition, Epoxies, Rheology, Thin Films, Mechanical and Thermal properties of Polymers
- P. Choudhury—Computational Modeling of Materials for the Energy and Environment; Specific Research Areas include Surface Engineering, Catalysis, Gas Sensors, Proton Transport Membranes, Sorbent Materials and CO₂ Reduction
- S. Chowdhury—Plasmonic nanoMaterials, Nanoparticle□Bioparticle Interactions, Single Molecule Microscopy, Proton Transport Membranes, Plasmon Enhanced Photocatalysis
- C. Leclerc—Catalysis, Reactor Design, Alternative Fuels, Biofineries, Hydrogen Production
- Y. Lee—Functional Polymeric Materials, Organic Solar Cells, Polymeric Dielectric Materials, Scalable Processing
- M. Tartis—Biomedical Engineering, Targeted Drug Delivery

Mechanical Engineering

Professors : Bakhtiyarov, Ford, Zagrai

Associate Professors : Ghosh, Hargather, Kimberley, Lim (Chair of the Department), Ryu, Wei

Assistant Professors: Lee, O'Malley, Ebrahimkhanlou, Hasanalian

Adjunct Faculty: Anderson, Dinwiddie, Grow, Romero, Ruff, Stofleth, Westpfahl

Emeritus Faculty: Gerity, Ostergren

Degrees Offered: B.S. in Mechanical Engineering; M.E. in Mechanical Engineering; M.S. in Mechanical Engineering; PhD in Mechanical Engineering with Dissertation in Intelligent Energetic Systems

The Department of Mechanical Engineering at New Mexico Tech administers the following programs:

- Bachelor of Science in Mechanical Engineering
- Master of Engineering in Mechanical Engineering
 - Specialization in Explosives Engineering
 - Specialization in Fluid and Thermal Sciences
 - Specialization in Mechatronics and Robotics
 - Specialization in Solid Mechanics
- Master of Science in Mechanical Engineering
 - Specialization in Explosives Engineering
 - Specialization in Fluid and Thermal Sciences
 - Specialization in Mechatronics Systems and Robotics
 - Specialization in Solid Mechanics
- Doctor Philosophy in Mechanical Engineering
 - Dissertation in Intelligent Energetic Systems

Program Educational Objectives

The Department of Mechanical Engineering at New Mexico Tech will produce Bachelor of Science graduates who are independent thinkers, taking ownership in identifying problems and determining effective solution strategies in a timely manner.

Following working experience after graduation, they will:

1. Be employed successfully in government laboratories, graduate schools, industry, or other areas of the profession.
2. Have an understanding of the importance of life-long learning such that they seek personal and professional growth.
3. Have achieved a noteworthy level of workplace responsibility.

Student Outcomes for Undergraduate Program in Mechanical Engineering

Graduates of the Bachelor of Science in Mechanical Engineering program will have demonstrated

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences

4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Undergraduate Programs

Bachelor of Science in Mechanical Engineering

Mechanical engineering is considered to be one of the cornerstone engineering disciplines and is perhaps the broadest of all engineering disciplines. Mechanical engineers are found in every sector of our technology-based economy. Mechanical engineers find careers in (to name just a few): electric power generation and distribution; petroleum exploration, production and refining; automotive, truck and bus manufacturing; light and heavy rail transportation and manufacturing; agricultural equipment manufacturing; commercial and industrial construction industries; aeronautical design and manufacturing; national defense & energy industries; semiconductor manufacturing; biomedical technology; petrochemical process industries; basic Materials extraction and refining industries.

The undergraduate mechanical engineering program is very broad in its scope, yet it contains sufficient depth to ensure competency in the discipline. Mechanical engineering students must take a heavy load of science and mathematics as prerequisites for their engineering science courses.

Mechanical engineers in industry must be able to interact with many engineering disciplines, so they are required to take courses in other engineering disciplines. Also, because mechanical engineers design and manufacture components and systems, they are required to take courses that emphasize the engineering design/definition process. The mechanical engineering graduate engineer should be well equipped to undertake a professional engineering career in any technology that he or she chooses.

The mechanical engineering program at New Mexico Tech offers the students hands-on laboratory experience in fluid and thermal sciences, mechanics of Materials, vibrations, mechatronics, dynamic systems and controls, instrumentation, and measurement. Junior and senior mechanical engineering students work on design projects for two years that range from building an off-road vehicle for the Baja SAE® competition to aerospace aircraft design to designing and launching a rocket in the Spaceport American Cup Challenge. Included in the range of design projects are those sponsored by national laboratories and industry.

Minimum credit hours required—135

In addition to the General Education and Institute Core Curriculum (page 78 with MENG 341 substituted for ENGL 341),

the following courses are required:

- ES 201 (3), 216 (3)*, 302 (3), 303 (3), 316 (3), 332 (3), 347 (3), 350 (3)
- MENG 110 (2), MENG 110L (1), MENG 210 (3), MENG 302L (1), 304 (3), 305 (3), 341(3), 381 (2), 382 (2), 405 (2), 405L (1), 421 (2), 421L (1), 431 (2), 431L (1), 441 (3), 451 (3), 481 (3), 482 (3), 483 (2) & 483L (1)
- MTLs 202 & 202L (4)
- MATH 2532 (4), MATH 335 (3) , MATH 337 (3)
- Technical Electives: Three hours from upper-division (300, 400, or 500 level) technical courses chosen by the student with the faculty advisor's approval. Recommendations include classes from AE, EXPL, MENG, or other engineering or science disciplines.

Credit for MATH 1240, pre-calculus, and MATH 1230, trigonometry, is not allowed for mechanical engineering students.

Courses used for the degree, including the General Education Core Curriculum, may not be taken on an S/U basis except for two courses in Humanities and/or Social Science.

Mechanical engineering majors must take the Fundamentals in Engineering (FE) exam as a requirement for graduation. Passing this exam is a major step in the process of attaining professional registration. It is **strongly** recommended that the exam be taken in semester 7, before the graduation semester (semester 8).

It is strongly recommended that all Mechanical Engineering students follow the sample curriculum.

Sample Curriculum for the Bachelor of Science in Mechanical Engineering

Semester 1

- 3 ENGL 1110 (college English)
- 4 MATH 1510 (calculus)
- 4 CHEM 12155 & 1215L (general)
- 3 MENG110 & 110L (intro.)
- 3 Social Science
- 17 Total credit hours

Semester 2

- 3 ENGL 1120(college English)
- 4 MATH 1520(calculus)
- 5 PHYS 1310 & 1310L (general)
- 3 CHEM 1225 & 1225L (general)
- 16 Total credit hours

Semester 3

- 3 Humanities
- 4 MATH 2532 (calculus)
- 3 MENG 210 & 210L (soph design)
- 3 ES 201 (statics)
- 4 MTLs 202 & 202L (intro to Materials)
- 17 Total credit hours

Semester 4

- 3 MATH 335 (ordinary differential equations)
- 5 PHYS 1320 & 1320L (general)
- 3 ES 316 (engineering economics)
- 3 MENG 216/ES 216 (fluid mechanics)
- 3 ES 302 (mechanics of Materials)
- 1 MENG 302L (mechanics of Materials lab)
- 18 Total credit hours

Semester 5

- 3 MENG 305 (engineering analysis)
- 3 ES 303 (dynamics)
- 3 MENG 304 (advanced strength of Materials)
- 3 ES 347 (thermodynamics)
- 2 MENG 381 (junior design)
- 3 MENG 341 (mechanical engineering tech writing)
- 17 Total credit hours

Semester 6

- 3 ES 332 (electrical circuits)
- 3 MATH 337 (engineering math)
- 2 MENG 382 (junior design)
- 3 ES 350 (heat & mass transfer)
- 3 Humanities/Social Science
- 3 Social Science
- 17 Total credit hours

Semester 7 (Take FE exam)

- 3 MENG 405 & 405L (dynamic systems & controls)
- 3 MENG 451 (machine design)
- 3 MENG 481 (senior design)
- 3 MENG 441 (dynamics & vibration)
- 3 MENG 421 & 421L (finite element analysis)
- 3 Humanities/Fine & Creative Arts
- 18 Total credit hours

Semester 8

- 3 MENG 431 & 431L (fluid/thermal systems)
- 3 MENG 483 & 483L (mechatronics)
- 3 MENG 482 (senior design)
- 3 Technical Elective
- 3 Humanities/Social Science
- 15 Total credit hours

Minor in Mechanical Engineering

Minimum credit hours required – 18

The following courses are required:

At least eighteen (18) credit hours of ES or MENG courses and/or labs beyond those required for major. These courses and labs are subject to the approval of the Mechanical Engineering Minor Advisor.

Minor in Aerospace Engineering

Minimum credit hours required – 18

The following courses are required:

- AE 311, Aerodynamics I, 3 cr, 3 cl hrs
- AE 412, Aerospace Systems, 3 cr, 3 cl hrs
- Additional twelve (12) credit hours of AE courses. Aerospace-related graduate level (500) MENG courses may also be used with approval of the Aerospace Engineering

Minor Advisor.

Minor in Biomedical Engineering

Minimum credit hours required – 19

The following courses are required:

- BIOL 2110, 2110L, General Biology, 4 cr, 3 cl hrs, 2 lab hrs
- BIOL 331, Cell Biology, 3 cr, 3 cl hrs
- BIOL 351, Physiology I, 3 cr, 3 cl hrs
- BIOL 352, Physiology II, 3 cr, 3 cl hrs

Two courses from:

- MTL5 351, Introduction to Polymeric Materials, 3 cr, 3 cl hrs
- MENG 460, Introduction to Biomedical Engineering, 3 cr, 3 cl hrs
- MENG 465, Biorheology, 3 cr, 2 cl hrs, 3 lab hrs
- MTL5 516, Biomimetic Materials, 3 cr, 3 cl hrs
- CHE 473, Polymer Materials Engineering, 3 cr, 3 cl hrs
- MENG 576, Biomedical Mechatronics, 3 cr, 3 cl hrs
- MENG 486, Special Topics in Biomedical Engineering, 3 cr, 3 cl hrs

Senior Design Project:

Students, who are interested in a minor in Biomedical Engineering, will do their Junior/Senior Design Project in the Biomedical Engineering field. This is an opportunity for them to implement their learning in the mechanical engineering and life sciences fields to tackle a particular problem in the biomedical engineering field.

Minor in Explosives Engineering

Minimum credit hours required – 18

The following courses are required:

- EXPL 445/MENG 545, Introduction to Explosives Engineering, 3 cr, 3 cl hrs
- EXPL 449/MENG 549, Wave Propagation, 3 cr, 3 cl hrs
- One course from (ES fundamentals):
- MENG 216 (or ES 216) Engineering Fluid Mechanics, 3 cr, 3 cl hrs
- ES 302 Mechanics of Materials, 3 cr, 3 cl hrs
- ES 347 Thermodynamics, 3 cr, 3 cl hrs

Additional 9 credits hours from EXPL courses.

Explosives-related graduate level (500) MENG courses may be used with the approval of the Explosive Engineering Minor Advisor.

Graduate Program

Graduate Certificate in Explosive Engineering

The Graduate Certificate in Explosives Engineering provides formal coursework in the highly-specialized field of explosives engineering to post-baccalaureate professionals/graduate students who do not wish to pursue a graduate degree. The program is targeted at scientists and engineers that hold at least a BS degree in mechanical engineering or related field. The 12

credit hours of coursework cover fundamental aspects of explosives and wave propagation, and also allow flexibility to pursue topics of individual interest.

The requirement for the Graduate Certificate in Explosive Engineering,

1. MENG 545 Introduction to Explosive Engineering
2. MENG 549 Wave Propagation
3. 6 credit hours from the ImpactDynamics
 - MENG 513 ImpactDynamics
 - MENG 546 Denotation Theory
 - MENG 547 Pyrotechnics Theory and Application
 - MENG 550 Advanced Explosive Engineering
 - MENG 552 Explosive Technology and Applications
 - MENG 553 Computer Modeling of Denotations
 - MENG 555 Shock Propagation in Air
 - MENG 556 Compressible Fluid Flow.

Department Requirements for the Master of Science and Master of Engineering degrees in Mechanical Engineering

The Mechanical Engineering Department offers each of the Master degrees either as a general Mechanical Engineering degree or with one of four specializations. The four areas of specialization for the masters degrees, are listed below with the core classes for each specialization.

- *General Mechanical Engineering Degree*
12 core class credits are to be taken as any graduate level MENG courses which are approved by the advisory committee.
- *Specialization in Explosives Engineering*
Core Classes: MENG 545, Introduction to Explosives Engineering; MENG 546, Detonation Theory, MENG 549, Wave Propagation; MENG 550, Advanced Explosives Engineering; MENG 556 Compressible Fluid Flow; MENG 513, Impact Dynamics. (Note: Students who have completed the minor in explosives engineering program cannot re-use the classes (including co-listed classes) used for the minor program toward a master's degree in explosives engineering.)
- *Specialization in Fluid and Thermal Sciences*
Core Classes: MENG 556, Compressible Fluid Flow; MENG 575, Advanced Engineering Mathematics; MENG 577, Advanced Fluid Mechanics; MENG 578, Advanced Thermodynamics; MENG 579, Advanced Heat Transfer; MENG 580, Computational Fluid Dynamics and Reactive Flow.
- *Specialization in Mechatronics Systems and Robotics*
Core Classes: MENG 541, Vibrations in Elastic Continuum; MENG 544/EE 544, Modern Control Theory; MENG 548/EE 548, Manipulator Based Robotics; MENG 551, Optimal Control; MENG 572, Sensor Technology; MENG 575, Advanced Engineering Mathematics; MENG 576, Biomedical Mechatronics.
- *Specialization in Solid Mechanics*
Core Classes: MENG 504, Advanced Mechanics of

Materials; MENG 515, Theory of Elasticity; MENG 516, Plates and Shells; MENG 517, Advanced Finite Element Method; MENG 520, Fracture Mechanics; MENG 524, Continuum Mechanics; MENG 541, Vibration in an Elastic Continuum; MENG 583, Engineering Mechanics of Composite Structures.

Master of Science students must take MENG 585 each semester offered if the student is in residence. Distance-education students and part-time on-campus students enrolled in the Master of Science program are required to take two semesters of MENG 585. Students enrolled in the Master of Engineering program are not required to take MENG 585. Only one credit of MENG 585 may be used to fulfill degree requirements. MENG 585 must be taken for a letter grade if used to fulfill degree requirements.

Requirements

A minimum of 30 credit hours is required for the Master of Science or Master of Engineering in Mechanical Engineering.

Master of Science

- Core Specialization Courses—at least 12 credit hours from the selected specialization listed under graduate program requirements. For no specialization, any 12 credit hours from graduate level MENG courses constitute the core requirement.
- Elective Courses—6 credit hours of graduate level MENG courses. The advisory committee may allow for a maximum of 3 credits of out-of-department graduate level coursework hours to apply to the elective course requirement. Students may use no more than 3 credit hours of MENG 581, Directed Study, toward the MS. MENG 581 must be taken for a letter grade if used to satisfy degree requirements.
- Out-of-Department courses—6 credit hours of approved upper-division or graduate course work from another department. The advisory committee may determine that a student's previous academic experience has provided breadth and may recommend modification of this requirement.
- MENG 591, Thesis (6 credit hours) — A student must prepare and submit a thesis to his/her advisory committee for approval in accordance with the general requirements of the graduate school.

Master of Engineering

- Core Specialization Courses—at least 12 credit hours from the selected specialization listed under graduate department requirements. For no specialization, any 12 credit hours from graduate level MENG courses constitute the core requirements.
- MENG Elective Courses—at least 12 credit hours of graduate-level MENG courses. Students may not use MENG 581, Directed Study, to satisfy Master of Engineering degree requirements. The advisory committee may allow for a maximum of 3 credits of out-of-

department graduate level coursework hours to apply to the elective course requirement.

- Out-of-Department courses—6 credit hours of approved upper-division or graduate course work from another department. The advisory committee may determine that a student's previous academic experience has provided breadth and may recommend modification of this requirement.

Department Requirements for the Doctor of Philosophy in Mechanical Engineering with Dissertation in Intelligent Energetic Systems

The prospective doctoral candidate should develop a strong background in energetics, intelligent systems, and fundamental aspects of mechanical engineering. Candidates will also develop the ability to integrate aspects of these fields and apply them to cutting-edge research. Upon completion of the program the student shall exhibit: a) an ability to apply advanced knowledge of mathematics, science, and engineering, b) an ability to identify, formulate, and solve engineering problems, c) an ability to design, document, and conduct experiments, as well as to analyze and interpret data, d) an ability to analyze requirements, propose design and evaluate practical realization of an engineering system, e) an ability to communicate effectively, f) an understanding of professional and ethical responsibility, g) the broad education necessary to understand the impact of engineering solutions in a global and societal context, h) a recognition of the need for, and an ability to engage in life-long learning, i) a knowledge of contemporary (within the profession) issues, j) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Specific programs of study are developed by the student and their advisory committee, subject to the requirements listed below:

Requirements

A student is required to take 72 graduate credit hours beyond the Bachelor's degree (or equivalent), including 48 credit hours of coursework and 24-credit hours of dissertation research:

- 27 credit hours of core courses (9 credit hours from each core segment)
- 18 credit hours of elective courses, as approved by the graduate advisory committee, with a maximum of 9 credit hours of Directed Study (MENG 581) which must be graded.
- 3 credit hours of Graduate Seminar (MENG 585)
- 24 credit hours minimum of Dissertation Research

A student with a Master's degree in Mechanical Engineering (or closely related discipline) must complete the following minimal requirements of 48 credit hours beyond the Master's degree, including 24 credit hours of coursework and 24 credit hours of dissertation research:

- 18 credit hours of core courses with 9 credit hours from Energetics and 9 credit hours from Intelligent Systems core segments*
- 3 credit hours of additional coursework, with a maximum

of 3 credit hours of Directed Study (MENG 581 or related 581, must be graded)

- 3 credit hours of graduate seminar (MENG 585)
- 24 credits minimum of Dissertation Research

* In the case of a student who has completed equivalent courses in the energetics and/or intelligent systems core segments as part of their M.S. degree, the distribution of credits within the core segments may be adjusted to include credits from the Basic Engineering and Science core segment or additional out of department elective courses as determined by the Graduate Advisory Committee. A memo shall be submitted by the committee to the Graduate Dean approving any course substitutions.

Energetics core segment: MENG 545 Introduction to Explosives Engineering, MENG 546 Detonation Theory, MENG 547 Pyrotechnics Theory and Application, MENG 549 Wave Propagation, MENG 550 Advanced Explosives Engineering, MENG 552 Explosives Technology and Applications, MENG 513 Impact Dynamics, CHEM 540 The Chemistry of Energetic Materials.

Intelligent Systems core segment: MENG 544 Modern Control Theory, MENG 548 Manipulator Based Robotics, MENG 567 Smart Engineering systems, MENG 570 Advanced Mechatronics, MENG 572 Sensor Technology, MENG 574 Electrical Measurements of Non-Electrical Quantities, MENG 561 Digital Image Processing, EE 551 Discrete-Time Signal Processing, Filtering, and Estimation, CSE 568 Intelligent Systems.

Fundamental Engineering and Science core segment: MENG 515 Theory of Elasticity, MENG 575 Advanced Engineering Mathematics, MENG 577 Advanced Fluid Mechanics, MENG 578 Advanced Thermodynamics, MENG 579 Advanced Heat Transfer, MENG 517 Advanced Finite Element Method, MENG 583 Engineering Mechanics of Composite Structures, MENG 562 Design and Analysis of Experiments

Qualifying Examination:

Core competency in mechanical engineering fundamentals must be demonstrated. The qualifying exam will also assess a student's ability to rationally approach novel problems and apply engineering analytical tools. The student will take written exams in three of the following topic areas as selected by the student with approval of the academic advisor.

Exam Topic Areas:

- Control theory
- Dynamics
- Thermodynamics
- Fluid dynamics
- Heat transfer
- Mechanics of Materials
- Structural analysis

The exam questions will be written and graded by department faculty members. These exams will be used to evaluate the student's knowledge of mechanical engineering topics at the undergraduate level and their ability to a) apply advanced knowledge of mathematics, science, and engineering, b) identify, formulate, and solve engineering problems.

The exam will be offered the week before the start of each fall and spring semester. The exam must be first taken before the beginning of the 3rd semester and is subject to the following:

- Students must take exams from three selected topics at first exam attempt.
- A student who does not pass a topic exam may retake that topic exam (or another topic exam with advisor approval) at the next offering; they do not need to retake exams that they have passed.
- A student who has not passed exams in three topics by the completion of their second exam attempt does not advance, and will leave the program. The student will be able to pursue a M.S. or M.E. in Mechanical Engineering subject to those degree requirements.

Candidacy Examination:

- Written dissertation proposal in New Mexico Tech thesis template format
- Presentation of written proposal and oral exam on the proposal and related IES coursework
- Must be taken no fewer than 12 months after passing the qualifying exam
- Three possible outcomes:
 1. Pass: Student advances to Candidacy
 2. Pass with conditions: Six month window to correct minor deficiencies; student advances to Candidacy only after the Graduate Advisory Committee determines deficiencies have been corrected.
 3. Fail: Student does not advance to Candidacy and will leave the program.

Publication of Research:

The student must demonstrate dissemination of research results by publishing at least one article in a peer-reviewed science or engineering journal.

Dissertation & Defense:

- Written Dissertation
- Oral presentation with public and private (committee only) question and answer discussion time.
- Defense must take place no fewer than 12 months after passing the Candidacy Examination
- Possible Outcomes:
 - Pass
 - Pass with conditions: Student must correct minor deficiencies. Note that the deficiencies should be minor and not require a second defense.
 - Fail: Student has not satisfactorily presented/defended their dissertation and leave the program.

Aerospace Engineering Courses

AE 311, Aerodynamics I, 3 cr, 3 cl hrs

Prerequisites: MENG 216/ES 216

Fundamental concepts of aerodynamics, equations of compressible flows, irrotational flows and potential flow theory, singularity solutions, circulation and vorticity, Kutta-Joukowski theorem, thin airfoil theory, finite wing

theory, slender body theory, subsonic compressible flow and Prandtl-Glauert rule, supersonic thin airfoil theory, introduction to performance, basic concepts of airfoil design

AE 313, 313D, Orbital Mechanics, 3 cr, 3 cl hrs

Prerequisites: PHYS 1320 or 132, MATH 332 or MENG 305

This is a first upper-division course covering the Newtonian mechanics of orbits. Applications include ballistic missiles, satellites, and lunar and interplanetary orbits. (Same as PHYS 313.)

AE 318, Experimental Methods in Aerodynamics, 2 cr, 2 cl hrs

Prerequisite: ES 216/MENG 216

Experimental approach to problem solving and validation of theoretical/computational methods. Uncertainties in measurement. Review of fundamental equations of fluid dynamics, properties of gases and liquids, similarity laws. Wind tunnels, water channels, simulation of phenomena in processing equipment. Pressure sensors, including optically-reactive surface paint. Measurement of skin friction by direct force sensors, Preston and Stanton-tubes, diffusion analogies, liquid crystals. Flow visualization with laser light sheet; Schlieren, shadowgraph and interferometric methods. Future trends; flow control, impact of microelectronic sensors and actuators.

AE 318L, Experimental Methods in Aerodynamics Lab, 1 cr, 3 lab hrs

Corequisite: AE318

Laboratory demonstrations and exercises using available instrumentation in Mechanical Engineering Department.

AE 412, 412D, Aerospace Systems, 3 cr, 3 cl hrs

Prerequisites: ES 111; MATH 335; MENG 305

Corequisites: MENG 405, 451; EE 341 for EE majors or consent of instructor and advisor

The course explores formulation, development and implementation of a comprehensive approach to the design, analysis, and life-cycle cost management of highly complex, often adaptive systems. An appreciation for the strength of integrated, multidisciplinary skills, within a structured framework for concept development is a desired outcome of the course. A number of case studies are examined as leading examples for completion of a final class project in systems conceptualization and development management.

AE 414, 414D, Aerospace Structures, 3 cr, 3 cl hrs

Prerequisites: MENG 304, MENG 305

Behavior, analysis and design of discrete and continuous plates and shells, membrane and bending behavior, numerical methods of solution, Composite structures, Macro-mechanics to Structural design and development. Development of analytical procedures for determining material properties. Effective experimental methods and prediction of structural behavior.

AE 415, 415D, Aerodynamics II, 3 cr, 3 cl hrs

Prerequisites: AE 411

The course is covering advanced aerodynamic theories and their application. Includes airfoil shape, drag, velocity, lift, thrust, stability and control. Also included are advanced principles of performance including airplane capabilities and limitations, performance design criteria, load factors, weight and balance, comparative analysis of aircraft and aircraft certification.

AE 416, 416D, Aircraft Flight Dynamics and Controls, 3 cr, 3 cl hrs

Prerequisites: ES 332, MATH 2420 or equivalent, MATH 335, MENG405, AE 411, AE 412

The application of aerodynamic surfaces to determine the trajectory and the attitude of flight vehicles involves knowledge of the forces and moments applied to the vehicle from the surrounding media in subsonic, transonic and supersonic flow regimes. Methods of either specifying, or estimating the performance parameters of a flight vehicle, operating in a particular velocity range are introduced, including the critical factors in determining the size, shape and placement of control surfaces, and the forces or torques required to reliably and accurately position such surfaces in desired states. Time-domain methods are taught for simulating flight vehicles and synthesizing robust, stable control schemes.

AE 417, 417D, Aerospace Propulsion, 3 cr, 3 cl hrs

Prerequisites: ES 216/MENG 216, ES 347

Aerospace propulsion can be classified into four categories: propeller, jet, ramjet and rocket propulsion. Among them gas turbine engines and jet propulsion are the essentials for modern aircraft. In this course, the fundamentals of different propulsion systems will be first introduced. Then the course focus will be on gas turbine engines. The material can be divided into four parts: (1) review of thermodynamics and compressible flow; (2) one-dimensional gas dynamics analysis of gas engine performance; (3) analysis and performance of air breathing propulsion system; and (4) the analysis and design of gas turbine engine components, e.g. inlets, nozzles, turbomachinery (compressors, turbines, turbofan, turbopropeller) and combustors. Further, the fundamentals of ramjet and rocket propulsion will be also discussed in this course.

AE 418, Structural Dynamics in Aerospace Engineering, 3 cr, 3 cl hrs

Prerequisites: MATH 2532, ES 302, ES 303, AE 414.

This course explores structural dynamic topics covering a broad range of aerospace applications. Vibration of single and multi-degree-of-freedom systems is reviewed in the context of modeling the aerospace structural systems. Essential structural elements – bars, beams, and plates are addresses in the dynamics of continuous systems section. Structural response to transient, shock, and random loads is discussed and practical aspects of dynamic testing are presented.

AE 420, 420D, Compressible Fluid Flow, 3 cr, 3 cl hrs

Prerequisites: ES 216, ES 347

An introductory study of compressible fluid flow and gas dynamics. The course covers one-dimensional

flows including isentropic flow, normal shockwaves, Fanno flow, and Rayleigh flow. Oblique shock waves and expansion fans are discussed including applications to high-speed aerodynamics. One-dimensional unsteady flow is taught, including a detailed study of wave diagrams for various problems including shock tubes and as models for explosions. Applications of compressible flow are discussed including wind tunnels, aerodynamics, and explosives. An understanding of simple refractive imaging techniques is imparted to allow analysis of compressible flows from flow visualizations.

AE 489, 489D, Special Topics in Aerospace Engineering, 3 cr, 3 cl hrs

AE 491, Directed Study, cr to be arranged

Explosives Engineering Courses:

EXPL 101 - Beginning Explosives Engineering, 2 cr, 2 cl hrs

Prerequisites: none

This course will introduce the student to the subjects of pyrotechnics and explosives and encompasses subjects including basic combustion chemistry, the physical chemistry of energetic Materials, and some test instrumentation. This course also will include a design project.

EXPL 101L - Beginning Explosives Engineering Lab, 1 cr, 3 lab hrs

Prerequisites: none

This course is based primarily in the laboratory, however, two days will be spent at the Energetic Materials Research and Testing Center working with high explosives

EXPL 416, 416D Energetic Material Chemistry, 3 cr, 3 cl hrs

Prerequisite: Upper class standing or consent of instructor and advisor (Same as ChE 475)

An introduction to the chemical aspect of energetic Materials. Based on basic/advanced chemical and thermochemical concepts and dynamics, understand the characteristic and typical properties of energetic Materials.

EXPL 417, 417D Energetic Material Safety, 3 cr, 3 cl hrs

Prerequisite: Upper class standing or consent of instructor and advisor

Development of the concept of detonation process or Detonation-Deflagration Transition (DDT) mechanics. Analysis of the thermo-dynamic behavior of explosives, hydro hot-spot theory, shock initiation, explosives cook off, explosive sensitization.

EXPL 445, 445D Introduction to Explosives Engineering, 3 cr, 3 cl hrs

Prerequisites: ES 216, ES 302, and ES 347 (or MTL350/CHE349) or consent of instructor and advisor

Introduction to the broad field of explosives science and technology. Basic organic chemistry, decomposition reactions, properties of explosives, thermodynamics of explosives, shock wave theory, detonation theory, initi-

ators, Gurney equations, blast effects and demolition.

EXPL 447, 447D Theory of Propellant and Pyrotechnic, 3 cr, 3 cl hrs

Prerequisite: ES 216, ES 302, and ES 347 (or MTL350/CHE349) or consent of instructor and advisor
Fundamentals of basic concepts of pyrotechnic. Thermo-mechanical/chemical aspects of pyrotechnics, formulation and mixing of pyrotechnic mixtures, application of pyrotechnic including illumination, tracers, incendiaries, delays, etc.

EXPL 449, 449D Wave Propagation, 3 cr, 3 cl hrs

Prerequisites: EXPL 445 or consent of instructor and advisor

An in-depth study of the propagation of waves in various media. The derivation and application of the Rankine-Hugoniot jump equations. The concept of the rarefaction wave and various wave interactions. Derivation and application of the Mie-Grüneisen equation of state. The differential form of the conservation equations, as well as some numerical solutions for simple cases. Shares lecture with ME/MENG 549, with additional expectations for graduate credit.

EXPL 452, 452D Explosives Technology and Applications, 3 cr, 3 cl hrs

Prerequisite: EXPL 445 or consent of instructor and advisor

Focus on the application of explosives mechanics. Fundamentals of explosive welding/cutting, shaped charges, explosive-driven flux-compression generators, spallations, explosives initiation methods, explosives applied testing methods, etc.

EXPL 453 Computer Modeling of Detonations, 3 cr, 3 cl hrs

Prerequisite: EXPL 445 or consent of instructor and advisor.

Introduction to the numerical/hydrocode modeling of detonation behaviors. Focus on the area of detonation initiation, behavior of heterogeneous explosives, explosive/propellant performances, experiment interpretations, and numerical expressions of explosives relate theories.

EXPL 455, 455D Shock Propagation in Air, 3 cr, 3 cl hrs

Prerequisite: EXPL 445 or consent of instructor and advisor

An in-depth study of structural behaviors on blast and vibration. Structure damage prediction/estimation, blasting shockwave mitigation methods/concepts, shockwave propagation/properties on structures, structure failure criteria.

EXPL 462 Experimental Explosives Science, 1-2 cr, 1-3 cl hrs

Prerequisite: EXPL 445 or consent of instructor and advisor

An introduction to the explosive testing data acquisition systems. Basic concepts of the measurement of detonation product properties and characteristics of detonation process. Analysis of material properties under high pressure shock compression, and data interpretations

EXPL 462L Experimental Explosives Science lab, 1-3 cr, hrs, 1-3 lab hrs

Prerequisite: EXPL 445 or consent of instructor and advisor
Co-requisite: EXPL 462

An introduction to the explosive testing data acquisition systems. Basic concepts of explosives initiation and the measurement/characterization of detonation effects. Experimental analysis of energetic Materials and explosives devices utilizing various state-of-art testing equipment. Ultra-high speed camera, VISAR, shock measurement systems, etc. Analysis of material properties under high-pressure shock compression, and data interpretations.

EXPL 489, Special Topics in Explosives Engineering, 3cr., 3 cl. Hrs

EXPL 491 Directed Study, cr to be arranged

Mechanical Engineering Courses:

MENG 110, 110L Introduction to Mechanical Engineering, 3 cr, 2 cl hr, 3 lab hrs

Corequisites: MATH 1240 or higher; MENG 110 and 110 L are co-requisites of each other

A broad overview of mechanical engineering, including an introduction to mechatronics, explosives, thermal and fluid sciences, solid and structural mechanics. An introduction to basic engineering problem solving techniques and engineering tools. Students will engage in a semester long team design project where they use modern engineering tools including basic computer drafting and computations to address mechanical engineering problems.

MENG 210, 210L Sophomore Design and Measurements, 3 cr, 3 cl hr

Prerequisites: MENG 110 or equivalent, PHYS 1310

Fundamentals of mechanical engineering design and instrumentation. This course introduces basic engineering measurement techniques and approaches, including analog to digital conversion, binary numbers, logic gates, sensors and data processing. Basic C and Matlab programming will be introduced and used to collect and analyze experimental data. Data analysis will include calculation of statistical quantities and methodologies for graphing results. A semester-long design project will implement instrumentation, programming, and analysis topics. Laboratory experiments will include basic C programming, programming of data acquisition systems, application of a range of mechanical engineering instrumentation techniques, and basic design principles.

MENG 216, Engineering Fluid Mechanics, 3 cr, 3 cl hrs

Prerequisite: ES 201

Corequisite: MATH 2532

Fundamentals of fluid mechanics including fluid statics, velocity of continuous media, continuity, and momentum balance. Introduction of laminar and turbulent flows, similitude, dimensionless analysis, Bernoulli's equation, friction factor, introduction to pump and compressor selection.

MENG 302L, Mechanics of Materials Laboratory, 1 cr, 3 lab hrs

Corequisite: ES 302

Experiments in mechanics of Materials, testing methods, and measurement techniques.

MENG 304, Advanced Strength of Materials, 3 cr, 3 cl hrs

Prerequisites: ES 302 passed with C or better

Unsymmetrical loading of beams, shear flow and shear center in thin-walled beams, curved beams, thin plates, thick walled cylinders, stress concentrations, thermal stresses, impact loads, and vibration loads. Applying energy methods to various solid mechanics and beam problems.

MENG 305, Numerical Methods and Analysis, 3 cr, 3 cl hrs

Prerequisites: ES 216/MENG 216, ES 302; MATH 335

This course presents applied numerical methods and analysis for mechanical engineering students with a focus on implementing solutions using C, Matlab or Python programming. This course focuses on implementation of basic numerical methods to solve systems of equations, ordinary differential equations, and partial differential equations. Mechanical engineering problems will be used to frame the implementation of the numerical techniques to demonstrate optimization of engineering design and analysis of experimental data. Presentation of numerical results will be discussed including graphing philosophy, numerical errors, a comparison with analytical solutions. Topics include numerical error and accuracy, finite difference methods, integration, regression, initial value problems, discrete Fourier transforms, root finding, and optimization.

MENG 341, Mechanical Engineering Technical Writing, 3 cr, 3 cl hrs

Prerequisites: ENGL 1110 and 1120 or the equivalent passed with a grade of C or better. Junior Standing

This course is designed to offer instruction in theory and practice of effective technical communication, particularly as applied to Mechanical Engineering and the junior/senior design clinic. Students who successfully complete this course should be able to plan, organize, draft, revise, and edit technical communication that is professional in content and appearance and appropriately designed for its intended audience.

MENG 381, Junior Engineering Design Clinic I, 2 cr, 1 cl hr, 3 lab hrs

Prerequisites: MENG 210; junior standing

Corequisite: ES 216/MENG 216, ES 302

An academic-year-long engineering design project. Organized and directed by a faculty member. Weekly intensive workshops in specialized design topics pertinent to actual design project. Junior-level students are under the direct supervision of the faculty members and the senior-level students assigned to the project.

MENG 382, Junior Engineering Design Clinic II, 2 cr, 1 cl hr, 3 lab hrs

Prerequisite: MENG 381

Corequisite: ES 316

A continuation of MENG 381 academic-year-long engineering design project.

MENG 405, Dynamic Systems and Controls, 2 cr, 2 cl hrs

Prerequisites: ES 332 or consent of the instructor

Corequisite: MENG 405L

A practical survey course examining the basic components of instrumentation, measurement, and process control systems common to the field of engineering. Sensing and measurement (temperature, pressure, flow rate, level, stress-strain, concentration, etc.), signal generation and data acquisition, control loops and controllers, and process control theory.

MENG 405L, Dynamic Systems and Controls Laboratory, 1 cr, 3 lab hrs

Corequisite: MENG 405

Laboratory exercises involving instrumentation and design of basic control systems.

MENG 421, 421D, Finite Element Analysis and Design, 2 cr, 2 cl hrs

Prerequisites: MENG 304 passed with grade C or better, Math 337 or consent of instructor and advisor

Introduction to the theory of finite element analysis for structural and heat transfer analysis. Use of finite element analysis in engineering design.

MENG 421L, Finite Element Analysis and Design Lab, 1 cr, 3 lab hrs

Corequisites: MENG 421

Application of finite element computer codes to solve complex engineering design problems.

MENG 431, 431D, Fluid and Thermal Systems, 2 cr, 2 cl hrs

Prerequisites: ES 216/MENG 216, ES 347

Corequisites: ES 350, MENG 431L

A capstone course in the thermal-fluid sciences of Mechanical Engineering. The course combines the basic concepts and analysis techniques that were developed throughout the fundamental undergraduate thermodynamics, fluid dynamics, and heat transfer courses, to perform in depth analysis and design of complete thermal-fluid systems. Topics will include analysis and design of piping systems, heat exchangers, and pump systems, and their incorporation into complete systems such as refrigeration and power cycles. Advanced dimensional analysis, mathematical relationships, and computational analysis will be used to solve problems.

MENG 431L, Fluid and Thermal Systems Laboratory, 1 cr, 3 cl hrs

Corequisite: MENG 431

Experimental analysis of fluid flow, heat transfer and thermodynamic systems. Experimental techniques common to the fluid-thermal sciences fields will be used in hands-on laboratory experiments. Techniques include wind tunnel measurements, pitot-static systems, temperature measurement, flow visualization, pump power, and use of data acquisition systems. A final project including the application of measurement techniques and use of experimental facilities in the field of fluid and thermal sciences is required for each laboratory group. Laboratory reports are presented.

MENG 441, 441D, Dynamics and Vibrations in Structural Design, 3 cr, 3 cl hrs

Prerequisites: MATH 335 and MENG 305.

ES 332 recommended

Definition of various dynamic loads. Design and synthesis of structural systems and machine members subject to impact and periodic load conditions. Seismic and blast loads on structures. Relevant failure criteria for dynamically loaded systems in structural and mechanism design.

MENG 451, 451D, Design of Machine Elements, 3 cr, 3 cl hr

Prerequisites: ES 303; MENG 304; MTL 202 and 202L

Principles of design and failure analysis of mechanical machine elements such as fasteners, shafts, columns, and gears. Design of mechanical drives such as roller chains, belts, speed reducers, and hydraulic transmissions

MENG 460, 460D, Introduction to Biomedical Engineering, 3 cr, 3 cl hrs

Prerequisite: Sophomore classification or consent of instructor and advisor

An overview of research in biomedical engineering, biomechanics, biocompatibility, tissue engineering, biomedical instrumentation, and moral and ethical issues.

MENG 465, Biorheology, 3cr, 2 cl hrs, 3 lab hrs

Prerequisite: MENG 431L or consent of instructor and advisor

Concepts of rheology. Rheology of body fluids. Different rheological models of fluids and applications in diagnosis and treatment of diseases. Laboratory experiments of plasma and blood rheological characterization (viscosity, elasticity, plasticity, etc.).

MENG 481, Senior Engineering Design Clinic I, 3 cr, 1 cl hr, 6 lab hrs

Prerequisite: MENG 382, MENG 341

An academic-year-long engineering design project. Organized and directed by a faculty member. Senior-level students are under the direct supervision of the faculty member. Weekly intensive workshops in specialized design topics pertinent to actual design projects. Topics include costing of capital equipment, cost of Materials and labor, design optimization concepts, as well as specialized topics. Formal reports, fabrication drawings, and cost estimates prepared and submitted to faculty and outside industrial reviewers. Formal presentation to reviewing group.

MENG 482, Senior Engineering Design Clinic II, 3 cr, 1 cl hr, 6 lab hrs

Prerequisite: MENG 481

A continuation of MENG 481 academic-year-long engineering design project.

MENG 483, 483D, Mechatronics, 2 cr hr, 2 cl hr

Prerequisites: ES 332 or consent of instructor and advisor

Corequisite: MENG 483L

This course is an in-depth examination of the field of mechatronics, which is a consolidation of computer science (software), electrical engineering (microprocessor control), and mechanical engineering (machine design). Topics covered include: system analysis/ control theory, robotics, dynamic systems and control, elements of mechatronics systems, modeling and simulation of mechatronic systems and computer aided mechatronics.

MENG 483L, Mechatronics Lab, 1 cr hr, 3 cl hr

Corequisite: MENG 483

This is a hands-on lab where the student will design and build a simple mechatronics system. The student will learn the principles of instrumentation and sensors as they relate to the robotic control. The student will also learn the programming methods for the microprocessor controller.

MENG 484L, Design Clinic Lab, 1 cr, 3 lab hrs

Prerequisites: ES or MENG-110, ES or MENG-110L

Corequisites: MENG-381 or consent of the instructor

The Design Clinic Lab Course will introduce students to critical skills important in the engineering design and verification process. Weekly sessions will be conducted in specialized topics pertinent to the design process. Topics include Computer Aided Engineering (CAE), Computer Aided Design (CAD) using Solidworks, mechanical drawing layout, mechanical assemblies, clearances and tolerances, analytical modeling, concepts in machining of components, and the joining of components.

MENG 485, Advanced Design Clinic, 3 cr, 1 cl hrs, 6 lab hrs

Prerequisites: MENG 482

Enables students to enhance their understanding of the engineering design and verification process for mechanical design projects. Weekly seminars in specialized topics pertinent to the design process. Students focus on developing best practices for completing mechanical design projects. These best practices are used to improve the performance of design clinic project teams. Students participate in design project teams, contributing as senior technical members and/or advisers. Students contribute to the formal reports and oral presentations of these teams.

MENG 486, 486D, Special Topics in Biomedical Engineering, 3 cr, 3 cl hrs

MENG 489, 489D, Special Topics in Mechanical Engineering, 3 cr, 3 cl hrs

MENG 491, 491D, Directed Study, cr to be arranged

Graduate Courses:

The major content of these courses is directed toward a Master of Science degree in Mechanical Engineering.

MENG 500, Directed Research, cr to be arranged

Research under the guidance of a faculty member. This course may not be used to fulfill graduate degree requirements.

MENG 504, 504D, Advanced Mechanics of Materials, 3 cr, 3 cl hrs

Prerequisite: MENG 304 or graduate standing

Development of advanced mechanics of Materials principles and techniques for use in engineering design and problem solving. Topics include material yielding, torsion, unsymmetrical bending of beams, shear stresses in thin-walled structures, curved beams, beams on elastic foundations, axisymmetric thin-walled shells and thick-walled cylinders, column stability, stress concentrations, and material failure behavior under steady and cyclic loading.

MENG 505, 505D, Design and Analysis of Experiments, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor

This class will focus on statistically designed experiments, measurement standards, data analysis, regressions and general and detailed uncertainty analysis, including statistical treatment of experimental data. This course is intended to give you a broad introduction to statistical concepts used to design, conduct, and interpret your own experiments and to better your analysis of data presented in the scientific literature.

MENG 513, Impact Dynamics, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

A specialized but very important branch of engineering mechanics deals with the collision of multiple bodies throughout a broad range of relative velocities. The physical phenomenon during impact and subsequent response of each of the bodies is dependent on the mechanical Material properties of each, the impact velocities, and the relative size and orientation of each of the bodies. Impact response is most easily categorized based on the impact velocity (relative approach velocity of two bodies), ranging from elastic response with little change in temperature at low velocities, through plastic deformation and/or fracture at higher velocities, to physical state changes of bodies or a portion of a body at hyper-velocity impacts (>1 km/sec).

MENG 515, 515D, Theory of Elasticity, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of the instructor

An introduction to tensor analysis, analysis of stress, balance laws, infinitesimal and finite theories of motion, strain and rotation tensors, compatibility equations, con-

stitutive equations, Materials symmetry, uniqueness of the solution, solution of two-dimensional elasticity problems. Airy stress function, application of complex variable technique in elasticity, three-dimensional elasticity problems, energy methods, bending theory of plates. **(Same as ME 515)**

MENG 516, 516D, Plates and Shells, 3 cr, 3 cl hrs

Prerequisites: MENG 305, MENG 451 or approval of the instructor.

Behavior, analysis and design of discrete and continuous plates and shells, membrane and bending behavior, numerical methods of solution.

MENG 517, 517D /ME 517, Advanced Finite Element Method, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of the instructor

An introduction to the numerical analysis calculus of variation, weak form of a differential equation, weighted residual techniques, solution of one-dimensional problems by the finite element method, bending problems, Lagrange and Hermite interpolation functions, isoparametric elements, numerical integration, two-dimensional problems, solution of Poisson and Laplace equations, triangular and quadrilateral elements, elasticity problems, theorem of minimum potential energy stiffness matrix, examples. **(Same as ME 517)**

MENG 519, 519D, Adaptive Structures, 3 cr, 3 cl hrs

Prerequisites: MENG 305, Pre/Corequisite MENG 589 or approval of the instructor

Adaptive structures with embedded intelligent sensors and actuators, self-monitoring and self healing characteristics, biological system/ structures.

MENG 520, 520D, Fracture Mechanics, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of the instructor

An introduction to the theory of elasticity, singular stress fields, Westergaard method, complex variable technique, stress intensity factor, fracture energy, numerical and experimental methods in determination of stress intensity factor, fracture toughness, J-integral Elasto-plastic fracture. **(Same as ME 520)**

MENG 521, Elastic Stability, 3 cr, 3 cl hrs

Prerequisite: MENG 304 or consent of the instructor

Classical theory of elastic stability for beams, plates, and shell structures. Geometric non-linear equations for thin-walled structures. Linear, linearized, and non-linear solutions of problems. Approximate analytic methods and numerical methods for problem solving.

MENG 522, Mechanics of Inelastic Continuum, 3 cr, 3 cl hrs

Prerequisites: MENG 515, MENG 524 or approval of the instructor

Modeling systems that yield inelastic equations, coupled with methods for their solutions and analysis. Development of insight into the fundamental behavior of inelastic systems.

MENG 523, Engineering Mechanics of Cellular Structures, 3 cr, 3 cl hrs

Prerequisites: MENG 305, Pre/Corequisite MENG 589 or approval of the instructor

Cellular structures with combinations of mechanical, energy-absorption, thermal and acoustic/vibration characteristics and their implementation in diverse applications.

MENG 524, 524D, Continuum Mechanics, 3 cr, 3 cl hrs

Prerequisites: MENG 515, Pre/Corequisite MENG 517 or approval of the instructor

Matrix, indicial and direct notation, tensor calculus, deformation analysis; general principles of stress, curvilinear coordinates.

MENG 531, Mechanics of Viscous Fluids, 3cr, 3 cl hrs

Prerequisite: MENG 431 or consent of the instructor

Fundamental laws of motion for a viscous fluid. Navier-Stokes equation. Laminar fluid flow, turbulent boundary layer topics. Compressible and incompressible flow problems.

MENG 541, 541D, Vibrations in an Elastic Continuum, 3 cr, 3 cl hrs

Prerequisites: ES 302, 303; MENG 441; or consent of instructor and advisor

Analysis of single and multi degree-of-freedom systems for time dependent loads, including periodic and impact loads. Thin-walled structures—beams, plates, and shells. Dynamic stability of thin-walled structures.

MENG 544, 544D, Modern Control Theory, 3 cr, 3 cl hrs

Prerequisites: MENG 405 or consent of instructor and advisor

Designing and analyzing modern control systems that can be devised from dealing exclusively in the time domain. Methods of expanding control concepts from simple single-input single-output processes to full multi-input multi-output, continuous and discrete, linear and nonlinear systems will be explored. Students will submit a semester-long research paper.

MENG 545, 545D, Introduction to Explosives Engineering, 3 cr, 3 cl hrs

Prerequisites: Graduate Standing ; or consent of instructor and advisor

Introduction to the broad field of explosives science and technology. Basic organic chemistry, decomposition reactions, properties of explosives, thermodynamics of explosives, shock wave theory, detonation theory, initiators, Gurney equations, blast effects and demolition.

Students will submit a semester-long research report.

MENG 546, 546D, Detonation Theory, 3 cr, 3 cl hrs

Prerequisites: MENG 549 or consent of instructor and advisor.

Development of classical detonation model for full order detonation of secondary explosives. Ideal versus non-ideal detonation. Burn-rate models for pyrotechnics. Derivation and application of the Mie-Gruneisen equation of state. The concept of deflagration to detonation transition. (Same as ME 546)

MENG 547, 547D, Theory of Propellant and Pyrotechnic, 3 cr, 3 cl hrs

Prerequisites: Graduate Standing or consent of instructor and advisor

Fundamentals of basic concepts of pyrotechnic. Thermo-mechanical/chemical aspects of pyrotechnics, formulation and mixing of pyrotechnic mixtures, application of pyrotechnic including illumination, tracers, incendiaries, delays, etc.

MENG 548, Manipulator Based Robotics, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: MENG 405 or equivalent or consent of instructor and advisor

Fundamentals of the multi-disciplinary field of robotics. Emphasis is placed on understanding how to model and control robotic manipulators while providing an appreciation of the importance of sensing to robotic applications. Topics include: forward, inverse, and motion kinematics; dynamic modeling; position, velocity, and force control. Shares lecture/lab with EE 448, but is graded separately, and additional graduate-level work is required. (Same as EE 548)

MENG 549, 549D, Wave Propagation, 3 cr, 3 cl hrs

Prerequisites: MENG 545 (or consent of instructor and advisor)

An in-depth study of the propagation of waves in various media. The derivation and application of the Rankine-Hugoniot jump equations. The concept of the rarefaction wave and various wave interactions. The differential form of the conservation equations, as well as some numerical solutions for simple cases. Shares lecture with EXPL 412, with additional expectations for graduate credit. (Same as ME 549)

MENG 550, 550D, Advanced Explosives Engineering, 3 cr, 3cl hrs

Prerequisites: MENG 549 or consent of instructor and advisor

The detonation of non-ideal explosives, equation of state for porous media, shaped charge effect and explosively formed projectiles. Shock compaction of powders, explosive welding and experimental methods used in the evaluation of explosives and their applications. The dynamic fracture of ductile and brittle Materials. (Same as ME 550)

MENG 551, 551D, Optimal Control Systems, 3 cr, 3 cl hrs

Prerequisites: ES 332, MATH 2420 or equivalent, MATH 335, MENG 405

Formulation of stochastic dynamic systems models, combined with optimal full-state and reduced-state estimators are introduced. Various cost functionals are defined and used to design real-time control algorithms that produce specific desired system responses. Mathematical measures of control robustness are defined which allow the student to gain an appreciation for predicting and measuring system stability margins under sub-optimal conditions.

MENG 552, 552D, Explosives Technology and Applications, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor and advisor

Focus on the application of explosives mechanics. Fundamentals of explosive welding/cutting, shaped charges, explosive-drives flux compression generators, spallations, explosives initiation methods, explosives applied testing methods, etc. Students will submit a semester-long research report.

MENG 553, 553D, Computer Modeling of Detonations, 3 cr, 3 cl hrs

Prerequisites: MENG 545 or consent of instructor and advisor.

Introduction to hydrodynamic modeling applied to explosives. Numerical methods for modeling shock physics, detonation, and material response. Finite difference, finite element and smoothed particle hydrodynamic methods, equation of state and strength models, and numerical fracture and fragmentation.

MENG 554, Embedded Control Systems, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: EE 308 or EE 443 or MENG 405 or equivalent or consent of instructor and advisor

Micro-controller or microcomputer based embedded control systems. A comparative survey of currently available embedded computers/controllers including SBC's, PIC's, basic-stamps, and single-chip computer solutions. Real time operating systems including real-time LINUX, and hard real-time process requirements. Projects will include the implementation of an embedded real-time control solution. (Same as EE 554)

MENG 555, Shock Propagation in Air, 3 cr, 3 cl hrs

Prerequisites: MENG 545 or consent of instructor and advisor

An in-depth study of shock propagation in air in an engineering point of view. Estimation of overpressure, blast wave and it parameters, normal/oblique shock reflection analysis, blast wave scaling with Buckingham pi theory, and structural response under airblast including shockwave mitigation methods/concepts.

MENG 556, 556D Compressible Fluid Flow, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor.

An introductory study of compressible fluid flow and

gas dynamics. The course covers one-dimensional flows including isentropic flow, normal shockwaves, Fanno flow, and Rayleigh flow. Oblique shock waves and expansion fans are discussed including applications to high-speed aerodynamics. One-dimensional unsteady flow is taught, including a detailed study of wave diagrams for various problems including shock tubes and as models for explosions. Applications of compressible flow are discussed including wind tunnels, aerodynamics, and explosives. An understanding of simple refractive imaging techniques is imparted to allow analysis of compressible flows from flow visualizations.

MENG 557, Multiphase Flow, 3 cr, 3 cl hrs

Prerequisites: MENG 431 or equivalent or consent of the instructor

Selected topics in multiphase flows with emphasis on engineering applications. Topics include basic two-phase flow equations, pressure drop in two-phase flow, gas-liquid, gas-solid and liquid-solid two-phase flows.

MENG 558, 558D, Non-Newtonian Fluid Mechanics, 3 cr, 3 cl hrs

Prerequisite: consent of the instructor

This course offers the specific techniques and understanding necessary for being able to compute and understand issues associated with non-Newtonian fluid dynamics. Issues of rheology and analytic techniques are covered

MENG 559, Theory and Design of Internal Combustion Engines, 3 cr, 3 cl hrs

Prerequisites: ES 347, ES 350, MENG 304, MENG 421, or consent of the instructor

Thermodynamic analysis and performance characteristics of spark ignition and compression ignition engines. Effects of thermodynamics, heat transfer and combustion on engine power, efficiency and emissions. Design of internal combustion engines; stress analysis, kinematics and dynamics of the crank mechanism, design of piston, connecting rod and crankshaft.

MENG 560, 560D, Principles of Combustion, 3 cr, 3 cl hrs

Prerequisites: ES 347 or consent of the instructor

Covers the fundamentals of combustion. Topics include chemical reactions, calculation of adiabatic flame temperature, chemical kinetics and flammability limit, characteristics of premixed, diffusion, laminar and turbulent flames.

MENG 561, 561D, Digital Image Processing, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor

This class will provide an introduction to digital image processing, beginning with a discussion of imaging systems and storage of digital images then progressing to image filtering, segmentation, correlations, and applications in mechanical and aerospace engineering. Basic image manipulation including subtraction, addition, dilation, and smoothing will be covered using binary images. Grayscale images will then be used to discuss histogram manipulation, edge detection routines, and filter-

ing, including Fourier-based techniques. Image correlation will be covered, including its applications for fluid-dynamic measurement systems like Particle Image Velocimetry (PIV) and Digital Image Correlation (DIC). Color theory will be presented including conversion of images between color schemes including RGB and HSI. Additional applications for machine vision and scene reconstruction will be discussed. The course will use MATLAB to perform all image manipulations; all students are expected to have working knowledge of MATLAB and undergraduate-level programming skills

MENG 562 Experimental Explosives Science, 1-2 cr, 1-3 cl hrs

Prerequisite: MENG 545 or consent of instructor and advisor

An introduction to the explosive testing data acquisition systems. Basic concepts of the measurement of detonation product properties and characteristics of detonation process. Analysis of material properties under high pressure shock compression, and data interpretations

MENG 562L Experimental Explosives Science lab, 1-3 cr, 1-3 lab hrs

Prerequisite: MENG 545 or consent of instructor or advisor

Co-requisite: MENG 562

An introduction to the explosive testing data acquisition systems. Basic concepts of explosives initiation and the measurement/characterization of detonation effects. Experimental analysis of energetic Materials and explosives devices utilizing various state-of-art testing equipment. Ultra-high speed camera, VISAR, shock measurement systems, etc. Analysis of material properties under high-pressure shock compression, and data interpretations.

MENG 567, 567D, Smart Engineering Systems, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor.

Artificial neural networks, with emphasis on multiplayer feedback networks, self-organizing networks, and Hopfield-style networks. Learning algorithms. Introduction to fuzzy systems and evolutionary computing. Engineering applications of soft computing.

MENG 568, Smart Engineering Systems II, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor.

Overview of the major paradigms of soft computing: neural networks, fuzzy systems, and evolutionary computing. In-depth coverage of selected topics in each area as relevant to intelligent systems. Recent advances in the field, and case studies of intelligent systems. Coursework includes a large-scale project.

MENG 570, 570D, Advanced Mechatronics, 3 cr, 3 cl hrs

Prerequisite: MENG 405 or EE 443 or equivalent or consent of instructor and advisor

The theory, design, manufacture and use of instrumenta-

tion and control in the various sciences. The use of electrical and electronic instruments and equipment to measure, monitor and/or record physical phenomena. Measurements of force, mass dimension, strain; displacement, velocity, and acceleration; tensile, impact and comprehensive strength; temperature and thermal properties; time and frequency; thrust and torque; pressure vacuum and flow; electrical quantities; photo-optics and radiation.

MENG 571, Haptic Systems, Teleoperation, & Virtual Reality, 3 cr, 3 cl hrs

Prerequisite: MENG 405 or EE 443 or equivalent or consent of instructor and advisor

Haptic and virtual-reality interfaces are designed with the sensing, control, and actuation capabilities of both humans and robots in mind. This course provides a practical introduction to select aspects of these capabilities. Mathematical formulations fundamental to the course will be derived. Students' ability to comprehend and synthesize the often dense and technical content of research papers will be improved through frequent reading and discussion assignments. Students will design computer algorithms throughout the semester that will culminate in a final programming project.

MENG 572, 572D, Sensor Technology, 3 cr, 3 cl hrs

Prerequisites: ES 332 and MENG 405, or EE 443 or equivalent, or consent of instructor and advisor

The operating principles and properties of sensors/transducers for the measurement of physical quantities in the mechanical domain, as well as the associated interface circuits. Focus is on commercially available sensors, but where appropriate, recent trends toward miniaturization, integration, and higher quality performance will be addressed.

MENG 574, Electrical Measurements of Non-Electrical Quantities, 3 cr, 3 cl hrs

Prerequisites: ES 332 and MENG 405, or EE 443 or equivalent, or consent of instructor and advisor

This course is particularly reliant on advances in scientific knowledge. Establishment of units and scales of measurement, their development, realization, maintenance and dissemination, as well as the performance of traceable measurements. Hence, this course serves a key factor of modern manufacture through automation, which both enhances productivity and ensures consistent quality. The demand for improved and assured quality means ever better instrumentation. Focus on the course will be on measurement science, design principles for instrument systems, electrical measurements of thermal quantities, electrical measurements of mechanical quantities, electrical measurements of optical quantities, and electrical measurements of chemical quantities.

MENG 575, 575D, Advanced Engineering Mathematics, 3 cr, 3 cl hrs

Prerequisites: MENG 305 or consent of the instructor

A comprehensive study of applied mathematics. Vector analysis, tensors and Eigenvalue problems. Analytical solutions to linear ordinary and partial differential equations. Separation of variables, boundary value problems, and Laplace and Fourier transforms. Numerical analysis of non-linear ordinary and partial differential equations with emphasis on engineering applications. Complex Analysis; complex numbers, Cauchy-Riemann equations and conformal mapping.

MENG 576, 576D, Biomedical Mechatronics, 3 cr, 3 cl hrs

Prerequisites: MENG 405 or EE 443 or ES 332 or equivalent or consent of instructor and advisor

This course will give students direct experience with computational tools used to create simulations of human movement. Lectures and labs cover animation of movement; kinematic models of joints; forward dynamic simulation; computational models of muscles, tendons, and ligaments; creation of models from medical images; control of dynamic simulations; collision detection and contact models. The course is intended as an introduction to medical device design for graduate engineering students because the class will have a significant design and prototyping emphasis.

MENG 577, 577D, Advanced Fluid Mechanics, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of the instructor

Fundamental concepts and analysis of Fluid Mechanics. Derivation of the partial differential equations governing the conservation of mass, momentum and energy. Introduction to potential flows. Exact solutions of the Navier-Stokes equations. Laminar and turbulent boundary layers. Compressible and incompressible flow problems.

MENG 578, 578D, Advanced Thermodynamics, 3 cr, 3 cl hrs

Prerequisites: ES 347 or consent of the instructor

The first and second laws of thermodynamics. Clapeyron relation, availability concepts and analysis, equations of state, non-reacting mixtures and thermodynamics of chemical reactions.

MENG 579, 579D, Advanced Heat Transfer, 3 cr, 3 cl hrs

Prerequisites: ES 350 or consent of the instructor

Covers analytical and numerical techniques in conduction, convection, radiation with emphasis on combined heat transfer.

MENG 580, 580D, Computational Fluid Dynamics and Reactive Flow, 3 cr, 3 cl hrs

Prerequisites: MENG 560, MENG 577 or consent of the instructor

Introduction to Computational Fluid Dynamics and application of CFD tools to thermal and fluid flow problems. Coupling of fluid flow with combustion chemistry. Discussion of combustion modeling, importance of the mixing intensity, heterogeneous and homogeneous chemical reactions, and application of computer analysis to chemically reacting flow problems.

MENG 581, Directed Study, cr to be arranged

Faculty Teaching & Research Interests

- Anderson – Experimental Shock and Detonation Studies, High-Pressure Equations of State, Dynamic Damage Formation, Planetary Interiors, Meteoroid Impact Phenomena
- Bakhtiyarov—Non-Newtonian Fluid Mechanics, Heat and Mass Transfer, Rheology, Multiphase Flows, Instrumentation, Fluidized Beds, Porous Medium Flows, Nanotechnology, Self-Healing Materials, Tribology, Turbulence
- Ebrahimkhanlou- Artificial intelligence, machine learning, infrastructure sensing and monitoring, and nondestructive evaluation
- Ford – Written and Oral Communication, Teamwork, Communication Pedagogy, Leadership
- Ghosh—Macro Behavior of Composites, Biomechanics, Finite Element Analysis, Experimental Mechanics and Instrumentation, Structural Health Monitoring and Restoration, Construction Materials and Project Management
- Grow – Robotics, Biomedical & Surgical Devices, Haptics, Dynamic Modeling
- Hargather – Shock and Gas Dynamics, Experimental Thermal - Fluid Dynamics, High-Speed Gas Dynamics, Explosive Characterization, Impact Dynamics
- Hassanalian - Fixed and flapping wing micro and Nano-air vehicles, tilt-rotor and tilt-wing drones, morphing drones, space and marine drones, separation and swarming flight of micro-drones, flight dynamics, biomimetics, fluid-structure interaction, and optimization
- Kimberley – Solid Mechanics, Impact Studies, Dynamic Behavior of Materials
- Lee - Uncertainty Quantification, Distributed Network Control Systems, Multi-Objective Optimization, Robotics
- Lim-Energetic Materials, Explosives Technology, Extreme Dynamics/Materials and Environment, Shock Physics, Extreme Tension Physics, Linear and Conical Shaped Charges
- Miller, A.K. —System Dynamics, System Modeling and Simulation, Actuators and Actuator Controls
- O’Malley– Structural Dynamics and Mechanics, Design of Intelligent Systems and Structures, Design Optimization, Nondestructive System Monitoring and Evaluation, Vibration Test Development.
- Romero—Energetic Materials, Shock Phenomena, High Energy Physics
- Ruff – Mechanics of Materials, Instrumentation
- Ryu – Mechanics of Materials, Smart Materials and Structures, Continuum Mechanics, Sustainable Infrastructures, Structural Health Monitoring, Advanced Sensing Technologies, Autonomous Composites, Multifunctional Materials, Nanomaterials and Nanocomposites, Optics and Optoelectronics
- Stofleth – Instrumentation and Measurements, Explosives Technology
- Wei – Thermal-Fluid Science, Wall-Bounded Flow, Flow Instabilities, Enhancing or Reducing Heat Transfer Coefficients, Turbulent Mixing, and Fluid Drag.
- Westpfahl - Dynamics of Spiral and Dwarf Galaxies
- Zagrai---Structural Dynamics and Acoustics, Intelligent Systems and Structures, Sensor Networks, Structural Health Monitoring and Nondestructive Evaluation.

Mineral Engineering

Professors Chávez, Mojtabei (Chair of the Department)

Associate Professor Razavi, Saiang

Assistant Professor Roghanchi

Adjunct Faculty Bakhtar, Kuhn, McLemore, Patton,

Emeritus Professor Oravec, Aimone-Martin, Fakhimi

Degrees Offered: B.S. in Mineral Engineering; B.S. in Mineral Engineering with Emphasis in Explosives Engineering; M.S. in Mineral Engineering; Ph.D in Mineral Engineering.

Department Mission Statement

- Provide the students with an education in the fundamentals of engineering that will allow immediate entry into industry, government, research or academia and provide a solid theoretical and applied foundation for future professional development and growth.
- Maintain high level of commitment and excellence in teaching and research, provide the time and effort to understand the individual students particular learning abilities and needs, give guidance and provide the environment to achieve those abilities.
- Prepare students for the opportunities and challenges of a diversified professional career in the rapidly changing mineral engineering related disciplines through exposure to various aspect of applied technology.

Program Educational Objectives

Program graduates will:

- 1) Develop creativity in thinking and skills in problem solving to enhance their employer's ability to be competitive within industry, as they advance in their professional career.
- 2) Develop leadership communication skills within the framework of a team while demonstrating the ability to work independently.
- 3) Maintain a strong sense of professional and ethical responsibility with a strong corresponding sense of social awareness.
- 4) Advance in engineering or management status and demonstrate measurable progress in achieving personal and professional goals after graduation.

Student Outcomes for Undergraduate Program

Graduates of the Bachelor of Science in Mineral Engineering program will have demonstrated:

- an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

- an ability to communicate effectively with a range of audiences
- an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Mineral engineering is concerned with the exploration for and development of minerals and earth Materials in the most efficient manner while protecting the environment. The undergraduate program is oriented toward developing the student's understanding of, and skill in, engineering design. Proficiency in project management and leadership are encouraged through coursework and projects that emphasize professional-quality written and oral communication skills. The objective of the program is to provide the student with an education in the fundamentals of engineering that will allow immediate entry into industry or research work while providing a good opportunity for continued professional growth. Emphasis is placed on developing a responsible professional with a sense of social awareness.

The curriculum includes basic engineering principles that provide the foundation for applied engineering design concepts. The program provides a concentrated study in mechanics, mineral evaluation and economics, ground and environmental control, environmental issues, and project management. Engineering design is introduced in courses covering surface and underground mining, ventilation, mineral processing, equipment selection, drilling and blasting, soil and rock mechanics, hydraulic structures, and geomechanics. Instruction in the environmental aspects of minerals development and production include mine permitting and reclamation, extending to the legal issues and concerns in natural resources development.

A large-scale design project is undertaken in the senior year. This project integrates engineering principles and design in one of three areas: economic evaluation and exploration for mineral properties; design and planning of a mining project; or the planning and implementation of geotechnical construction projects, such as landfills, tailings impoundments, earth dams, and structures.

The department has modern well-equipped laboratories for instruction and research in soil and rock mechanics, ventilation, blast vibrations, mineral evaluation, and computer applications. Students are provided the opportunity to work on a wide range of applied research projects within both the

department and the Institute. Students are encouraged to obtain summer jobs available in mines across the Southwest, providing excellent industrial experience.

Undergraduate Program

Bachelor of Science in Mineral Engineering

Minimum Credit Hours Required—127

In addition to the General Education and Institute Core Curriculum (page 80), the following courses are required:

- MATH 2532 (4), 335 (3)
- ES 201 (3), 216 (3), 302 (3), ES 303 or 347 (3)
- GEOL 1110 & 1110L (4), 200 & 200L(4)
- ME 101 (1), 320 (2), 340 (3), 360 (3), 380 (2),381(2), 410 (3), 413 (3), 420 (3), 422 (3),424 (3),425 (3), 435 (3), 437 (3), 440 (3), 462 (3), 470 (1), 471 (2)
- Technical Elective (3)
- All ME majors must take the Fundamentals in Engineering (FE) exam as a requirement for graduation.

Bachelor of Science in Mineral Engineering with Explosives Engineering Option

Minimum credit hours required—136

In addition to the General Education and Institute Core Curriculum (page 80), the following courses are required:

- MATH 2532 (4), 335 (3)
- ES 201 (3), 216 (3), 302 (3), ES 332, ES 303 or 347 (3)
- GEOL 1110 & 1110L (4), 200 (4)
- ME 101 (1), 320 (2), 340 (3), 360 (3), 380 (2),381(2) , 410 (3), 420 (3), 422 (3), 424 (3),425 (3), 435 (3), 437 (3), 440 (3), 462 (3), 470 (1), 471 (2)
- Technical Elective (3),
- Three approved courses from any of the explosive engineering courses offered on campus.
- All ME majors must take the Fundamentals in Engineering (FE) exam as a requirement for graduation.

Students are strongly encouraged to do their senior design project in the area of Explosive Engineering or related projects

Minor in Mineral Engineering

Minimum credit hours required—18

Chosen from the following courses:

ME 320 (2), ME 340 (3), ME 360 (3), ME 380 (2),ME 381 (2) , ME 410 (3), ME 413 (3), ME 420 (3), ME 422 (3), ME 424 (3),ME 425 (3), ME 435 (3), ME 437 (3), ME 440 (3), ME 462 (3)

Other courses can be used with the department's approval

Sample Curriculum for the Bachelor of Science in Mineral Engineering

Semester 1

- 1 ME 101 (intro to mineral engineering)
- 4 GEOL 1110 & 1110L (principals)
- 4 MATH 1510 (calculus I)

- 4 CHEM 12155 & 1215L (general)
- 3 ENGL 1110 (college English)
- 16 Total credit hours

Semester 2

- 3 ENGL 1120 (college English)
- 4 MATH 1520 (calculus II)
- 4 CHEM 1225 & 1225L (general)
- 3 Social Science/Humanities
- 3 Social Science/Humanities
- 17 Total credit hours

Semester 3

- 5 PHYS 1310 & 1310L (general physics)
- 4 MATH 2532 (calculus III)
- 3 ES 201 (statics)
- 3 Social Science/Humanities
- 2 ME 320 (economics analysis)
- 17 Total credit hours

Semester 4

- 5 PHYS 1320 & 1320L (general physics)
- 3 ES 302 (strength of materials)
- 4 GEOL 200 & 200L (mineralogy)
- 3 ME 340 (geostatistics \$mineral evaluation)
- 15 Total credit hours

Semester 5

- 3 ME 360 & 360L (exploration and field mapping)
- 3 ENGL 341 (technical writing)
- 3 ME 420 & 420L (soil mechanics)
- 2 ME 380 (surface mining)
- 2 ME 381 (underground mining)
- 3 ES 216 (fluid mechanics)
- 16 Total credit hours

Semester 6

- 3 ME 413 (foundation engineering)
- 3 ME 422 & 422L (rock mechanics)
- 3 MATH 335 (applied analysis)
- 3 ES 347 (thermodynamics) or ES 303 (dynamics)
- 3 Social Science/Humanities
- 15 Total credit hours

Semester 7

- 1 ME 470 (senior design I)
- 3 ME 435 (rock slope stability)
- 2 ME 424 (materials handling)
- 3 ME 440 (mine ventilation)
- 3 ME 462 (mineral deposits)
- 3 Social Science/Humanities
- 15 Total credit hours

Semester 8

- 2 ME 471 (senior design II)
- 2 ME 425 (Health & Safety,Professional Responsibility)
- 3 ME 410 & 410L (environmental issues)
- 3 ME 437 (tunneling & underground excavations)
- 3 Technical Elective
- 3 Social Science/Humanities
- 17 Total credit hours

Graduate Program

Master of Science in Mineral Engineering

Admission to the Master of Science in Mineral Engineering program requires competence in mathematics, chemistry, physics, and engineering science comparable to the bachelor of science degree in mineral engineering. Applicants without an engineering degree may apply for the graduate program in Mineral Engineering. However, the student will be required to take all deficiencies as required the advisory committee.

The student's course of study must be approved by the student's advisory committee and fulfill the general requirements for the master's degree.

Of the 30 hours required for the M.S. degree, a minimum of 12 credit hours must be in approved Mineral Engineering courses. All graduate students must complete at least one credit of ME 572 (graduate seminar). Under special consideration, a student may petition the advisory committee with approval of the Department Chair to pursue a Master of Science degree with Independent Study (three hours of ME 590). A formal paper will be submitted with an oral presentation to the advisory committee.

The student may select one area of specialization as outlined below; within each specialization, recommended courses are provided.

Specialization in Mineral Exploration

At least 12 credits selected from ME 511, ME 521, ME 522, ME 523, ME 551, ME 562, ME 563. Other courses can be substituted with the approval of the research advisor and committee.

Specialization in Geotechnical Engineering and Geomechanical Engineering

At least 12 credits selected from ME 506, ME 508, ME 515, ME 517, ME 520, ME 525, ME 531, ME 534, ME 535, ME 537, ME 540, ME 541, ME 561. Other courses can be substituted with the approval of the research advisor and committee.

Specialization in Explosive Engineering

At least 12 credits selected from ME 515, ME 517, ME 520, ME 534, ME 545, ME 546, ME 548, ME 549, ME 550 or MENG 550, ME 552, ME 553 or MENG 570. Other courses can be substituted with the approval of the research committee and the department.

Learning Outcomes

The graduates will:

- be able to effectively and proficiently communicate in written text, with well-organized and professional-style reports and publications, as well as oral communication, capable of compiling, organizing, and presenting research and related information in oral form to peers, professionals.
- be able to contribute to the development of scientific knowledge by producing and publishing high level

scientific articles in journals and reputable conferences.

- be able to identify industrial and scientific problems and conduct research and development to address these problems or provide high level science founded solutions.
- understand professional codes-of-ethics and know what is expected of them as they enter the professional environment.

Doctor of Philosophy in Mineral Engineering

The proposed Mineral Engineering PhD degree is a multi-disciplinary and interdisciplinary program. Some level of flexibility is allowed to meet the focused research area of the student. However, the student's graduate committee, the department chair, and the dean of graduate studies must approve all courses.

The PhD requirement include the following

1. A student must complete a minimum of 72 credit hours beyond the Bachelor of Science degree in a related area. The total credits may be distributed as followings:
 - 48 credit hours of approved course work. Up to 30 credit hours from an appropriate M.S. degree, with the approval of the student's graduate committee and the department chair, may be applied; excluding thesis or independent study credits. Each student must take at least one credit seminar (ME 572).
 - 24 credit hours of dissertation.
 - A minimum of 24 credits of course work of 500-level or above, with at least 12 graduate credit hours of mineral engineering courses are required; ME 500, ME 590, and ME 591 do not count. Students may take courses from other departments, with the approval of the research committee and the chair, to complement their needs to complete their PhD requirements.
 - Any undergraduate courses (300 or 400 level) must have the approval of the research advisor and the department chair.
2. As candidates can choose a specific area of specialization, such as geotechnical and geomechanical engineering or exploration and mineral economics. These are the two main fields of specialization in the mineral engineering department. Other potential research areas are health and safety, environmental issues, explosive engineering, and mine operations. A detailed course program will be arranged according to the candidate's research area. This will be done with the approval of the research committee and the department chair.
3. The qualifying exam is to determine if the student is prepared and has sufficient background in his/her research area. The exam questions will be prepared and graded by the department faculty. Exams will be

written. The student must take the exam during the first year. If the student fails the exam, he/she may retake it only once. If the student fails the second exam, he/she will be terminated from the program. The student may appeal for another opportunity to remain in the program. In the event of a failure in a particular topic, the advisory committee with the approval of the department chair may recommend the student to take courses to cover the deficiencies.

- The student must present a detailed proposal for his/her research work. An oral presentation to the research committee must be presented after passing the qualifying exam. The presentation is open to the public. The candidate must pass the exam to advance to Candidacy. If there are deficiencies and shortcomings, the student will be given a second chance to correct these issues. If the student cannot resolve the deficiencies, he/she does not advance and will leave the program.

Additional requirements include the New Mexico Institute of Mining and Technology Graduate Program requirements.

Mineral Engineering Courses:

ME 101, Introduction to Mineral Engineering, 1 cr, 1 cl hr

The fundamentals of geology and mineral resource exploration and development applied to engineering. The role of the mineral engineer in mining, exploration, and geotechnical engineering. Field trips to mining and construction operations as well as guest speakers from industry, government, and research.

ME 215, Health and Safety, 2 cr, 2 cl hrs

Offered on demand

The roles of health and safety in the construction, operation, and maintenance of extractive mineral facilities. Federal and state health and safety codes. Laboratory and field work.

ME 320, Economic Analysis, 2 cr, 2 cl hrs

Corequisite: MATH 1510

Economic principles applied to decision-making problems in mineral engineering. Compound interest, depreciation, present worth and rate of return pertinent to project evaluation.

ME 340, Geostatistics and Mineral Evaluation, 3 cr, 3 cl hr

Prerequisites: ME 320

Introduction to statistics. Obtaining, evaluating, and presenting mineral resource information. Ore reserves estimation using geometric weighting techniques and geostatistical methods. The use of computers is emphasized.

ME 360, Exploration and Field Mapping, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: GEOL 200

Corequisite: ENGL 341

The acquisition and presentation of field geological data

applied to engineering site characterization and mineral exploration. Data presentation. Elements of exploration techniques including field applied mineralogy, geophysics, structural geology, geochemistry, drilling and sampling, and mapping. Laboratory reports and oral presentations.

ME 380, Surface Mine Design, 2cr, 2 cl hrs,

Prerequisite: ME 340

Surface mining methods and design, mine road and ramp design, introduction to drilling and blasting design

ME 381, Underground Mine Design, 2 cr, 2 cl hrs,

Prerequisite: ME 340

Generic underground mining methods, new generation of underground mining methods, mining method selection and design methodologies, stope/room and pillar dimensioning, ground stress control techniques, shaft sinking, underground mining automation and intelligent systems, sustainable mining considerations.

ME 410, Environmental Issues, 3 cr, 3 cl hrs

Prerequisites: ME 380

Corequisite: ME 413

Mine waste characteristics; regulations affecting mine operations; site selection, design and stability analysis of tailings impoundments. Water quality issues and control in mining. Mine waste management. Mine permitting requirements and reclamation. Design projects.

ME 413, Foundation Engineering, 3 cr, 3 cl hrs

Prerequisite: ME 420

Principles of soil mechanics and foundation engineering. Immediate and time dependent settlements, service loads, lateral loads, loading, approximate analysis methods, performance requirements, shallow foundations, lateral earth pressure, design of retaining walls, deep foundations, special footings, slope stability, and computer modeling of foundations. (Same as CE 413).

ME 420, Soil Mechanics, 3 cr, 2 cl hrs, 3 lab hrs

Corequisites: ES 302

Phase relationships, soil classification, clay mineralogy, compaction, flow of water in soils, effective stress, Mohr circle, stress-strain relationships and failure criteria, Mohr-Coulomb failure criterion, shear strength, consolidation, and consolidation settlement.

ME 421, Applied Economic Geology, 3 cr, 2 cl hrs, 3 lab hr

Prerequisite: GEOL 200

Offered on demand

Lithologic and lithochemical characterization of metalliferous ore deposits through the use of ore and alteration sample suites collected from various classes of deposits. Identification of hand specimen mineralogy; thin section and polished section analyses to establish paragenesis of both ore and gangue mineralization. Theoretical considerations ascertained by use of appropriate phase diagrams. Interpretation of wallrock alteration and characteristics of mineral

paragenesis for major ore deposit types. Design and implementation of mineral exploration using field and laboratory observations.

ME 422, Rock Mechanics, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: ME 420

Mechanical properties of intact rock and rock masses, classification of rock masses for engineering purposes, rock failure criteria, in situ stress measurement techniques, rock deformability. Labs consists of sample preparation, point load test, Brazilian test, Uniaxial test, and Triaxial test

ME 424, Materials Handling and Equipment Selection, 2 cr, 2 cl hrs

Prerequisites: ME 380 and ME 381

Truck and shovel operation, rail transport systems, conveyor belt selection, hoisting systems, storage and stockpiling.

ME 425, Occupational Health and Safety, Professional Responsibility, 3 cr, 3 cl hrs

Prerequisites: Junior standing

An overview of mine health and safety, Effective health and safety management systems, applications of behavioral science to health and safety, regulation and enforcement, incident reporting and analysis, industrial hygiene in mining.

ME 427, Site Investigation, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: ME 420

Offered on demand

Design of engineering site investigation for project planning and construction; acquisition, presentation, and interpretation of geologic field data for engineering design. Design concepts for rock and soft ground tunneling, rock slopes, tailings dams, landslides, ground subsidence, collapsible and swelling soils. Computer-aided data reduction and design.

ME 434, Drilling and Blasting Engineering, 3 cr, 3 cl hrs

Prerequisite: ES 302

Offered on demand

Introductory course in the application of explosives to rock fragmentation; theory of detonation and mechanisms of rock failure, dynamics, and propagation. The effects of rock properties on breakage. Blasting systems and production blasting techniques used in both surface and underground designs; environmental considerations and regulations. Principles of blasthole drilling and drill performance. Drilling and blasting economics.

ME 435, Rock Slope Engineering, 3 cr, 3 cl hrs

Prerequisite: ME 422

Field exploration and presentation of geologic data pertaining to rock slope engineering. Shear strength of rock discontinuities. Structural analyses and application of stereonet and stereographic projection. Basic mechanics and modes of slope failure. Plane, wedge, and toppling failure analyses. Effect of groundwater. Improvement of slope stability by drainage and support. Monitoring. Computer

applications. Shares lecture with ME 535, with additional expectations for graduate credit.

ME 437, Tunneling and Underground Excavation, 3 cr, 3 cl hrs

Prerequisite: ME 435

Field exploration and presentation of geologic data pertaining to underground excavations in rock. Rock mass classification systems. Empirical design and support selections, structural analysis and block stability. Application of stereonet and stereographic projection. Stress and rock mass strength, elastic and elasto-plastic analysis. Applications of numerical modeling. Review of machine excavation methods. Shares lecture with ME 537, with additional expectations for graduate credit.

ME 440, Mine Ventilation, 3 cr, 3 cl hrs

Prerequisite: ME 380 and ME 381; ES 216

Control of underground environmental problems; dusts, gases, temperature, and humidity. Analysis of natural and mechanical ventilation systems and equipment. Measurement techniques

ME 462, Mineral Deposits, 3 cr, 2 cl hrs, 2 lab hrs

Prerequisite: GEOL 200

Ore formation processes and ore mineralogy; geologic and geochemical characterization of ore deposits using hand specimen, petrographic, and field mapping techniques. Visits to prospects and operating mines to observe variations in ore deposit characteristics to document geologic and geochemical parameters used to describe ore-forming systems. (Same as GEOL 462)

ME 470, Senior Design I, 1 cr, 1 cl hr

Prerequisites: ME 380 and ME 381

Initiation of senior design project including written and oral project proposal; estimation of project design requirements and costing. Preliminary data acquisition and evaluation. Design topics are selected from mineral exploration, mine or geotechnical engineering.

ME 471, Senior Design II, 2 cr, 2 cl hrs

Prerequisite: ME 470 passed with a grade of "C" or better.

Continuation of design projects initiated in ME 470; implementation and evaluation of design details including cost analysis. Preparation of final project report with written and oral professional-style presentations.

ME 491, Directed Study, 1–4 cr as arranged

Special projects or topics in mining or geological engineering.

ME 500, Directed Research, cr to be arranged

This course may not be used to fulfill graduate degree requirements. Research under the guidance of a faculty member.

ME 506, Soil Mechanics, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: Graduate standing or Consent of instructor

Phase relationships, soil classification, clay mineralogy, compaction, flow of water in soils, effective stress,

Mohr circle, stress-strain relationships and failure criteria, Mohr-Coulomb failure criterion, shear strength, consolidation, and consolidation settlement.

ME 508, Rock Mechanics, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: Graduate Standing or consent of instructor

Mechanical properties of intact rock and rock masses, classification of rock masses for engineering purposes, rock failure criteria, in situ stress measurement techniques, rock deformability. Labs consists of sample preparation, point load test, Brazilian test, Uniaxial test, and Triaxial test.

ME 511, Mineral Economics, 3 cr, 3 cl hrs

Prerequisite: ES 316 recommended, or consent of instructor and advisor

Domestic and international mineral statistics, marketing, trade, conservation, and taxation. Energy economics. Labor economics. Economic calculations for feasibility studies on mineral properties. Participants prepare and present professional-style reports on international mineral development.

ME 512, Advanced Rock Mechanics, 3 cr

Prerequisite: Graduate standing or consent of instructor

Failure process, prediction of rock damage, ground reaction curve, ground support applications, dynamic rock failure and mine seismicity, measurements and monitoring techniques, blast induce rock damage and rock preconditioning, stability assessment techniques, and numerical modelling.

ME 515, Theory of Elasticity, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of the instructor

An introduction to tensor analysis, analysis of stress, balance laws, infinitesimal and finite theories of motion, strain and rotation tensors, compatibility equations, constitutive equations, Materials symmetry, uniqueness of the solution, solution of two-dimensional elasticity problems. Airy stress function, application of complex variable technique in elasticity, three-dimensional elasticity problems, energy methods, bending theory of plates. (Same as MENG 515)

ME 517, Advanced Finite Element Method, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of the instructor

An introduction to the numerical analysis calculus of variation, weak form of a differential equation, weighted residual techniques, solution of one-dimensional problems by the finite element method, bending problems, Lgrange and Hermite interpolation functions, isoparametric elements, numerical integration, two-dimensional problems, solution of Poisson and Laplace equations, triangular and quadrilateral elements, elasticity problems, theorem of minimum potential energy stiffness matrix, examples. (Same as MENG 517)

ME 520, Fracture Mechanics, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of the instructor

An introduction to the theory of elasticity, singular stress fields, Westergaard method, complex variable technique, stress intensity factor, fracture energy,

numerical and experimental methods in determination of stress intensity factor, fracture toughness, J-integral Elasto-plastic fracture. (Same as MENG 520)

ME 521, Advanced Minerals Exploration, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Practical application of geologic, geochemical, and geophysical exploration techniques to ore search. Remote sensing technology and integration into grassroots exploration programs. Recent developments in geophysical and geochemical prospecting. Case histories. Field application of mineral exploration techniques.

ME 522, Advanced Mineral Exploration Field Mapping, 3 cr, 2 cl hrs, 2 lab hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Detailed mapping of mineral deposits and prospects in collaboration with professional exploration geologists and engineers with application to minerals exploration. Design and implementation of orientation surveys. Field studies will include geochemical and geological laboratory analysis. Written reports and oral presentation of projects will be reviewed by professionals.

ME 523, Ore Petrography, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Identification and description of opaque and semi-opaque minerals using polished sections complemented by reflected-light petrographic techniques. Sampling techniques for exploration, mining, and environmental remediation purposes. Preparation of polished samples from rock, rock chip, ore concentrate, and tailings sample types. Heavy liquid separation techniques for concentration of heavy minerals and quantitative mineral analyses.

ME 525, Rock and Soil Plasticity, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of the instructor

Introduction to the theory of elasticity, Tresca, Von Mises and Mohr-Coulomb failure criteria, flow rule, hardening, softening and perfect plasticity, method of characteristics in solving plasticity problems, kinematics and velocity discontinuity, plastic limit analysis, upper- and lower-bound theorems, examples in soil and rock mechanics.

ME (526) – Applied Numerical Methods in Geomechanics, 3 cr

Prerequisite: Graduate standing or consent of instructor

Finite element method, finite difference method, boundary element method, particle interaction method, hybrid methods, elastic modeling and analysis, plastic modelling and analysis, constitutive models and rock mass response, rock mass parameter derivation, failure criteria, boundary conditions, 3D modelling and analysis of real problems.

ME (528) – Advanced Mine Ventilation, 3 cr

Prerequisite: Graduate standing or consent of instructor

Principles and methodology involved in underground space environmental control, ventilation network design, contamination control, fire and explosion modeling, primary and auxiliary ventilation design.

ME 531, Advanced Foundation Design and Analysis, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Advanced foundation design. Design of construction projects including but not limited to highways, airports, landfills, and slopes. Application of geosynthetics in design. Causes and remediation of structural cracking and foundation failures. Legal aspects. Case studies.

ME 534, Advanced Drilling and Blasting Engineering, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of the instructor

Application of explosives to rock fragmentation; theory of detonation and mechanisms of rock failure, dynamics, and propagation. The effects of rock properties on breakage. Blasting systems and production blasting techniques used in both surface and underground designs, environmental considerations and regulations. Principles of blasthole drilling and drill performance. Drilling and blasting economics.

ME 535, Stability of Rock Slopes, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Basic mechanics of slope failure. Field exploration and presentation of geological data. Shear strength of rock and rock discontinuities. Groundwater pressure and flow. Plane, wedge, circular, and toppling failure. Improvement of slope stability by drainage and support. Monitoring of slope displacements. Shares lecture with ME 435, with additional expectations for graduate credit.

ME 537, Design and Construction of Underground Openings, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Rock mass classification systems. Empirical design and support selections, stand-up times, block stability, and structural analysis. Elasto-plastic strain around openings. Ground reaction and response. Rock bolting and rock-support interaction analysis. Shares lecture with ME 437, with additional expectations for graduate credit.

ME 540, Computer Application in Geotechnical Engineering, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor; and ME 420 or 506

Computer programming using MATLAB, image processing and its applications in geotechnical engineering, introduction to finite difference and finite element methods with applications to various problems in geomechanics including steady, consolidation, slope stability, design of foundations, and underground

excavations.

ME 541, Ground Improvement, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor and advisor

Principles of ground improvement; mechanical modification including shallow compaction, dynamic deep compaction, vibro-flotation, and compaction by using explosives; hydraulic modification; modification by inclusions and confinement; physical and chemical modification.

ME 545, Vibration Analysis and Control, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor

Characteristics and analysis of vibrations from mining and construction blasting, heavy equipment and transient loads. Prediction of ground motions, air blast, and frequency; response spectra, structural response and damping. Damage analysis and prediction; probabilistic study of cracking. Human response. Vibration monitoring equipment and control.

ME 546, Detonation Theory, 3 cr, 3 cl hrs

Prerequisite: MENG 549 or ME 549; or consent of instructor and advisor. MENG 556 is recommended.

Development of classical detonation model for full-order detonation of secondary explosives. Ideal versus non-ideal detonation. Burn-rate models for pyrotechnics. The concept of deflagration to detonation transition. **(Same as MENG 546)**

ME 548, Rock Fracturing and Fragmentation by Explosives, 3 cr, 3 cl hrs

Prerequisite: Graduate or senior standing or consent of instructor and advisor

Fundamentals of dynamic rock strength, mechanisms of fracturing and fragmentation of rocks by explosives. Theoretical treatment of rock stress induced by internal explosion, methods for computer calculations of rock damage. Brief overview of devices, accessories, and methods used in industrial applications of fragmentation.

ME 549, Wave Propagation, 3 cr, 3 cl hrs

Prerequisite: MENG 545 or ME 545 and MATH 335; or consent of instructor and advisor

An in-depth study of the propagation of waves in various media. The derivation and application of the Rankine-Hugoniot jump equations. The concept of the rarefaction wave and various wave interactions. Derivation and application of the Mie-Grüneisen equation of state. The differential form of the conservation equations, as well as some numerical solutions for simple cases. Shares lecture with EXPL 412, with additional expectations for graduate credit. **(Same as MENG 549)**

ME 550, Advanced Explosives Engineering, 3 cr, 3 cl hrs

Prerequisites: MENG 549 or ME 549; or consent of instructor and advisor.

The detonation of non-ideal explosives, equation of state for porous media, shaped charge effect and

explosively formed projectiles. Shock compaction of powders, explosive welding and experimental methods used in the evaluation of explosives and their applications. The dynamic fracture of ductile and brittle Materials. **(Same as MENG 550)**

ME 551, Industrial Minerals, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor and advisor. Offered alternate years

Study of basic concepts of production and use of industrial minerals in modern society. Emphasis on complex interactions between economics, geology, processing, marketing, and transportation. Selected industrial minerals studies in detail. Several field trips to operations and occurrences. **(Same as GEOL 551)**

ME 552, Applied Explosives Engineering, 3 cr, 3 cl hrs

Prerequisite: Graduate or senior standing or consent of instructor and advisor

Commercial and other applications of explosives. Basics of thermal decomposition, explosion, shock initiation, and detonation. Laboratory methods of performance evaluation of explosives including shock initiation tests and underwater explosion tests. Techniques of forming and shaping of detonation waves. Some unusual applications of explosives in creating large magnetic fields.

ME 553, Computer Modeling of Detonations, 3 cr, 3 cl hrs

Prerequisite: MENG 549 or ME 549; or consent of instructor and advisor. MENG 517/ME 517 is recommended.

Introduction to hydrodynamic modeling applied to explosives. Numerical methods for modeling shock physics, detonation, and material response. Finite difference, finite element and smoothed particle hydrodynamic methods, equation of state and strength models, and numerical fracture and fragmentation.

(Same as MENG 553)

ME 561, Advanced Topics in Engineering Geology, 3 cr, 3 cl hrs

Offered on demand

Study of special topics in geologic hazards, site characterization, and related fields of interest in engineering geology.

ME 562, International Mining Field Trip, 3 cr, 3 cl hrs

Field trip in conjunction with the Student Chapter of the Society of Economic Geologists to a geologic and mining interest in a foreign country, usually Chile. Seminar-style class with a required term paper. Students are responsible for preparation of a field-trip guidebook, to be used by students and professionals participating in the field trip.

ME 563, Field Studies in Hydrothermal Alteration, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor and advisor

A field and lab-based course emphasizing the geochemistry and mineralogy of hydrothermal ore deposits, with substantial hands-on exercises and field-based descriptive work. Lab exercises utilize thin

section and polished section samples from hydrothermal ore deposit suites to demonstrate variations in protolith and alteration mineralogy, and result in the production of professional-style reports, interpreting the geochemical and exploration significance of the alteration assemblages observed. Field trips to mineral deposits emphasize the areal extent of hydrothermal alteration associated with porphyry, epithermal and skarn-style ore deposits.

ME 564, Economic Geology Field Camp, 1-4 cr to be arranged

Prerequisites: Graduate standing or consent of instructor and advisor

Field-based course emphasizing detailed mapping of mineral deposits and preparation of professional-style reports. Field areas comprise of distinct ore deposit settings, and involve description and recognition of rock types, alteration assemblages, and ore-related minerals. mapping in operating mines, and at prospects. Preparation of professional-style Executive Summary reports required. In autumn to be held in western U.S.; summer course to be held in western U.S. and in eastern U.S. in alternate summers.

ME 565, Mine Waste Characterization, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing or Consent of instructor

Environmental aspects of mine waste Materials. Geologic, geochemical, and engineering evaluation of tailings, waste rock dumps, and processing chemicals. Sampling and mineralogic analysis of mine wastes. Characterization of physical, chemical, and biological environments surrounding mine sites. Current environmental and mining regulations. Field trips, laboratory studies, and case histories.

ME 566, Mine Waste Management and Control, 3 cr, 3 cl hrs

Prerequisite: ME 565

Control of wastewater and solid pollutants from mining and processing of minerals. Design of facilities to control and manage waste streams resulting from mine and mill operations. Mine land reclamation and closure design. Design projects and field trips.

ME 570, Advanced Topics in Explosives Engineering, 3 cr, 3 cl hrs*Prerequisite: Consent of instructor*

Study of special topics in the application of explosives in the fields of rock blasting, structure response to vibrations, and ordnance.

ME 571, Advanced Topics in Mineral Engineering, 2-3 cr**ME 572, Graduate Seminar, 1 cr, 2 cl hrs***Prerequisite: Graduate standing*

Presentation and discussion of research ideas, including presentation of published papers.

ME 581, Directed Study, 1–3 cr**ME 590, Independent Study, cr to be arranged**

Independent research organized and conducted by the student under the direction of the student's advisor. Written final report and oral presentation required.

ME 591, Thesis (master's program), cr to be arranged**ME 595, Dissertation (master's program), cr to be arranged****Faculty Research Interests**

Chávez — Applied Mineral Exploration, Ore Deposits, Natural Resource Utilization

Fakhimi — Geomechanics, Numerical Modeling

Kuhn — Engineering Geology

McLemore — Economic Geology

N. Mojtabai — Site Investigation, Rock Fragmentation, Mine Design, Geomechanics, Drilling and Blastong

Razavi – Soil Mechanics, Image Processing, X-Ray computer Tomography

Roghanchi – Mine Ventilation, Health and Safety, Mine Design

Saiang – Geomechanics, Computer Modeling, Surface and Underground Mining

Oravec — Rock Mechanics, Surveying

Petroleum Engineering

Professors Engler, Nguyen

Associate Professors Chen, Rahnama (Chair of the Department)

Assistant Professors Ampomah

Adjunct Faculty: Balch, Buckley, Foster, Grigg, Harris, Juanjia, Liu, Lorenz, Martin, Quoyin, Seright, Stubbs, Yu, Zhang

Degrees Offered: B.S. in Petroleum and Natural Gas Engineering, M.S. and Ph.D. in Petroleum Engineering

Petroleum and natural gas engineering is a broad-based discipline primarily concerned with the development, exploration, and conservation of oil and gas resources. Petroleum and natural gas engineers plan and supervise drilling and well-completion programs, design and select drilling and production equipment, optimize the production of oil and natural gas, estimate reserves, and manage oil and gas properties.

The oil and gas industry is a progressive and highly technical business, which offers opportunities to young engineers, both in the United States and abroad. A petroleum and natural gas engineering graduate may obtain a responsible position with an oil company, establish a consulting business, or become an independent oil producer.

Program Educational Objectives

The mission of the Petroleum Engineering program is to prepare students for the challenges of such a diversified career by providing students with the necessary skills to achieve success in their future profession. To achieve this mission, the following educational objectives are emphasized:

- Our graduates will use their highly competitive skills in a range of engineering career paths to become leaders in the energy industry.
- Our graduates will seek out continuing education opportunities, striving for technical excellence
- Our graduates will leverage evolving technology through collaborative engagement in both industry workshops and professional societies.

By graduation, a student will be capable of solving a variety of petroleum engineering problems and be able to integrate petroleum engineering concepts to a practical design project.

Student Outcomes for Undergraduate Program in Petroleum Engineering

Graduates of the Bachelor of Science in Petroleum Engineering program will have demonstrated

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions

that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Undergraduate Program

Bachelor of Science in Petroleum and Natural Gas Engineering

Minimum credit hours required—134

In addition to the General Education and Institute Core Curriculum (page 80), the following courses are required:

- PETR 101 (1), 111 (3) 245 & 245L (4), 311 & 311L (4), 345 & 345L (4), 370 (3), 413 (3), 424 & 424L (4), 425 & 425L (4), 445 (3), 450 (3), 470 (3), 471(3), 472 (3)
- ES 201 (3), 216 (3), 302 (3), 303 (3), 316 (3), 347 (3)
- MATH 2532 (4), 335 (3)
- GEOL 1110 & 1110L (4), 2330 (3), GEOL 460 (3)
- Petroleum Electives: Three credit hours of upper-division technical and petroleum and natural gas engineering electives are selected by the student with the faculty advisor's approval to fulfill the requirement of 134 credit hours needed for graduation.

Petroleum and natural gas engineering majors must obtain a C or better in all petroleum engineering courses to graduate.

Only courses in Areas 4, 5, and 6 of the general education core curriculum requirements (page 80) may be taken on an S/U basis.

Sample Curriculum for the Bachelor of Science in Petroleum and Natural Gas Engineering

Semester 1

- 1 PETR 101 (intro)
- 4 MATH 1510 (calculus)
- 4 CHEM 12155 & 1215L (general)
- 3 ENGL 1110 (college English)
- 4 GEOL1010 & 1010L (earth processes)
- 16 Total credit hours

Semester 2

- 4 MATH 1520 (calculus)
- 3 PETR 111 (Comp applications)

5 PHYS 1310 & 1310L (general)

3 ENGL 1120 (college English)

3 Social Science/Humanities

16 Total credit hours

Semester 3

4 MATH 2532 (calculus)

4 CHEM 1225 & 1225L (general)

5 PHYS 1320 & 1320L (general)

3 ES 201 (statics)

16 Total credit hours

Semester 4

4 PETR 245 & 245L: (petroleum fluids)

3 MATH 335 (ordinary differential equations)

3 ES 216 (fluid mechanics)

3 ES 302 (mechanics)

3 ES 347 (thermodynamics)

3 GEOL 2330 (Earth's crust)

19 Total credit hours

Semester 5

4 PETR 311 & 311L (drilling)

4 PETR 345 & 345L (reservoir engineering I)

3 ES 303 (dynamics)

3 ENGL 341 (technical writing)

3 Social Science/Humanities

17 Total credit hours

Semester 6

3 PETR 370 (formation evaluation)

3 PETR 450 (well testing)

3 PETR 413 (well design)

3 PETR 445 (reservoir engineering II)

3 GEOL 460 (subsurface geology)

3 Social Science/Humanities

18 Total credit hours

Semester 7

4 PETR 424 & 424L (production engineering)

3 PETR 470 (reservoir simulation)

3 PETR 471 (reservoir description)

3 ES 316 (economics)

3 Social Science/Humanities

16 Total credit hours

Semester 8

4 PETR 425 & 425L (well completions)

3 PETR 472 (reservoir management)

3 PETR Elective

3 Humanities/Social Science/Fine & Creative Arts

3 Humanities/Social Science

16 Total credit hours

Minor in Petroleum Engineering

Minimum credit hours required—18

The following courses are required:

- PETR 245 (3), 311 & 311L (4), 345 & 345L (4), 424 & 424L (4),
- At least one of the following: PETR 413 (3), 445 (3)

Graduate Program

The Petroleum Engineering program offers two options for a Master of Science Degree—with thesis or independent study—and a Doctor of Philosophy degree. All graduate students are required to register for and attend the Graduate Seminar (PETR 570) each semester it is offered. Exceptions may be made only with approval of the student's advisor and the department chair.

The Ph.D. and master's programs are open to students with degrees in fields other than petroleum and natural gas engineering. A special course program will be tailored for those students who have not completed a B.S. in petroleum and natural gas engineering to provide an appropriate background. Prospective students are encouraged to visit www.nmt.edu/~petro for more details.

Master of Science in Petroleum Engineering

Thesis Option

The master's program requires a minimum of 24 credit hours of coursework and 6 credit hours of thesis. The courses are designed to advance the student's knowledge in topics of petroleum engineering. The research thesis provides a means to do independent and analytical thinking on a specific subject. The student's course of study must be approved by the student's advisory committee and the department chair and must fulfill the general requirements for the master's degree.

Independent Study Option

Candidates for the non-thesis Master of Science option must complete a total of 36 credit hours, of which a minimum of three (3) credit hours must be independent study (PETR 590). At least 18 of the credit hours must be from graduate-level Petroleum Engineering courses, excluding PETR 581 and 590. The student's course of study must be approved by the student's advisory committee and must fulfill the general graduate requirements for the master's degree without thesis. The final outcome of the independent study is to submit a formal paper followed by an oral presentation to the advisory committee.

Doctor of Philosophy in Petroleum Engineering

In order to be admitted to the Ph.D. program, a student must meet the requirements as set forth by the Graduate Program and have completed an M.S. degree with thesis. A minimum of 60 credit hours past the master's degree is required. New Mexico Tech courses taken to satisfy this requirement must have content different from courses applied to previous degrees. In addition to the department administered preliminary examination, the student is required to successfully complete a candidacy examination and a defense of the dissertation administered by the student's advisory committee. (See www.nmt.edu/~petro for more detailed information.)

The 60-credit requirements should be distributed as follows:

1. Minimum 30 credits regular* courses and Directed Study (581).
 - Minimum 12 credits of regular* 500-level petroleum engineering courses.
 - Maximum 9 credits of Directed Study (PETR 581); maximum 6 credits from the same professor.
 - Minimum 6 credits from outside of petroleum engineering in either engineering, engineering management, or science disciplines. Students with degrees in disciplines other than Petroleum engineering may take an additional 6 credits of petroleum engineering courses instead.
2. Minimum 24 credits and maximum 30 credits of Dissertation (PETR 595).
3. Registration in Graduate Seminar (PETR 570) is required.

* Courses are considered regular only if a course title and scheduled meeting time are specified and the course is open to all qualified students.

Petroleum Engineering Courses

PETR 101, Introduction to Petroleum Engineering, 1 cr, 1 cl hr

Introduction to energy supply and demand. Define reservoir, drilling and production aspects of petroleum engineering. Included are professionalism and ethics in the work environment.

PETR 111, Computer Applications for Petroleum Engineering, 1 cr, 3 lab hrs

Corequisite: MATH 1240

Development of algorithms in Excel™ to solve petroleum engineering problems: gas z-factor, static and flowing gradients, pump design, well testing functions and others.

PETR 245, 245D, Petroleum Fluids, 3 cr, 3 cl hrs

Prerequisites: CHEM 1225; MATH 1520

Corequisite: PETR 111

Characteristics and properties of reservoir fluids. Representation of fluid property data for computer uses with models and regression.

PETR 245L, Petroleum Fluid Laboratory, 1 cr, 3 lab hrs

Corequisite: PETR 245

Characterize pressure, volume and temperature relationships using virtual simulation and Laboratory measurement of reservoir fluid properties.

PETR 311, Drilling Engineering, 3 cr, 3 cl hrs

Prerequisite: ES 216

Corequisite: ES 302

Introduction to drilling engineering through the study of rig equipment functions. Engineering analysis of drill string buoyancy, drilling mud circulation and flow hydraulics, drill string components, and well control. Preliminary discussion of pore and fracture pressure gradients. Well plan profile including drill bit selection, drilling fluid selection, drill string component section, and well control.

PETR 311L, Drilling Mud Laboratory, 1 cr, 3 lab hrs

Corequisite: PETR 311

Basic drilling operations, drilling hydraulics and well control operation using a drilling simulator. Standard API measurements and design of the properties of drilling fluids.

PETR 345, Reservoir Engineering I, 3 cr, 3 cl hrs

Prerequisite: ES 216

Corequisites: PETR 245

Properties of reservoir rocks and homogeneous and multiphase fluid flow in reservoirs. Capillary phenomena, relative permeability, compressibility, and fluid saturation distribution. material balances. Statistical analysis using regression, probability concepts, and computer applications to reservoir data.

PETR 345L, Reservoir Engineering Laboratory, 1 cr, 3 lab hrs

Corequisite: PETR 345

Laboratory measurement of reservoir fluid/rock properties, core flood tests and experimental data analysis.

PETR 370, Formation Evaluation, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: PHYS 1320; PETR 345

Introduction to logging tool principles and operation. Evaluation of reservoir properties and interpretation of open hole well logs. Multiwell correlations with application to volumetric calculations. Lab exercises on reservoir mapping and well log case studies. (Same as GEOL 370)

PETR 411, Advanced Drilling, 3 cr, 3 cl hrs

Prerequisite: PETR 311 or consent of instructor and advisor

Drilling operations technology with an emphasis on field practices and techniques. Advanced topics including drilling fluids rheology and hydraulics. Mechanics of BHA in vertical and directional holes. Directional well trajectory predictions and design. Modeling of drag and torque. Dynamics of drill string, wellbore measurements, deepwater drilling and heat transfer in wells.

PETR 413, Well Design, 3 cr, 3 cl hrs

Corequisite: PETR 311

Details of the development of pore and fracture pressure gradients. Casing depths using pore and fracture pressure gradients plots. Review of engineering analysis for casing string design. Selection of casing, cement class and well cementing equipment and methods. Development of detailed well plan for drilling and completion of oil and gas wells. Directional and horizontal drilling and drillstring design.

PETR 424, Production Engineering, 3 cr, 3 cl hrs

Prerequisite: PETR 345, ES 216

Elements of producing oil and gas wells. Flow of single and multiphase fluids in vertical and horizontal pipes. Choke performance. Nodal analysis systems approach to well production performance optimization. Production decline analysis using exponential,

harmonic, and hyperbolic decline curves applied to actual well production data. Introduction to artificial lift techniques.

PETR 424L, Production Engineering Laboratory, 1 cr, 3 lab hrs

Corequisite: PETR 424

Basic data acquisition system, experimental determination of frictional pressure losses in pipes, comparison of experimental data with published engineering fluid flow data, artificial lift methods, and multiphase flow in wellbores.

PETR 425, Well Completion, 3 cr, 3 cl hrs

Prerequisite: PETR 345

Corequisite: PETR 413

Well completion methods. Design and selection of tubing; perforating performance; sand, water and gas control. Introduction to stimulation operations, selection of stimulation techniques, design of acid and hydraulic fracture treatments.

PETR 425L, Well Completions Lab, 1 cr, 3 lab hrs

Corequisite: PETR 413

Corequisite: PETR 425

The composition, testing, and design of cement slurries and fracturing fluids. Application of hydraulic fracture design using stimulation software.

PETR 440, Directional Drilling & Innovative Drilling Methods, 3 cr, 3 cl hrs

Prerequisites: PETR 311

Two and three dimensional directional well path design; horizontal drilling; mathematical model deflection tool analysis; 2D and 3D vector application; down-hole motors and MWD techniques; underbalanced drilling; casing while drilling; coiled-tubing drilling.

PETR 441, Natural Gas Reservoir Engineering, 3 cr, 3 cl hrs

Prerequisite: PETR 345

Estimation of gas reserves for dry and gas condensate reservoirs. Evaluation of deliverability tests and subsequent development of flow equations. Determination of gas recovery from unconventional reservoirs; e.g., coalbed methane, tight gas sands, shales. Strategies for gas field development. Additional work is required at graduate level.

PETR 445, Reservoir Engineering II, 3 cr, 3 cl hrs

Prerequisite: PETR 345

Advanced reservoir engineering principles and applications including material balances, decline curve analysis, unsteady flow in porous media, partial penetration, water influx, reservoir heterogeneity, fractional flow, and frontal advance.

PETR 446, Improved Petroleum Recovery, 3 cr, 3 cl hrs

Prerequisite: PETR 445 or consent of instructor and advisor

Water flooding techniques. Water handling. Injection and production well patterns. Productive techniques for economic operations. Introduction to enhanced oil

recovery; polymer, surfactant, thermal and miscible flooding.

PETR 450, Well Performance, 3 cr, 3 cl hrs

Prerequisite: PETR 345, MATH 335

Diffusivity equation and solutions for slightly compressible liquids; dimensionless variables; type curves; applications of solutions to buildup, drawdown, multi-rate, interference, pulse and deliverability tests; extensions to multiphase flow; analysis of hydraulically fractured wells, production data analysis, rate normalized pressure analysis.

PETR 460, Numerical Simulation, 3 cr, 3 cl hrs

Prerequisite: PETR 445

Application of finite difference and finite element techniques for solving reservoir engineering problems.

PETR 470, Applied Reservoir Simulation, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: PETR 445

Use reservoir simulator for numerical modeling of petroleum engineering problems beyond classical approaches. Introduction to simulation fundamentals, work with post- and pre-processing software, design and construct black oil, compositional and thermal models. History matching, predict and optimize well performance.

PETR 471, Reservoir Description, 3 cr, 3 cl hrs

Prerequisites: PETR 370, 445; GEOL 460

Corequisite: PETR 424

Offered fall semester

Integration of reservoir, production, and other field data into a comprehensive design project. Development and optimization of multiple design options.

PETR 472, Reservoir Management, 3 cr, 3 cl hrs

Prerequisite: PETR 471; ES 316

Offered spring semester

Economic analysis of petroleum-producing properties; evaluation of reservoir management decisions for oil and gas development; establishing the effect of risk and uncertainty on economic evaluation. Prepare an Authority for Expenditure (AFE) project report.

PETR 478, Petroleum Seminar, variable credit, 2 cl hr

Prerequisite: Senior standing or consent of instructor and advisor

Current topics in petroleum and natural gas engineering. Techniques of oral presentation of research and development data.

PETR 491, Special Problems in Petroleum and Natural Gas Engineering, 1–3 cr as arranged

Prerequisite: Senior standing or consent of instructor and advisor

Individual studies in petroleum and natural gas engineering problems of special interest.

PETR 523, Numerical Simulation, 3 cr, 3 cl hrs

Prerequisite: PETR 445 or consent of instructor and advisor; ability to write a computer program

The simulation of subsurface fluid reservoirs using

numerical models.

PETR 524, Fluid Flow in Porous Media, 3 cr, 3 cl hrs

Prerequisites: PETR 445 or consent of instructor and advisor.

Physical concepts involved in the flow of fluids in porous media; aspects of Darcy's Law; multiphase flow concepts of relative permeability and capillary pressure.

PETR 532, Advanced Well Stimulation, 3 cr, 3 cl hrs

Prerequisite: Consent of instructor

Theories of hydraulic fracturing, mechanics of fracturing, rheology of fracturing fluids, acid fracturing treatment, models for matrix acidizing, evaluation of stimulation operations.

PETR 537, Petroleum-Related Rock Mechanics, 3 cr, 3 cl hrs

Studies of theories and applications of rock mechanics to petroleum engineering. Topics include laboratory measurements of porosity, permeability, and deformation behavior as a function of stress state, in situ stress measurements, wellbore stability, sand control, and reservoir compaction/subsidence.

PETR 541, Natural Gas Reservoir Engineering, 3 cr, 3 cl hrs

Prerequisite: PETR 345

Estimation of gas reserves for dry and gas condensate reservoirs. Evaluation of deliverability tests and subsequent development of flow equations. Determination of gas recovery from unconventional reservoirs; e.g., coalbed methane, tight gas sands, shales. Strategies for gas field development. Additional work is required at graduate level.

PETR 544, Advanced Reservoir Engineering, 3 cr, 3 cl hrs

Prerequisite: PETR 445 or consent of instructor and advisor

Studies of natural water drive reservoirs in finite and infinite aquifers. Transient pressure behavior in heterogeneous reservoirs. Material Balance Equations from advanced viewpoint.

PETR 545, Advanced Production Design, 3 cr, 3 cl hrs

Prerequisite: PETR 425 or consent of instructor and advisor

Oil and gas well production principles. Flowing well performance, two-phase vertical flow, theory and design of artificial lift systems.

PETR 546, Advanced Formation Evaluation, 3 cr, 3 cl hrs

Prerequisite: PETR 370 or consent of instructor and advisor

Study of physical and textural properties of reservoir rocks which provide a link between reservoir engineering and well logging. Advanced exploration and production logging. Estimation of geological environment. Quantitative reservoir evaluation in different lithologies from log data. New logging techniques.

PETR 547, Naturally Fractured Reservoirs, 3 cr, 3 cl hrs

Geological characterization and reservoir simulation of

naturally fractured reservoirs. Description of natural fractures and fracture systems from surface outcrops, core analysis, log interpretation, and well testing. Fluid-flow simulation of fractured reservoirs using numerical models.

PETR 548, Reservoir Geomechanics, 3 cr, 3 cl hrs

Prerequisites: PETR 445 or consent of instructor and advisor

Fundamentals and issues of coupled fluid-flow/thermal/geomechanics associated with hydrocarbon production. Topics include elasticity, poroelasticity, thermo-poroelasticity, reservoir stress depletion/rebound, productivity of stress-sensitive reservoirs, and waterflood-induced fracturing.

PETR 552, Fluid/Surface Interactions, 3 cr, 3 cl hrs

Prerequisite: Consent of instructor

The physics and chemistry of interfaces, focusing on the behavior of multifluid systems both in the presence and absence of solids. How basic interactions among microscopic particles can explain macroscopic phenomena. Application-oriented, focusing on interactions important in hydrology, petroleum engineering, and environmental engineering. (Same as HYD 552)

PETR 554, Advanced Natural Gas Engineering, 3 cr, 3 cl hrs

Prerequisite: PETR 464 or consent of instructor and advisor

Gas flow in vertical and inclined pipes, surface facilities, gas processing, overall transportation requirements.

PETR 556, Advanced Drilling, 3 cr, 3 cl hrs

Prerequisite: PETR 311

The following topics will be covered in this class: directional and horizontal drilling, drag and torque modeling, advanced wellbore hydraulics, and innovative drilling methods including underbalanced drilling, casing drilling and coil tubing drilling.

PETR 557, Advanced Artificial Lift Methods, 3 cr, 3 cl hrs

Prerequisite: PETR 424

Offered Fall Semester

This class will cover most of the common artificial lift methods in oil and gas industry including: Electrical Submersible Pump (ESP), Gas Lift, Rod Sucker Pump, Plunger Lift, and Progressive Cavity Pump.

PETR 558, Advanced Topics in Enhanced Oil Recovery Methods, 3 cr, 3 cl hrs

Prerequisite: PETR 446 or consent of instructor and advisor

Advanced topics may include surfactant and alkali flooding mechanisms. Polymer flooding and rheology of non-Newtonian fluids. Gas injection methods including carbon dioxide, hydrocarbons, and nitrogen. Thermal recovery.

PETR 560, Phase Behavior of Petroleum Fluids, 3 cr, 3 cl hrs

Prerequisite: PETR 245 or consent of instructor and advisor

Use of equations of state for predicting PVT behavior of complex petroleum fluids. Emphasis on the descriptions of fluids used in simulating gas injection recovery processes and multiphase flow in pipes. Correlations for phase viscosity and interfacial tension.

PETR 564, Advanced Well Testing, 3 cr, 3 cl hrs

Prerequisite: PETR 370 or consent of instructor and advisor

The partial differential equations for liquid and gas flow in porous media, boundary conditions including skin and well-bore storage effects. Applications of Laplace transformation. Pressure buildup and drawdown tests.

PETR 570, Graduate Seminar, 1 cr, 2 cl hrs

Prerequisite: Senior or graduate standing

Presentation and discussion of research ideas. Review of recently published papers/new concepts.

PETR 571, 572, Advanced Topics, 2–3 cr, 2–3 cl hrs

Offered on demand

Prerequisite: Consent of instructor

Special topics in petroleum and natural gas engineering.

PETR 581, Directed Study, 1–3 cr each semester

Prerequisite: Consent of instructor

Research and literature survey as directed by advisor on subjects of interest pertaining to petroleum and natural gas engineering.

PETR 590, Independent Study, 1–3 cr

Independent research organized and conducted by the student under the direction of the student's advisor. Written final report and oral presentation required.

PETR 591, Thesis (master's program), cr to be arranged**PETR 595, Dissertation (doctoral degree program), cr to be arranged**

Prerequisite: Successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.

Faculty Research Interests

Ampomah: Numerical Optimization, Reservoir Geomechanics, Reservoir Characterization, Geological Modeling and Upscaling, Enhanced Oil Recovery, Multiphase Reservoir Flow Modeling, History Matching, Reduce Order Modeling, Uncertainty Quantification, CO2 Sequestration.

Balch: Fuzzy Expert Systems, Data Mining

Buckley: Petrophysics and Surface Chemistry, Reservoir Wettability

Chen: Well Testing, Reservoir Mechanics

Engler: Formation Evaluation, Petrophysics, Unconventional Gas Recovery, Stimulation

Grigg: Gas Flooding Processes, Phase Behavior

Jianjia: Hollow fiber membrane based desalination technologies for oilfield produced water treatment; Fluids flow in porous media at high temperature and high pressure (HTHP); CO2 floods and nanoparticle assisted CO2 foam floods for enhanced oil recovery (EOR);

Kelly: Reservoir Evaluation and Management

Nguyen: Drilling, Artificial Lift Methods, Well Stimulation, Geomechanics in Unconventional / Partially Depleted Reservoirs and Horizontal Wells, and Multiphase Flow.

Quoyin: Chemical flooding using surfactants for enhanced oil recovery, .e., alkaline/surfactant/polymer flooding, and surfactant/polymer flooding.

Rahnema: Simulation/Modeling, IOR, Reservoir Phase Behavior

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