NMT Course Catalog 2017-2018
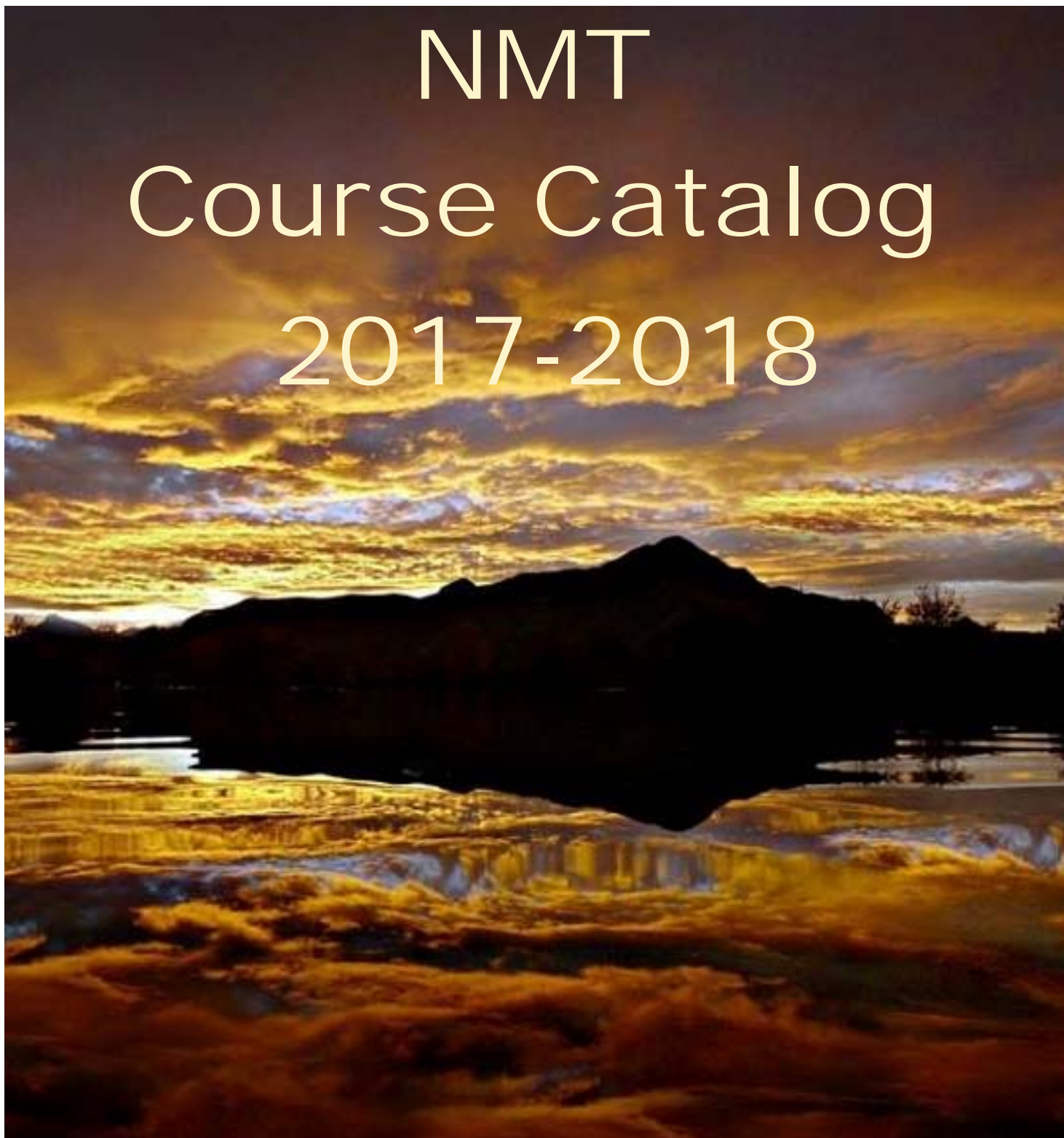
NEW MEXICO TECH

SCIENCE • ENGINEERING • RESEARCH UNIVERSITY

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For information on undergraduate admission, please contact:

Director of Admission
New Mexico Tech
801 Leroy Place
Socorro, NM 87801
575.835.5424
1.800.428.TECH
admissions@nmt.edu
www.nmt.edu/future-students

International students who wish to apply for undergraduate admission, please contact:

International & Exchange Programs
575.835.5022
International@nmt.edu

For information on graduate admission, contact:

Dean of Graduate Studies
New Mexico Tech
801 Leroy Place
Socorro, NM 87801
575.835.5513
1.800.428.TECH
graduate@nmt.edu

Prospective graduate students,
both domestic and international,
should use the address above.

Academic Calendar

2017 Fall Semester

Deadline for December Intent to Graduate	July 1
Validation Day	August 21
Classes Begin	August 21
Late Registration Fees Begin ($30/day)	August 24
Last day to add a class	August 29
Academic Holiday	September 04
Non-Validated Student Disenroll	September 06
Last day to drop a class	September 08
Registration Closes	September 08
Midsemester	October 11
Academic Holiday	October 20
Grade Option Deadline (pass/fail or Audit)	November 08
Last Day to Withdraw from a class	November 08
Thanksgiving Vacation	November 23, 24
Pre-Registration for Spring 2017	Nov 27—Dec 1
Last Day of Classes	December 08
Finals Begin	December 09
End of Finals	December 15
End of Semester	December 15

2018 Spring Semester

Deadline for May Intent to Graduate	December 1
Academic Holiday, Offices Open	January 15
Validation Day	January 15
Classes Begin	January 16
Late Registration Fees Begin ($30/day)	January 18
Last day to Add a Class	January 23
Non-validated Student Disenroll	January 31
Last day to Drop a class	February 02
Registration Closes	February 02
Midsemester	March 07
Spring Vacation	March 12-16
Academic Holiday	March 30
Grade Option Deadline (pass/fail or Audit)	April 04
Last day to Withdraw from a class	April 04
Pre-Registration for Summer 2018	April 09-13
Pre-Registration for Fall 2018	April 16-20
Last Day of Classes	May 2
Finals Begin	May 3
End of Finals	May 08
End of Semester	May 08
Commencement	May 12

2018 Field Camp

Geology Field Camp	May 19-July 1

2018 Summer Session

Deadline for August Intent to Graduate	June 1
Validation Day	June 11
Classes Begin	June 11
Non-validated Student Disenroll	June 13
Late Registration Fees Begin ($30/day)	June 14
Last day to add/drop a class	June 19
Registration Closes	June 19
Academic Holiday	July 04
Grade Option Deadline (pass/fail or Audit)	July 18
Last day to Withdraw from a class	July 18
End of Semester	August 03

Degrees Offered at Tech

Associate Degrees
Associate of General Studies
Associate of Science in Business

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 and Natural
    Gas Engineering
Physics
Psychology
Technical Communication

Bachelor of General Studies

Graduate Certificate
Electrical Engineering
Hydrology
Scientific & Professional Communication

Master of Engineering Management

Master of Science for Teachers

Master of Science
Biology
Chemistry
Computer Science
Electrical Engineering
Environmental Engineering
Geochemistry
Geology
Geophysics
Hydrology
Materials Engineering
Mathematics
Mechanical Engineering
Mineral Engineering
Petroleum Engineering
Physics

Doctor of Philosophy
Biotechnology
Chemistry
Computer Science
Earth and Environmental Science
    Geobiology
    Geochemistry
    Geology
    Geophysics
    Hydrology
Electrical Engineering
Materials Engineering
Mathematics
    Applied & Industrial Mathematics
Mechanical Engineering
    Intelligent Energetic Systems
Petroleum Engineering
Physics
    Astrophysics
    Atmospheric Physics
    Mathematical Physics

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

Undergraduate Minors
Aerospace Engineering
Biology
Biomedical Engineering
Chemistry
Chemical Engineering
Civil Engineering
Computer Science
Earth Science
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 Studies
Technical Communication

Other Principal Areas of Instruction
(no degree offered)
Aerospace Studies (AFROTC)
Art History
English
Fine Arts
History
Languages
Music
Philosophy
Physical Recreation
Political Science

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 213 Fitch 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.

Other Formats

The New Mexico Tech 2017-2018 catalog is available on-line at: ***www.nmt.edu***

The catalog is also available in other formats upon request. Contact:
    The Office of Admission
    New Mexico Tech
    801 Leroy Place
    Socorro, NM 87801
    575.835.5424 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.

Terms and Abbreviations You Should Know

Academic Terms

Academic Load

The academic year at 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.

Undergraduate Student 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 load; 3 credit hours is half-time.

Graduate Student 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. Fine Arts (FA), Community Education courses (CED), Health and Wellness (HW), and Physics Recreation (PR), do not count toward the minimum credit hours for graduate students. Graduate loads only count courses numbered 300 and above, except when preapproved with a lower division course approval signed by the Graduate Dean.

Veteran Student Load

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 (PR), Fine Arts (FA), and Community Education courses (designated by the letter "C" in the course number) do not count toward the minimum credit hours for veterans. Complete information can be obtained in the Veterans Affairs Office.

Auditing a Class

If you wish to participate in a course to learn about the subject but not be required to earn a letter grade, you can audit the course. You will receive a grade of satisfactory audit (SA) or unsatisfactory audit (UA) as determined by the instructor, but no credit. Payment is the same as for a credit class. Professors will expect you to attend class and to be prepared to participate in the course.

Graduate Auditing a Class

Graduate students who earn unsatisfactory audits are not making satisfactory academic progress. Graduate students may only audit at most one (3-4 credit) course.

Challenge Exams

If you think you already know the material in a course you are required to take, ask the department chair for a challenge exam. For a small fee, you will be tested on the course material. Depending on the department, you may receive a letter grade or an "S" (for Satisfactory), or they may simply waive the course. Or, of course, you may be told you have to take the course anyway.

Course Numbers

Courses numbered from 100 to 199 are intended primarily for first-year students (freshmen); 200 to 299 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. Graduate students may be allowed credit for courses numbered 300 and above. Exceptions may be made with the approval of the major advisor and instructor.

Credit Hours

Credit hours for all courses, including synchronous and asynchronous distance delivery courses, are measured in class hours (cl hrs), lab hours (lab hrs), or recitation/discussion hours (recitation hrs).

"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 about 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.

To graduate with a bachelor's degree, you will need a minimum of 120 credit hours, depending on your chosen major.

Directed Study

Directed study courses are usually self-paced 300- to 500-level classes. Typically, a directed study is research-oriented and allows you to work and progress in a relatively unstructured situation. To sign up, you will need the instructor's permission, the approval of the department chair, and a special form from the Office of the Registrar.

Graduate Directed Study

Directed Study may only be counted toward graduate degrees with earned letter grades of A through C *and* permission of the student's graduate committee.

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. Please refer to the specific degree requirements for your major.

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 or a Bachelor of General Studies. However, some majors allow students to use these classes to fulfill elective credit.

Graduate Electives

All graduate electives must be 300-level or above *and* graded with a letter grade (A through C). See your program requirements for further restrictions.

General Education Core Curriculum Requirements

These are courses in humanities, mathematics, and basic science which all bachelor of science students must complete in order to graduate. The general degree requirements should be met by the end of your sophomore year.

Good Academic Standing (Undergraduate)

Graduate students: For information on satisfactory progress, see page 53

A regular undergraduate student will be considered to be in good standing if the student maintains the minimum semester grade-point average (GPA) listed below:

Total semester hours attempted (cumulative)	Minimum semester GPA needed to maintain good standing
0-29	1.60
30-59	1.80
60 or more	2.00

For determination of academic standing, "semester hours attempted" means courses in which a student earns grades of A, A-, B+, B, B-, C+, C, C-, D+, D, F, S, U, and all transfer credits. "Semester hours attempted" does not include courses in which a student earns grades of IN, SA, UA, W, or WO. Transfer credits are not used in computing the GPA.

A student whose semester GPA falls below the minimum requirements needed for good standing will be placed on academic probation (see page 72).

Academic Warning

Any undergraduate student whose GPA for the preceding semester is less than 2.00 or whose cumulative GPA is less than 2.00 will be placed on academic warning, regardless of their total semester hours attempted or academic standing.

When a student is placed on academic warning, he or she must:

- visit the Office of the Registrar and complete all of the self-assessment activities indicated by the Associate Dean of Student Success.
- meet with their academic advisor or their major Department Chair and develop an academic action plan for the next three semesters
- submit the academic action plan to the Office of the Registrar no later than 10 days prior to the close of registration during the Fall and Spring semesters or 2 days prior to the close of registration during the Summer semester.

The Academic Standards and Admissions Committee will review the academic action plan and determine if the above conditions have been successfully met. Failure to comply with these requirements will result in a hold placed on the student's account until these conditions are satisfied.

Grade Point Average (GPA)

Your semester GPA is found by multiplying the number of credit hours for each course with a number corresponding to your grade in the course and then dividing by the total number of credit hours in the semester. A=4, B=3, C=2, D=1, F=0. For example, a student taking two three-hour courses who received an A and a B would have a GPA for that semester of 3.5.

$$([(3 \times 4.0) + (3 \times 3.0)]/[3 + 3]=21.0/6=3.5)$$

See page 70 for a complete list of possible grades and their grade points.

Courses taken for grades of S, U, SA, and UA are not calculated in your GPA.

Your cumulative GPA is an average over your entire Tech career. Transfer credits are not included in your cumulative GPA.

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. You may declare or change your major at the Office for Student Learning.

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, a minimum of 18 credit hours is required. 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. You may declare or change your minor at the Office for Student Learning.

Prerequisites and Corequisites

Some courses have prerequisites, courses you must successfully complete before enrolling in that course. Exceptions may be made with approval of the instructor and advisor. If you enroll in a course in which you do not have the prerequisites without the proper approval, 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 offered.

Satisfactory Academic Progress for Financial Aid

To be in good standing for financial aid purposes, a student must earn at least 67 percent of the hours attempted with a cumulative G.P.A. of:

1.6 if you have attempted 0 to 29 credit hours

1.8 if you have attempted 30 to 59 credit hours

2.0 if you have attempted 60 or more credit hours

See pages 42-43 for further information about satisfactory academic progress for financial aid purposes.

Validation

Validation is acceptance of your financial responsibilities to New Mexico Tech for all courses you are registered for. You must validate with the New Mexico Tech Business Office before your registration process can be considered complete. Students who are not validated by the Wednesday before the drop deadline are subject to disenrollment from classes.

Course Abbreviations

AE	Aerospace Engineering
ACCT	Accounting
ANTH	Anthropology
ART	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
COMM	Communication
CSE	Computer Science Engineering
ECON	Economics
EDUC	Education
EE	Electrical Engineering
EMGT	Engineering Management
ENGL	English
ENVE	Environmental Engineering
ENVS	Environmental Science
ERTH	Earth Science
ES	Engineering Science
FA	Fine Arts
FIN	Finance
FREN	French
GEOB	Geobiology
GEOC	Geochemistry
GEOL	Geology
GEOP	Geophysics
GERM	German
HIST	History
HUMA	Humanities
HW	Health & Wellness
HYD	Hydrology
IT	Information Technology
LIFE	Lifestyle
MATE	Materials Engineering
MENG	Mechanical Engineering
MATH	Mathematics
ME	Mineral Engineering
METE	Metallurgical Engineering
MGT	Management
MKT	Marketing
MUS	Music
OPT	Optics
PETR	Petroleum Engineering
PHIL	Philosophy
PHYS	Physics
PR	Physical Recreation
PS	Political Science
PSY	Psychology
SPAN	Spanish
SS	Social Science
ST	Science Teaching
TC	Technical Communication
WGS	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
CEMED	Center for Energetic Materials and Devices
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
GOLD	Group Opportunities for Learning & Development
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
ISD	Information Services Department
ITV	Instructional Television
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
OIEP	Office of International and Exchange Programs
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
RCN	Residential Computing Network
ROTC	Reserve Officer Training Corps
SA	Student 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)
TCC	Tech Computer Center
UC	User Consultant (at the TCC)
VLA	Very Large Array radio telescope
VLBA	Very Long Baseline Array radio telescope
VSQ	Visiting Scientists' Quarters
WIPP	Waste Isolation Pilot Project

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 21 Bachelor of Science programs or pursue a degree in general studies (Associate of General Studies and Bachelor of General Studies), an interdisciplinary degree that allows students to create a unique educational portfolio structured to specific interests and career goals. 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 approximately 2,000 undergraduate students and 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.

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.

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.

Accreditation

New Mexico Tech is accredited by the North Central Association of Colleges and Secondary Schools 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:
New Mexico Tech is accredited by The Higher Learning Commission, which is part of the North Central Association of Colleges and Schools. http://www.ncacihe.org/ (312) 263-0456.

NMT Contact Information:
New Mexico Tech 801 Leroy Place Socorro NM 87801 575-835-5434

The bachelor's programs in chemical engineering, civil engineering, electrical engineering, mechanical engineering, environmental engineering, materials engineering, mineral engineering and petroleum engineering are accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

The 'Bachelor of Science in Computer Science' program is accredited by the Computing Accreditation Commission (CAC) of ABET, http://www.abet.org.

New Mexico Tech is also a member of the American Society for Engineering Education.

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 not only with employment but also with educational work experiences that enhance their value to future employers.

Center for Energetic Materials and Devices (CEMED)

The Center for Energetic Materials and Devices (CEMED) is a research organization that develops applications for energetic materials and energetic devices. It consists of New Mexico Tech, Sandia National Laboratories, and Los Alamos National Laboratory in a consortium that is administered by New Mexico Tech. The facilities of the CEMED partners are world-class and CEMED's development capabilities include more than 200 professional staff, state-of-the-art laboratories, thousands of acres of field test ranges and access to the most advanced computational equipment available.

The prime advantage to CEMED's customers is the single entity working on the customer's research problem with the facilities and skills of three research organizations. CEMED provides cost effective design, development, and testing of energetic devices for commercial, civilian and military applications. CEMED also provides educational opportunities for undergraduate students, graduate students and post doctoral researchers. These students are the future workforce for research and development of energetic materials and devices both in New Mexico and around the country.

Energetic Materials Research and Testing Center (EMRTC)

(www.emrtc.nmt.edu)

In existence for more than 50 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, film 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.

In addition, EMRTC conducts several anti-terrorist training programs under a grant from the Department of State for students from allied foreign governments. New Mexico law enforcement personnel have also attended these courses.

• **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.

Institute for Complex Additive Systems Analysis (ICASA)

(www.icasa.nmt.edu)

The Institute for Complex Additive Systems Analysis (ICASA) is a cooperative alliance among academia, industry, and government that New Mexico Tech administers under contract with the Department of Defense along with the support of the state of New Mexico. This alliance is dedicated to studying the behavior, vulnerabilities, and predictability of complex systems through ICASA's unique approach, known as the Complex Additive Systems Analysis (CASA) process. This process gathers information-age research and applies this research to real-world problems.

ICASA's basic research focus is to understand the additive effects—or unintended consequences—of efficient design in interdependent systems of systems. Research is pursued through four strategic thrusts: carrying out basic research on complex additive systems; applying research to real-world problems in the private and public sectors; developing key enabling technologies to assist in applying research results; and establishing training and education programs to meet customer's unique needs. ICASA's research is characterized by the study of dynamical systems, control theory, mathematical physics, and economics using the tools of theoretical analysis, modeling, and simulation.

ICASA's Electrical Power (EP) team works to understand and model cascading power failures. The EP team uses the CASA process, mathematical modeling, computer simulation and visualization, hardware implementation, and control of dynamical systems to analyze power grids. Currently, they are working on a multimillion dollar training and decision support system that will allow power operators to react more effectively to power grid failures.

The primary function and goal of ICASA is to assist and encourage the implementation of formal degree programs at New Mexico Tech. These programs integrate components of the computer science, engineering, and management departments. The first integrated program was Information Technology (IT), which is jointly managed by the computer science and management departments. The IT program has since flourished from a small venture into a full-fledge accomplished program by being the only IT program offered in the state of New Mexico. It was also named as a Center of Excellence in Information Assurance by the National Security Agency (NSA) in 2002. Only 50 universities in the nation have been awarded this designation. ICASA will continue to assist and support more degree programs, which may include the combining of computer science and engineering as well as other disciplines.

ICASA offers New Mexico Tech undergraduate and graduate students, and on occasion, commendable high school seniors throughout the state, opportunities to research real-world problems. Students in their freshman or sophomore years may apply for a Student Research Initiative (SRI), a program that introduces the basic principle of complex additive systems and the CASA process. Project topics include electrical power, financial networks, research organizations, and epidemics. Students also learn about the development and presentation of scientific research while working with a mentor.

SRI is part of ICASA's career path program designed to take a student from basic research projects during their freshman and sophomore years to student internships for their junior and senior years. Eventually, opportunities may be offered for graduate assistantships and a professional appointment with ICASA or their partner organizations. As ICASA continues to grow and embrace new disciplines, New Mexico Tech students are offered additional educational and research opportunities through the institute.

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.

The Instrument Center also hosts the Array Operations Facility for the seismological USArray component of EarthScope (*www.earthscope.org*), an NSF Earth Science research project of unprecedented scope studying the geology and geophysics of the North American continent and the deep Earth.

Langmuir Laboratory for Atmospheric Research
(www.ee.nmt.edu/~langmuir)

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 (17 air miles) 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. Because of its location and unusual climatic situation, the site provides unique opportunities for studies of thundercloud mechanisms, lightning, and precipitation. Overnight living accommodations are available for faculty and students working at the laboratory.

The Langmuir Research Site consists of 33,000 acres of Cibola National Forest which surrounds Langmuir Laboratory. Public Law 96-550, passed by Congress in 1980, preserves the land in its undeveloped state and encourages scientific research as a prime land use in this national forest. Restricted Airspace R-5113 supports flights of instrumented airplanes, rockets, and balloons. The laboratory is operated under a special use permit issued by the U.S. Forest Service.

Magdalena Ridge Observatory (MRO)
(www.mro.nmt.edu)

The Magdalena Ridge Observatory's 2.4-meter telescope is now operational. It is optimized for observations of Solar System objects.

The Magdalena Ridge Observatory Interferometer (MROI) is currently in construction and development stages, and will be a world-class, state-of-the art astronomical research facility. At an elevation of almost 10,400 feet in the Magdalena Mountains of the Cibola National Forest, and just a one-hour drive from campus, the MRO will be the fourth highest observatory in the world.

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 MRO interferometer will link ten large optical and infrared telescopes to provide the resolving power of a single 400-meter telescope. This instrument will have better optical resolution than the Hubble Space Telescope by a factor of 300.

Mount Erebus Volcano Observatory (MEVO), Antarctica
(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)
(http://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 speleology. NCKRI promotes and performs projects of national and international application through dedicated staff and partners. NCKRI partners with programs and departments at NMT to support research projects such as the development of caves and karst, characterizing their unique geomicrobiology, and evaluating their hydrogeology.

Karst landscapes and their associated features like caves, springs, underground rivers, and sinkholes are fascinating, but often not well-understood by students and professionals in earth and natural sciences. Karst landscapes are prevalent on 20-25% of the land worldwide. Karst is a fragile landscape with vulnerable aquifer systems. Though over 40 million US residents depend on karst aquifers for drinking water, few have ever heard the word. This fact, along with

significant scientific discoveries in caves, led to the foundation 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 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

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)
(baervan.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 (CO_2)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; CO_2 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 CO_2 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 Research and Economic Development Division

(www.nmt.edu/~red)

Faculty and student involvement in research is a distinguishing characteristic of New Mexico Tech. The Research and Economic Development Division (R&ED) encourages research throughout Tech in many ways. R&ED 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 of R&ED 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 specialized computer facilities for data analysis, the New Mexico Tech Seismologic Observatory, numerous cloud physics radar facilities, and a Schweizer 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.

R&ED is Tech's central link for information about potential funding sources and program guidelines for sponsoring agencies. Other R&ED services include a machine shop equipped for specialized research projects, an instrument and supply room that focuses on the distinct needs of researchers, 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. R&ED further serves as a point of contact for economic development. R&ED 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.

New Mexico Tech Research/Industrial Park

New Mexico Tech's Research/Industrial Park, 600 acres located west of the main campus, is ideally suited to house industrial firms interested in the development of chemical/explosives technologies; companies seeking a site for testing and experimental procedures more appropriate to a field laboratory setting than a conventional lab; and centers for environmentally sensitive research and development. Tenants of the Research/Industrial Park can benefit from the expertise of Tech faculty and researchers as well as the various research laboratories and support services on campus.

New Mexico Tech Seismological Observatory

(http://www.ees.nmt.edu/outside/Geop/NMTSO)

The Earth and Environmental Science Department Geophysics program operates a state-wide network of seismographs dedicated to recording and study of earthquakes and other seismological phenomena throughout New Mexico and the southwestern United States. The program also coordinates earthquake educational outreach activities in association with the Bureau of Geology through support from the New Mexico State Department of Public Safety, the United States Geological Survey, the Incorporated Research Institutions for Seismology (IRIS), the National Science Foundation, and other agencies.

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

The Playas Research, Development, Test and Evaluation (RDT&E) and Training Complex, located in the "bootheel" of New Mexico, is a "real-world" training center for programs in prevention and response to suicide bombings, terrorist activities, and other related programs. Operated by New Mexico Tech's EMRTC, Playas is used for simulations of urban warfare, emergency preparedness drills, anti-terrorism training, military operations training in urban terrain, hostage negotiation training, and other activities.

The U.S Department of Homeland Security (DHS) has formally committed to using Playas for training purposes during the next five years. Other federal, state, local, and tribal government departments, agencies and organizations have also expressed strong interest in the complex and its capabilities.

Joseph R. Skeen Library
(http://infohost.nmt.edu/~nmtlib/)

The Joseph R. Skeen Library's collection and services support the educational, research, public service, and economic development mission of New Mexico Tech. Although the library maintains a collection of over 600,000 printed books, maps, government documents, and periodicals, the vast majority of the items in the library's collection are digital and are 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 91 hours a week during the semester. The library houses a coffee shop, 6 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 wireless Internet connections, as well as having a large number of computers dedicated only for student use.

The library also provides inter-library loan services to students and faculty members thus allowing access to the collections of 72,000 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 also has a collection of archival materials relating to the history of New Mexico Tech (previously known as The New Mexico School of Mines), a map collection, a historical microform collection of Socorro newspapers, an extensive collection of historical geologic and mining materials, 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 *http://infohost.nmt.edu/~nmtlib/*

Tech Computer Center (TCC)
(www.nmt.edu/~tcc/)

The TCC 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 TCC regulations and the New Mexico Tech Computer Usage Policy.

Each TCC user is given an e-mail address and access to the Internet, as well as an initial storage space. The TCC has a wide range of scientific software available.

TCC 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 TCC there are many other computer systems on campus used in conjunction with departmental programs and funded research.

The TCC 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 *tcc@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

(http://act.nmt.edu/distance)

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 Mechanical Engineering and 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/ced-home

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)

FA (Fine Arts)

LIFE (Lifestyle non-credit)

PR (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/ced-home,
 including downloadable catalogs with course descriptions. To speak with someone about Community Education, please visit the offices in Cramer 201 & 202 or call 575.835.6581.

Office for Student Learning (OSL)

The Office for Student Learning, located in the Martin Speare Building, is a nexus for student academic support initiatives and includes the following services:

Tutoring, Homework Help, Test Corrections, 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 offer test corrections -- a focused way 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 stop by -- the OSL team and the friendly 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.

Learning Communities

The OSL offers project-based Learning Communities that involve students in research at the very start of their NMT experience. Learning Community students have the opportunity to participate in a research project, receive supplemental academic support from Learning Coaches, learn how to best utilize available NMT resources, and develop a strong sense of connection to their peers, their faculty, and their major -- leading to enhanced engagement and academic success.

New Student Advisor Services

AT NMT, students are advised by faculty, who are the student's most important resource for developing academic and career goals.

The OSL coordinates the advising process at NMT by facilitating communication between faculty advisors and their students. The OSL maintains the advising website, which provides resources relating to student advisee responsibilities, including registration, major changes degree programs and requirements, deadlines, and communicating with faculty.

Academic Counseling

Individual and group counseling is offered to help students identify their learning style and develop academic success skills such as time and stress management, study skills, and adaptive choice-making.

Writing Center

The Writing Center assists both graduate and undergraduate students with many forms of writing from essays, technical papers, to resumes and everything in between. Hours are drop-in. Services are free and are offered each regular semester.

Academic Referral

The Academic referral program is designed to identify and aid students who are having academic problems and to help them deal with those problems early in a given semester. The program serves students who are referred by faculty members, students on probation, and students who are academically under prepared for the rigorous and demanding curricula at New Mexico Tech.

Student Affairs

The goal of the Student Affairs office is to help Tech students succeed in college. Offices include Career Services, Multicultural Programs, and International and Exchange 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. Located in the Joseph A. Fidel Center, offices are open 8 a.m. to 5 p.m. daily.

Career Services

Career Services provides career counseling; resume, cover letter, and interviewing skills assistance; and listings of permanent, temporary, on-campus, internship, fellowship, and research positions. 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 http://www.nmt.edu/career-services

Cooperative Education Program

The Cooperative Education/ Internship Program is a three-way partnership among the employer, the student, and the University. 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.

Counseling Services

Counseling Services provides students with individual, couples/family, and group counseling, outreach programs, and consultation. We adhere to the Code of Ethics of the New Mexico Board of Social Work Examiners. All services are strictly confidential and are free to students enrolled for six or more credits hours. The office is located in the Joseph A. Fidel Center and is open from 8 a.m. to 5 p.m. weekdays. Crisis intervention is available; counseling is provided by New Mexico independently licensed clinical social worker and substance addiction therapist.

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

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. Multicultural Programs works to provide academic and financial support as well as providing information about opportunities within and outside the institution. Multicultural Programs is in the Student Affairs Office on the second floor of the Joseph A. Fidel Center.
http://www.nmt.edu/multicultural-programs

International and Exchange Programs

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 (page 29), and participates in the New Mexico International Education Consortium. http://www.nmt.edu/international-and-exchange-programs-cs-student-services

Student and Campus Life

Residential Life

www.nmt.edu/welcome-to-res-life

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. For photos and more detailed information on housing options, please visit our webpage: http://www.nmt.edu/halls-and-apartments

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://www.nmt.edu/current-student-info/144-residence-halls-standards. .

Dining and Meal Plans

http://www.nmt.edu/prospective-a-incoming-students/134-meal-plans-dining-info

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: http://www.nmt.edu/prospective-a-incoming-students/134-meal-plans-dining-info

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. 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.

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 named 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 leaderships 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 2 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 riffle 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)** brings a wide variety of entertainment to campus, free to regular NMT students. In any given season, 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, to see professors in a social setting, and to experience an amazing array of national touring performers.

The Student Activities Board (SAB) also brings entertainment to campus. The SAB sponsors events such as Comedy Night, Movie Night, pool parties, dances with live salsa or swing bands, barbecues with DJ's, dances, open-mic nights, and mid-night breakfast held on Friday before finals week each semester. The SAB organizes two big celebrations each year. In the fall, 49'ers is a celebration of Tech's mining heritage. Spring Fling gives students a fun break in the spring. Both feature casino night, games, contests, music, dances, barbecue dinners, and other events. The SAB is run by students along with two NMT staff members.

The Student Association funds various Tech clubs. *(see student government association on page 26)*

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

Chorus

Drama Club

Jazz Band

Orchestra

Spring Musical

Club Sports

Biking (mountain)

Caving

Climbing

Golf

Paintball

Rugby: Men's & Women's

Shooting (air riffle)

Soccer: Men's & Women's

Street Hockey

Taekwondo

Track and Field

Ultimate Frisbee

Volleyball: Co-Ed

Games

Adventurers' Guild

Billiards Club

Chess Club

Just for Fun

Anime Addicts

Aquatic Recreation

KTEK (student radio station)

Miner's Ink (creative writing journal)

Paydirt (student newspaper)

Society for Creative Anachronism

Tech Amateur Radio Association

Professional Associations

American Society of Mechanical Engineers (ASME)

Association for Computing Machinery (ACM)

Institute of Electrical and Electronics Engineers (IEEE)

International Society of Explosives Engineers (ISEE)

Society of Economic Geologists, student chapter (SEG)

Society of Hispanic Professional Engineers (SHPE)

Society of Mexican American Engineers and Scientists

Society of Women Engineers (SWE)

Society for the Advancement of Chicanos and Native Americans in Science (SACNAS)

Tau Beta Pi, Engineering Honor Society

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 88. 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.

Preprofessional Programs

Preprofessional programs are available in the sciences allied with biology, chemistry, and medicine. Among the careers for which preprofessional courses are available at Tech are medicine, dentistry, physical therapy, optometry, pharmacy, and veterinary science. A Bachelor of Science degree in Biology, Chemistry, and Basic Sciences with suitable elective courses will qualify a student for admission to most professional schools related to medicine. Be sure to check the specific requirements of the professional school you are interested in attending. The Bachelor of Science degree in Biology with Medical Technology Option is granted at Tech in cooperation with accredited schools of medical technology.

The undergraduate requirements for admission to a school of law may also be fulfilled. See page 232 for more information about preprofessional programs.

Combined Five-Year Bachelor of Science/Master of Science Programs

New Mexico Tech offers four 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 , Electrical Engineering, Environmental Engineering, 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 (pages 15-20).

Study Abroad Opportunities

Arrangements for all types of study abroad are made through the Student Affairs. 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 Student Affairs.

International Exchange through NMIEC

Through the New Mexico International Education Consortium, students at any of the State's public universities may gain access to study-abroad programs available at other State 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.

Applying for Undergraduate Admission

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 *http://www.nmt.edu/admissions/office.*

Regular Admission

Entering 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. If you do not meet these requirements but you believe you can succeed at Tech, see the section on Appeal of Admission Decisions, page 35.

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.

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.) 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.

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.

   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 35).

Application Deadlines

August 1 for fall semester
December 15 for spring semester
June 1 for summer session.

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, page 35.

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.) 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.

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. (See pages 37-38 & 77 for transferability of credits).

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 103 (Pre-Calculus) or higher. See page 35 for math placement information.
3) The student must be in good academic standing at the last institution attended.
4) 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, a transfer 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, reflecting all courses 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 35).

Application Deadlines

August 1 for fall semester
December 15 for spring semester
June 1 for summer session.

Transfer Credit

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. Credit earned at any institution while a student is on academic or disciplinary suspension will not be accepted at New Mexico Tech. Grades earned at other universities are not transferred to Tech.

See pages 37-38 for a guide for students transferring from another New Mexico college or university. A more complete list of courses offered at other New Mexico colleges and universities and their Tech equivalents is online at *http://hed.state.nm.us/colleges/trnsfercredits.asp*

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 540 (paper-based) or 207 (computer-based) or 76 (iBT next generation). Information and application forms for this test may be obtained from:
   The College Board
   P.O. Box 592
   Princeton, NJ 08541

(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 *www.nmt.edu/international-undergraduate-bs-degree-admission-requirements*

• 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 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.

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 .

Dual Credit Program for High School Students

The primary purpose of the Dual Credit Program at New Mexico Tech is to increase the educational opportunities and options for high school students and increase the overall quality of instruction and learning available through secondary schools.

The Dual Credit Program allows students to earn credit at the secondary and postsecondary levels simultaneously and provides students an early glimpse of college life and college-level studies. Enrolling in college course work is a commitment of your time and energy. Please consider whether enrolling in the Dual Credit Program is a realistic option based on your extracurricular activities and family schedules.

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/Orientation schedule each semester

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

Eligibility

Students must be either a junior or senior in high school and enrolled in a public school district during the fall and spring in one-half or more of the minimum course requirements approved by PED for public school students in order to participate in the Dual Credit Program at New Mexico Tech. Students must also have a minimum 3.0 GPA (on a 4.0 scale) and an ACT composite score of 21 or an equivalent SAT critical reading and math score. Students who have not taken the ACT or SAT may submit PSAT scores for review of eligibility. All students must have approval from the school district and the high school counselor prior to registration.

Financial Aid

Dual Credit students are not eligible for financial aid or scholarships.

Applying for the Dual Credit Program

Students interested in enrolling in the Dual Credit Program at New Mexico Tech should 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 students parent/guardian)

Copies of the forms are available at the high school counseling office.

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.

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.

The deadline for all readmission materials is the Wednesday 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 and subject to all the rules and regulations of a student on probation.

For students readmitted on academic probation, failure to meet the minimum GPA for academic good standing (page 9) in the semester following readmission will result in academic suspension (page 72) from New Mexico Tech.

Credits earned at another institution during the period of academic suspension at New Mexico Tech will not be accepted for transfer.

If you have attended another college institution of higher education since your last enrollment at New Mexico Tech, you must submit a transcript or letter from the registrar of that institution attesting that you are in good standing at the institution.

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.

Appeal Deadlines

Deadlines for appealing admission decisions are:

> July 1 for fall semester
> December 1 for spring semester
> June 1 for summer session.

Placement

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 111 waived as a requirement. Students who score 19 or lower on the ACT English test or 470 or lower on the SAT Critical Reading test are advised to begin with ENGL 103.

College Level Examination Program

No credit is given for the College Level Examination Program (CLEP). However, challenge exams are available in various courses (page 75).

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 Math Score	SAT Redesign Math Score	Initial Math Course
20 or lower	490 or below	520 or below	MATH 101
21 to 25	500 to 580	530 to 600	MATH 103
26 to 29	590 to 660	610 to 690	MATH 104
30 or higher	670 or higher	700 or higher	MATH 131

You may also enroll in MATH 131 (Calculus and Analytic Geometry I) if:
1) You are transferring college credit in precalculus and trigonometry.
2) You have earned a 3 on the Advanced Placement (AP) Calculus AB exam or a 3 on the AB subscore of the Calculus BC exam.

An optional math placement test, which covers algebra 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. Please contact the Registrar's Office at *registrar@nmt.edu* for information about the math placement test. **Waivers into 100-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.**

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 grades of 1 or 2.

Subject	AP Score	Credits Earned
Art History	3, 4, and 5	Receive credit for ART 272 for a total of (3) credits.
Biology	3, 4, and 5	Receive credit for BIOL 111 for a total of three (3) credits. Students must take BIOL 111L for laboratory credit.
Calculus AB	3	Receive two (2) elective credits in mathematics. Students proceed directly into MATH 131, Calculus and Analytic Geometry I.
	4 and 5	Receive credit for MATH 131 for a total of four (4) credits. Students proceed directly into MATH 132, Calculus and Analytic Geometry II.
Calculus BC		Use Calculus AB subscore. Credit awarded as above.
Chemistry	3 and 4	Receive credit for CHEM 121(3) for a total of three (3) credits. The student should consult the department chair concerning laboratory credits.
	5	Receive credit for CHEM 121 (3) and 122 (3) for a total of six (6) credits. The student should consult the department chair concerning laboratory credits.
Computer Science A	3, 4, and 5	Receive credit for CSE 213 for a total of three (3) credits.
Computer Science AB	3, 4, and 5	Receive credit for CSE 122 and 213 for a total of six (6) credits.

Economics
  Macroeconomics
  Microeconomics
	
	4 and 5
	4 and 5
		
		Receive credit for ECON 251 for a total of three (3) credits.
		Receive credit for ECON 252 for a total of three (3) credits.

English	4 and 5	English/Composition **or** English/Literature/Composition: Receive credit for ENGL 111 for a total of three (3) credits and proceed directly into ENGL 112. English/Composition **and** English/Literature/Composition: Receive credit for ENGL 111 (3) and literature (3) for a total of six (6) credits and proceed directly into ENGL 112.
Foreign Languages	3, 4, and 5	May take a challenge exam to waive the first semester course of that language and receive three (3) credits. The exam is graded S/U only.
Government	3, 4, and 5	Receive credit for PS 171 for a total of three (3) credits.
History U.S. History	 3, 4, and 5	 Receive credit for HIST 141 and 142 for a total of six (6) credits.
European or World History	3, 4, and 5	Receive credit for HIST 151 and 152 for a total of six (6) credits.
Music Listening and Literature	3, 4, and 5	Receive credit for MUS 101 (3) and 102 (3) for a total of six (6) credits.
Music Theory	3, 4, and 5	Receive credit for MUS 201 for a total of three (3) credits.
Physics C Mechanics	3, 4, and 5	Receive credit for PHYS 121 for a total of four (4) credits. The student should consult the department concerning laboratory credit.
Physics C E & M	3, 4, and 5	Receive credit for PHYS 122 for a total of four (4) credits. The student should consult the department concerning laboratory credit.
Psychology	5	Receive credit for PSY 121 for a total of three (3) credits.

Transfer among New Mexico Higher Education Institutions

During the 2005 New Mexico Legislative session, Senate Bill 161, consistent with requirements of state law (Chapter 224 of the Laws of New Mexico, 1995 as amended) was signed into law to further enhance and facilitate the articulation of general education courses among New Mexico's colleges and universities. In accordance with policies established by the New Mexico Higher Education Department, designated general education core courses successfully completed at any regionally accredited public institution of higher education in New Mexico are guaranteed to transfer to any New Mexico public institution if the student passed the class with a grade of C or higher. 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.

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 than all pre-transfer coursework will meet the requirements of the desired degree.

Transferable Lower-Division General Education Common Core

Students enrolling for first-year study who have not yet selected either an academic focus or the institution where they wish to graduate are advised to take courses during their freshman year outlined in the Lower Division General Education Common Core. For students enrolled at any public institution in New Mexico, the following courses are guaranteed to transfer to any other New Mexico public college or university, and apply toward associate and baccalaureate degree program requirements if the student passes the classes with a grade of C or higher. Students should consult advisors at their current institutions regarding which specific courses fit these categories. Students preparing for careers in engineering, health sciences, or other profession-related fields are advised that some of this coursework may not transfer toward general education requirements but in most cases will apply toward elective requirements.

The core matrix of approved courses guaranteed to transfer and meet general education requirements at any New Mexico college or university can be found on the New Mexico Higher Education Department website at http://hed.state.nm.us. Follow the "Colleges and Universities" link to the drop down menu and select "Transferring Credits", then select "Core Matrix". Courses are listed by institution, whether university or community college, under each of the five general education areas. Students may also be able to access this list by going directly to http://hed.state.nm.us/colleges/matrix.asp.

Area I: Communications   select 9 cr hrs
  a) College-level English Composition   3–4 cr hrs
  b) College-level Writing
       (a second course building on the above)   3 cr hrs
  c) Oral Communication *   3 cr hrs

Area II: Mathematics   select 3 cr hrs
  a) College Algebra *   3 cr hrs
  b) Calculus   3 cr hrs
  c) Other College-level Math+   3 cr hrs

Area III: Laboratory Science   select 8 cr hrs
  a) General Biology with Lab   4–8 cr hrs
  b) General Chemistry with Lab   4–8 cr hrs
  c) General Physics with Lab#   4–8 cr hrs
  d) Geology/Earth Science with Lab   4–8 cr hrs
  e) Astronomy with Lab   4–8 cr hrs

Area IV: Social/Behavioral Sciences   select 6–9 cr hrs
  a) Economics (macro or micro)   3 cr hrs
  b) Introductory Political Science   3 cr hrs
  c) Introductory Psychology   3 cr hrs
  d) Introductory Sociology   3 cr hrs
  e) Introductory Anthropology   3 cr hrs

Area V: Humanities and Fine Arts   select 6–9 cr hrs
  a) Introductory History Survey   3 cr hrs
  b) Introductory Philosophy   3 cr hrs
  c) Introductory Course in History,
       Theory or Aesthetics of the Arts or Literature 3 cr hrs

           Total to be selected   **35 cr hrs**

*   Will not meet General Education Core Curriculum (page 88)
+   Should be Calculus II
#   Must be calculus-based physics

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. A copy of New Mexico Tech's complaint policy may be obtained from the New Mexico Higher Education Department, 1068 Cerrillos Road, Santa Fe, NM 87505, 505.476.6500, *http://hed.state.nm.us/*

Lower-Division 64-hour Transfer Modules

Students who have selected a field of study but have not yet selected the college or university where they wish to earn their baccalaureate degree are advised to take courses during their freshman and sophomore years outlined in one of the Lower-Division 64-hour Transfer Modules. For students enrolled at any public institution in New Mexico, these courses are guaranteed to transfer to any New Mexico university and apply toward bachelor's degree program requirements. Students should consult advisors at their current institutions regarding which specific classes fit these categories. Lower-division transfer modules currently exist for:

- Biological Sciences
- Business
- Early Childhood Education
- Engineering
- Physical Sciences
- Social and Behavioral Studies

Modules for additional areas of study are being developed. Copies of these transfer modules may be obtained at *http://hed.state.nm.us/colleges/transfercredits.asp*

New Mexico Common Course Numbering System (NMCCNS)

A common course numbering system has been devised by New Mexico colleges and universities in compliance with the New Mexico Post-Secondary Education Articulation Act. The purpose of the system is to assist New Mexico students who are transferring between institutions within the state. The system provides a neutral state wide course identifier for those courses that are similar in nature and considered to be equal in transfer. Students will find in the course description section of the catalog the state wide **course** identifier and the area of the General Education Common Core in brackets following the New Mexico Tech course for which the course can meet general education requirements.

Transfer among New Mexico Higher Education Institutes
New Mexico Transfer Module by Discipline

	NMCCN	Course Title	Credit Hour	NMT Course
Business	2113	Principles of Accounting I	3	ACCT 201
	2123	Principles of Accounting II	3	ACCT 202
	2113	Principles of Macroeconomics	3	ECON 251
	2123	Principles of Microeconomics	3	ECON 252
	2113	Business Statistics	3	BCS 283
	1113	Business Information Systems	3	BCS 209
For Majors	2113	Principles of Finance	3	FIN 302
	2113	Principles of Marketing	3	MKT 335
	2133	Intermediate Accounting	3	ACCT 371
	2123	Business Law II	3	BA 317
Early Childhood Education	1113	Child Growth & Development & Learning	3	PSY 323

Financial Aid for Undergraduate Students

[Contact: Financial Aid Office, New Mexico Tech, 801 Leroy Place, Socorro, N.M. 87801; 575.835.5333; fax: 575.835.6519]

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 (Gold, Silver, Presidential, Copper)
   Transfer Students (Phi Theta Kappa, Transfer Excel, Tech Transfer, Regents)
   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 and

3) In addition to scholarships, we offer **financial aid**, which includes
   • Federal grants (e.g., Pell Grant and SEOG Grant)
   • Federal loans (e.g., Perkins Loan, 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/financial-aid* 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:

1) 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.)
2) Be pursuing a first bachelor's degree;
3) Be enrolled in a regular degree program at New Mexico Tech; and
4) Carry at least 12 credit hours per semester. Students receiving the Legislative Lottery Scholarship must carry at least 15 credit hours per semester.
5) 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			
	Gold Silver PTK Transfer Excel	Endowed NM Scholars International Competitive*	Presidential Tech Transfer Competitive (U.S. Citizens)	Copper Regents CORE WUE NM Lottery**
GPA Requirement	3.25	3.00	3.00	2.50

RETENTION OF AWARD:

1) Scholarship recipients must maintain a minimum of twelve (12) credit hours of course work for each Fall and Spring semester. *Qualified Lottery Students and International Competitive recipients must maintain fifteen (15) credit hours per semester. Grades of *U, F, W, I,* and audits do not count as completed credits for scholarship retention purposes. 2) 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.) 3) Inability to meet minimum requirements by the end of the spring semester will result in scholarship loss for the following academic year. 4) Students who lose scholarship eligibility may submit a written appeal (by the posted deadline) of extenuating circumstances with appropriate documentation. 5) 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 percentage 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.

The three components of the Satisfactory Academic Progress Policy (qualitative, quantitative, and maximum time frame) are explained below.

Qualitative Standard

Students must meet the following GPA requirements:

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

Cumulative GPA calculation includes grades of A, A-, B+, B, B-, C+, C, C-, D+, D, and F.

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 IN, 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.

If you are still below the policy standards after the financial aid warning semester, you are no longer eligible for Title IV aid.

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.

Satisfactory Academic Progress Status

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

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.

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
- Perkins Loan
- 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.studentlloans.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 (page 43). 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 www.nmt.edu/financial-aid 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.)

The Graduate Program

(www.nmt.edu/~graduate-studies)

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 Management program 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 a venture dedicated to studying the behavior, vulnerabilities and predictability of complex systems. ICASA's unique, interdisciplinary, strategic approach harnesses information-age relevant research, the application of that research to real-world problems, development of key enabling technologies, and the 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 information assurance.

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. Applicants are strongly encouraged to submit online applications available on the internet at **www.nmt.edu/~graduate-studies**. Printed forms can be requested by e-mail from *graduate@nmt.edu* or by mail from:

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

To be assured of 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.

Master of Science and Doctor of Philosophy Degrees

In addition to completed application forms, applicants for Master of Science and doctoral programs must provide:

1)   Sealed, official transcripts of all college work (unofficial copies may be used for application, but sealed, official copies are required before admission).

2)   References from three professors and/or employers familiar with the applicant's academic, professional, and/or research performance

3)   An application fee of $45.00 for those using domestic and online international applications, or $60 for international application packets mailed to applicants

4)   Official Graduate Record Examination (GRE) scores. GRE General Exam scores are not required for the Master of Science for Teachers program, but are required for many other Master of Science, Master of Engineering Management and Doctor of Philosophy programs. Please refer to the listings at http://www.nmt.edu/graduate-degree -programs 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 admission.)

A few departments may also require a subject test score. Information related to departmental requirements for the subject GRE may be obtained online, from the Center for Graduate Studies, or by contacting the department to which you are applying. 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)   Sealed official transcripts of all college work (unofficial copies may be used for application, but sealed, official copies are required before admission);

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)   An application fee of $45.00 for those using domestic and online international applications, or $60 for international application packets mailed to applicants;

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) Sealed, official transcripts of all college work (unofficial copies may be used for application, but sealed, official copies are required before admission);

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) An application fee of $45 for those using domestic and online international applications, or $60 for international application packets mailed to applicants.

Certificate Programs

The Electrical Engineering, Hydrology, and Scientific and Professional Communication graduate programs offer post-baccalaureate certificates. 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.

International Students

New Mexico Tech is authorized under federal law to enroll nonimmigrant alien students. Such applicants wishing to be regular graduate students must complete the international (rather than the domestic) application form. 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.

For the 2017-2018 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 or qualified fellowships that cover the entire period of the semester. Financial statements must be included with the application. Applications from international students, complete with supporting documents, and application fee should arrive in the Center for Graduate Studies 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 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 online or 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 a five-year program:
   a) The student admitted to one of the approved five-year programs who wishes to qualify as a graduate student during his or her senior year must apply for admission and be admitted to the graduate program before the end of their junior year.
   b) Once admitted to the graduate program, the five-year student will spend his or her senior year as a dual registered student.
2) In the last semester before graduation, any student may apply for dual registration 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 not eligible for assistantship and fellowship appointments, but may have work authorizations.

Financial Assistance for Graduate Students

A 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-for-Admission 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 6 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*. 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 Graduate Dean 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 are sometimes 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. 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. 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 G.P.A. of at least 3.0. If you fall below this standard, you will be placed on financial aid warning for the following semester. During this semester, you will still be eligible to receive aid. To get back in good standing, you will need to meet the policy requirements by the end of the warning semester. If you do not meet the policy requirements by the end of the warning semester, you 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 for a master's degree is 45 attempted credit hours. This includes all hours attempted as a graduate student regardless of the course level. The maximum timeframe for a doctor of philosophy degree is 75 attempted credit hours. 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/grad-current/* 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 (six 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+ 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 6 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. 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 Science in Mechanical Engineering and the Masters of Engineering Management. 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.

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 can 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. 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 full time student 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 board. 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 Graduate Dean. 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 Graduate Dean.

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 of before the semester of graduation for Masters students and by the fifth semester for Doctoral students. Part-time and distance education students must formalize their committees by the time they complete 18 credits. The course program is reported on the committee report form, available online and from the Center for Graduate Studies. Graduate course programs must be approved by the Graduate Dean.

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 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; six credit hours during the summer semester if they are progressing towards the degree. Part-time graduate students must register for eight or fewer credits per semester. 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 Graduate Dean 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 course requirements, but do not earn credits toward a degree. 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 may require seminar courses, which may be graded S/U.

Part-time status is not granted as a means to reduce registration for a full-time student while completing the final requirements leading to their degree. 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 graduate dean. While in this category, the student must enroll for at least three credit hours of thesis, independent study, or dissertation. Full time students may only have a work authorization with a reduced registration of at least six credits.

After successful defense of the thesis or dissertation, with advisor approval, a full-time student may register for one credit for one semester to complete corrections to the thesis or dissertation.

See the Center for Graduate Studies web page for all graduate deadlines (http://www.nmt.edu/grad-current).

Grades

At the time of graduation, the cumulative GPA must be 3.0 or higher for all courses numbered 300 or above. Only courses with a grade of "C" or higher may count towards the graduate degree. The grade point average for course credits designated for the degree must be 3.0 or above. 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 other courses taken on a S/U basis may not be used to fulfill graduate degree requirements.

Graduate Co-op Experience

Graduate students may chose 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 Graduate Dean 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 forms available online or from the Center for Graduate Studies. Time limits for degree programs apply.

Leave of Absence

In certain circumstances, a candidate may interrupt progress toward the degree by petition to the Graduate Dean 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;
- receive no grade less than C for those courses in which a standard letter grade is received;
- formalize their advisory committee:
    - 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;
    - 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
    - full-time students must satisfactorily complete a minimum of nine credit hours (12 credit hours if on support) each fall or spring semester; six credit hours must be completed during the summer semester if in residence (as described under Academic Load, page 74);
    - part-time students must be registered for eight or fewer credits each semester; distance students must register according to the plan on file with the Center for Graduate Studies;
    - all graduate students may audit at most three credits per semester (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 Graduate Dean. Any student who fails to maintain satisfactory progress for two consecutive semesters will be dropped from regular graduate student status. Such students 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 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/grad-current/*. 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 in 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.

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/grad-current/*.

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 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 seven 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 Graduate Dean. Time limitations for part-time students will be considered on an individual basis.

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

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 239.

Tuition and Fees

Please refer to pages 60-65 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 or independent study paper must be in the hands of the advisor.

Two weeks prior to the defense, the complete defense draft (with the preliminary section, 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. 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.

The chair of each graduate advisory committee will submit a written report to the student with copies to the chair of the department and Graduate Dean 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 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 including final submission to ProQuest (in correct format).

Appeal

All requirements for graduate degrees may be appealed 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, at least 6 of them at the 500 level. At the doctoral level, a minor requires at least 18 hours, 12 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 minors must be approved by the Graduate Council and Faculty Senate.

Master of Science Degree

General requirements are common to all Master of Science degree curricula in the science and engineering fields. Specific requirements are listed under appropriate departments.

General Requirements

It is required that a student preparing to complete the M.S. degree:

1. Have a minimum of six credit hours of approved upper-division or graduate course work from another department,
2. Declare a major with at least 12 credit hours of course work above the 500-level, exclusive of research credits, and
3. Complete a research project culminating in a thesis or independent study paper.

Approvals

1) The appropriate department grants admission to its graduate program.
2) The appropriate department and the Graduate Dean must approve the composition of each graduate student's advisory committee.

3) 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.

4) 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 Graduate Dean.

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 three final copies of the thesis to the Center for Graduate Studies.

Submission of a digital copy of the thesis to the Center for Graduate Studies.

Combined Five-Year Bachelor of Science/Master of Science Programs

These programs in which a student may earn a Bachelor of Science degree as well as a Master of Science degree in five years are available:

Biology: Five-Year Program ,

Environmental Engineering: Five-Year Program,

Hydrology: Five-Year Program ,

Materials Engineering: Five-Year Program ,

Mathematics: Five-Year Program ,

Electrical Engineering: Five-Year Program ,

Physics: Five-Year Program ,

Students admitted to five-year programs must apply for admission to the graduate program during their junior year. Students who are enrolled in five-year programs may count at most one 500 level course (3 credits) towards both their undergraduate and graduate degree; no undergraduate courses may be counted toward both degrees. During their senior year, these students will be dual registered (page 48).

Master of Engineering Management

New Mexico Tech's Master of Engineering Management graduate program is designed to provide working engineers and on-campus graduate students with a one-year terminal degree in Engineering Management. 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 288.

General Requirements
Approvals

The Management Department grants admission to its graduate program.

The Management Department and the Graduate Dean must approve the composition of each graduate student's advisory committee.

The graduate student's advisory committee must approve the student's final research project. The MEM degree will not be awarded until the final project 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 and the Graduate Dean.

Research Option

In addition to a final project, the Master of Engineering Management degree 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 final project paper describing the results of the final project to the candidate's advisor and advisory committee.

Submission of a digital abstract of the final project paper to the Center for 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 240-241.

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 Graduate Dean 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.

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

Submission of three final copies of the thesis to the Center for Graduate Studies.

Submission of a digital copy of the thesis to the Center for Graduate Studies.

General Requirements for a Second Master of Science Degree at Tech

Students who wish to earn a second master's degree at Tech must:

Satisfy the specific course requirements in both fields, and

Complete either:

9 additional approved credit hours plus a thesis (6 or more credit hours) in the second field, or
12 additional approved credit hours plus an independent study (3 or more credit hours) in the second field.

Second degrees may not be available from some departments.

Doctor of Philosophy Degree Requirements

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, materials, mathematics, 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 the respective departments 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 distributed over one or more years must be devoted to the dissertation after candidacy has been achieved. 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 54. 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 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 must be completed before close of registration 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.

Expenses

The information below is for the 2017-2018 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

$15	Undergraduate
$45	Graduate

Admission Fees

$50	Undergraduate
$25	Graduate

Miscellaneous Fees

$10	Challenge Exam fee (per semester hour)
$25	Deferred Payment Plan Fee
$25	ID Card Replacement Fee
$30	Late Registration Fee (per day)
$65	Orientation Fee
$8	Transcript Fee (paper transcript)
$3.82	Withdrawal Fee

Graduation Fees

$30	Associates Degree
$40	Bachelors Degree
$50	Masters Degree
$60	PhD Degree

Refundable Charges

Tuition per semester, Full Time Resident

$3,066.48	Undergraduate (12 - 18 credit hours)
$3,203.10	Graduate (9 - 13 credit hours)

Tuition per semester, Part Time Resident, per credit hour

$255.54	Undergraduate
$355.90	Graduate

Tuition per semester, Full Time Non-Resident

$9,970.44	Undergraduate (12 - 18 credit hours)
$10,595.16	Graduate (9 - 13 credit hours)

Tuition per semester, Part Time Non-Resident, per credit hr

$255.54	Undergraduate, 1 to 6 credit hrs
$355.90	Graduate, 1 to 6 credit hrs
$830.87	Undergraduate, 7 to 11 credit hrs
$1,177.24	Graduate, 7 to 8 credit hrs

Qualified veterans may be eligible for in-state tuition. Please see the Veterans Administrator for more information.

Fees and Deposits

$6.00	Auxiliaries Fee (per credit hour)
$1.00	Institute Activities Fee (per credit hour)
Variable	Laboratory Usage Fee
$4.50	Sports Activity Fee, (per credit hour)
$93.00	Student Activity Fee, Undergraduate, 7 credit hours or more
$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)
$16.00	Student Counseling Fee (per semester)
$200.00	Room Reservation/Damage Deposit
$200.00+$50.00 for each family member	Family Housing Deposit

Housing and Meal Plan Charges

See the current rate sheet at:
https://www.nmt.edu/prospective-a-incoming-students/135-rate-sheets

The minimum estimated expenses which must be met **per semester** by single, full-time students living on campus at New Mexico Tech during the 2017-2018 school year are:

Undergraduate Costs per Semester

Resident	Non-Resident	
$2,920.43	$9,495.74	Tuition (based on 12-18 credit hours)
$525.00	$525.00	Student fees (est. total based on 12 cr hrs)
$807.00	$807.00	Personal expenses (estimated total)
$3,030.00	$3,030.00	Room and board (double room, 150 + 75 Tech Dollar meal plan)
$527.00	$527.00	Books and supplies (estimated)
$7,809.43	**$14,384.74**	**Total Estimated Minimum Costs per Semester**

Graduate Costs per Semester

Resident	Non-Resident	
$3,050.55	$10,090.62	Tuition (based on 9-13 credit hours)
$514.84	$514.84	Student fees (est. total based on 9 cr hrs)
$807.00	$807.00	Personal expenses (estimated total)
$3,030.00	$3,030.00	Room and board (double room, 150 + 75 Tech Dollar meal plan)
$527.00	$527.00	Books and supplies (estimated)
$7,929.39	**$14,969.46**	**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.

The 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%

The student 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.

After the third Friday after classes begin:

No refunds are made to students who withdraw from any or all fall or spring classes after the third Friday after classes begin.

Tuition and Applicable Fees, Summer Semester
Prior to 5 p.m. on the first Friday after summer classes begin

The student who drops any or all summer classes at New Mexico Tech prior to 5 p.m. on the first Friday after classes begin will receive a 100% refund.

After the first Friday after classes begin

No refunds are made to students who drop or withdraw from any or all summer classes after the first Friday after classes begin.

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 43.

Room (Apartment or Residence Hall) Cancellation Policy
Entering Students
1. Students entering New Mexico Tech for the following terms may cancel their agreement without penalty by **June 1 (fall term), December 1 (spring term), and May 1 (summer term).**
2. Between above dates and the beginning of the Apartment/Residence Hall term, the student will be charged a $400 fee for breaking their agreement.
3. Room cancellations made after the beginning of the Apartment/Residence Hall term will receive no refund on their room rent. Fall semester residents who cancel their room for the following Spring semester will still pay the cost of the room.

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. 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. *www.nmt.edu/welcome-to-res-life*

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.

Board

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 and have two options through the e-billing system – three- or four-payment installment plans. 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. 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 it 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.

Late Validation

Students are required to validate their registration on the day of registration. Validation means the student has either paid their account balance in full, setup a valid payment plan on Touchnet, or has been to student accounts physically and made arrangements for paying their account balance.

Orientation Fee

A fee is charged for new student orientation.

Readmission Fee

A fee is charged for processing readmission to Tech.

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 (page 62). 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.

Tech Dollars Fee

Tech Dollars are the same as cash and may be used for the purchase of drinks, snacks, to go items, and all menu items sold in the Fire & Ice Coffee Shop. As an example, if you have 75 Tech Dollars after the purchase of $3 worth of food items the remaining balance would be 75 Tech Dollars. Tech Dollars apply to one semester only and may not be carried over to the next semester. No **Refunds** will be given for Tech Dollars. At the end of each semester Tech Dollars remaining in a student's account will be zeroed out.

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 pages 31-32 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 (PR), Fine Arts (FA), and Community College (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 Speare Hall, Office 145.

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. See page 32 for application deadlines.

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.

Registration

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

Orientation

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.

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 Math Score	SAT Redesign Math Score	Initial Math Course
20 or lower	490 or below	520 or below	MATH 101
21 to 25	500 to 580	530 to 600	MATH 103
26 to 29	590 to 660	610 to 690	MATH 104
30 or higher	670 or higher	700 or higher	MATH 131

You may also enroll in MATH 131 (Calculus and Analytic Geometry I) if:
1) You are transferring college credit in pre-calculus and trigonometry.
2) You have earned a 3 on the Advanced Placement (AP) Calculus AB exam or a 3 on the AB subscore of the Calculus BC exam.

An optional math placement test, which covers algebra 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. Once admitted, students can contact *mathplacement@nmt.edu* to request the placement test. **Waivers into 100-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.**

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. Registration after this period will depend upon the merits of each individual case.

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

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 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 Corequisites

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 may be disenrolled.

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 offered.

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:

- Undecided students work with the Associate Dean of Student Success who is located in the Office of the Registrar to determine the best placement until the major is declared.
- Advisor/Major changes are initiated in the Office for Student Learning.

- 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 (page 88) 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 (page 87) and the specific requirements of the graduate program.

Registration Fees

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.

Late Validation Fee

Students who fail to validate their registration by the first day of class are charged a late validation fee. Students who register late and who do not validate their registration that day will also be charged. This fee applies to all regular undergraduate and graduate students. Special students are not charged this fee.

Proof of Insurance

Regular full- or part-time students should have valid health and hospitalization insurance with a U.S.-based insurance company. Students are responsible for notifying the Student Health Center of any changes in their medical insurance.

Changes in Registration

A student may change his/her program 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.

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 70 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

(See also Withdrawal without Prejudice, page 71)

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 74-75 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.

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		Grade Points Per Sem. Hr
A		4.00
A-		3.67
B+		3.33
B		3.00
B-		2.67
C+		2.33
C		2.00
C-		1.67
D+		1.33
D		1.00
F		0.00
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

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) (see page 10). 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. (Transfer credits from other institutions are not included in the 18-hour maximum.). 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 (see Changes in Registration, page 69). 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, except for extenuating circumstances.

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 69)

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).

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 (page 9) 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.

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.

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/transcripts**. 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.

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 (PR), Fine Arts (FA), 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.

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.

Students on 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.

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.

Challenge Examinations

   In lieu of registering for a course, a student may request a challenge examination. (Students who have received a grade in a class taken at NM Tech may not take a challenge exam in that course.) These exams allow students to receive credit or waive the requirement for a course by passing a comprehensive test of the course material.

   Courses available through challenge exam are determined by department policy.

   Permission must be granted by the instructor of the course. A challenge examination fee is charged (page 63). The form of the examination (written, oral, practical, combination, etc.) will be determined by the instructor. 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. Some departments offer challenge exams on an S/U basis only.

   Credit hours and grade points earned in this way are exactly equivalent to those earned through successful completion of that course. The following regulations will apply to all challenge examinations:
   • Permission of the instructor of the course is required and the examination is given at a time of the instructor's choosing.
   • Information as to the nature of the challenge examination will be made available to a student upon request.
   • 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.
   • If a student is registered for the course, the challenge exam must be taken during the first three weeks of the fall or spring semester so the student's schedule can be adjusted.

Correspondence Courses

A student's total registration per semester is limited and requires approval of the advisor. Correspondence courses in progress during any semester must be recorded on the student's program. Approval of enrollment in a correspondence course does not necessarily imply that transfer credit will be allowed. If transfer credit is desired, regular evaluation procedures must be observed; moreover, a final grade for the course must be reported officially to the Registrar not later than 30 days before the end of the semester during which credit is desired.

Undergraduate Correspondence Courses

   Any undergraduate student who is enrolled for a correspondence course must report this fact in writing to the Vice President of Academic Affairs before registering for classes and also must obtain the Vice President's approval before enrolling for a correspondence course during a semester when enrolled at NMT.

Graduate Correspondence Courses

   A graduate student's total registration per semester, including all courses taken in residence and by correspondence, must not exceed 13 credit hours without approval of the advisor and Graduate Dean. Any student who is enrolled for a correspondence course must report this fact in writing to the Dean of Graduate Studies before registering for classes and also must obtain the Dean's approval before enrolling for a correspondence course during a semester when enrolled at NMT.

Directed Study Courses

Undergraduate Directed Study Courses

   To be included as part of a student's declaration of courses fulfilling degree requirements, 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 Information

New Mexico Tech adheres to the provisions set forth by the Family Educational Rights and Privacy Act of 1974, as amended. Under the provision of this Act, the following policies apply:

1. If you are a currently enrolled student or former student, you may inspect your educational records by submitting an official request and obtaining an appointment to do so.
2. You may challenge inaccuracies or misleading items. However, you may not challenge the fairness of a grade under this provision.
3. Your record is not released without your written consent except to New Mexico Tech school officials with a legitimate educational interest. School officials are agents of the university in an administrative, supervisory, academic, research or support staff position; members of university committees, boards and/or councils; and persons under contract to the university to perform a specific task, such as an attorney or auditor. School officials have a legitimate educational interest in accessing or reviewing a student's educational records if they are:
   * Performing a task that is specified in his/her position description or contract
   * Performing a task related to a student's education or to student discipline
   * Providing a service or benefit relating to the student or student's family.
   * Maintaining safety and security on campus.
   Other exceptions are to comply with a judicial order, or in an emergency involving the health or safety of a student or other person.
4. When a record is released, the recipient is notified by NM Tech that the record may not be released to a third party.
5. With the exception of disclosures to academic personnel, a record is kept of disclosures of personally identifiable information for which the student has not given written consent.
6. **Directory Information:** New Mexico Tech designates the following as directory information: name, student ID number, address, telephone number, dates of attendance, class, previous institution(s) attended, major field of study, awards and honors (includes honor roll), and degree(s) conferred (including dates). You have the right to withhold the disclosure of directory information. Any requests for such information from non-Tech persons or organizations will be refused. NM Tech will honor your request to withhold directory information but cannot assume responsibility to contact you for subsequent permission to release it. Regardless of the effect upon you, NM Tech assumes no liability for honoring your instructions that directory information be withheld.

For more information, contact the Office of the Registrar, Joseph A. Fidel Center, Room 285, 575.835.5133.

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.

D. **Overt acts requirement.**

Overt acts are required to 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 within the past twelve (12) months; or

- a transcript from an online high school showing a New Mexico address confirming attendance within the past 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.*

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. Credit earned at any institution while a student is on academic or disciplinary suspension from any institution will not be accepted at New Mexico Tech. Grades earned at other universities are not transferred to NM Tech.

Undergraduate Transfer Credits

A grade of "C" or higher is required for all transfer credit.

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

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 69).
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 71 for details).

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 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	Vehicles

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 is 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. If the issue or concern is with the department chair, the student should meet with the Associate Vice President of Academic Affairs. Every effort should be made to resolve the issues at this level.
- 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.
- Sexual harassment issues must be brought to the Director of Affirmative Action and Compliance.

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.

Graduation Requirements

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

1) The student must be a regular student.

2) The student must declare which catalog he or she is graduating under.

If a student is continuously enrolled (excluding summer sessions), the student may choose the degree requirements to be satisfied from:

a) the catalog in effect when the student first enrolled or

b) any subsequent catalog. 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. Each case will be dealt with individually.

A readmitted student **must** choose degree requirements to be satisfied from:

a) the catalog in effect when the student was readmitted or

b) any subsequent catalog provided the student is continuously enrolled after readmission.

3) 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 88 for the Bachelor of Science degree and page 127 for the Bachelor of General Studies degree.

4) 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. The minimum number of credit hours for any bachelor's degree is 120.

5) 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 88). However, these classes may be used to fulfill elective credit for some majors. Check the specific degree requirements for your major.

6) The student's cumulative grade point average (see page 10) must equal 2.0 or greater.

7) The student must complete a minimum of 30 credit hours at Tech.

8) 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 a Declaration of Intent are June 1 for those completing their degrees in August, July 1 for those completing their degrees in December, and December 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 department and the Registrar, to make sure that the courses fulfill all requirements for graduation. The final declaration 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.

9) All fees and financial obligations to NM Tech must be paid before a student will be awarded a degree.

10) 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 first degree.

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.

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 16 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 declaration of candidacy 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 between May 1 and the last day of the spring semester, that degree will be conferred by the Board of Regents on the last day of the spring semester. 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 early May.

If you finish your degree requirements prior to May, you may participate in ceremonies held for that academic year. 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 ERTH 480, Field Methods, during the summer immediately following commencement.

See 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

Any student having demonstrated superior scholastic competence and conduct may be named a "Tech Scholar" upon the recommendation of the advisor or major department chair and the approval of the Vice President for Academic Affairs. The student must normally have completed 30 or more letter-graded credit hours at NM Tech and achieved a cumulative GPA of 3.5 or better at Tech. A heavier than normal course load and employment hours will be taken into consideration. "Tech Scholar" status will remain in effect until the student graduates, but will be revoked if the student's cumulative GPA falls below 3.0. 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 he or she will be recognized at their graduation ceremony.

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 male and female 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 Anita 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 Pipkin Undergraduate Scholarship	Given to a junior or senior earth science student, with preference to students with interests in subsurface, sedimentary, and/or petroleum 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.
	Roswell Geological Society Award	Given to a graduate student or a graduating student who is majoring in earth science.
Environmental Engineering	Paige 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 GPA 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 undergrad student showing academic excellence that shows a financial need.
	Albuquerque Journal Scholarship	Given to a junior level undergraduate based on proposed research, to be applied to their senior year.
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 laboratory.
	Marvin Wilkening Award	Given to the graduating physics student who has demonstrated excellence in experimental physics. The technical tool kit is valued between $600 and $700.

Course Descriptions and Curricula

Course Descriptions

Course Numbers

Courses are arranged numerically by department or program. In general, courses numbered from 100 to 199 are intended primarily for first-year students (freshmen); 200 to 299 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.

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.

Most one-semester classes average three credit hours. To graduate with a bachelor's degree, you will need a minimum of 130 credit hours, depending on your chosen major.

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 offered.

Semester Offered

Not all courses are offered every semester. The first semester of a two-semester-sequence course (such as ACCT 201/202, ES 110/111, and ERTH 101/102) 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 "(Same as BCS 283)."

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 88). 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 88. 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 88).

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 Common Course Numbering System (NMCCNS)

A common course numbering system has been devised by New Mexico colleges and universities in compliance with the New Mexico Post-Secondary Education Articulation Act. The purpose of the system is to assist New Mexico students who are transferring between institutions within the state. The system provides a neutral state wide course identifier for those courses that are similar in nature and considered to be equal in transfer. Students will find in the course description section of the catalog the state wide course identifier and the area of the General Education Common Core in brackets following the New Mexico Tech course for which the course can meet general education requirements. (See Page 38)

General Education Core Curriculum Requirements

Requirements for a Bachelor of Science Degree

To fulfill the general education core curriculum requirements for the Bachelor of Science degree from New Mexico Tech, each student must complete the courses listed in this section. Where there are options, the student should consult with his or her appointed advisor.

Requirements for a Bachelor of General Studies Degree

The General Education Core Curriculum requirements for a Bachelor of General Studies are found on page 127.

Purpose of the General Education Core Curriculum Requirements

New Mexico Tech views its general education core curriculum requirements as the foundation for a broad and meaningful educational experience for all its undergraduates. The New Mexico Tech general education core curriculum requirements prepare students to communicate and reason well, evaluate and apply information, understand human societies and cultures, deepen their sense of values and ethics, and enrich their personal lives. Additionally, the general education core curriculum requirements equip students with the analytical, language, science, and mathematics skills necessary for the specific degree requirements of their majors. The courses and their sequence in the general education core curriculum requirements are designed specifically to achieve these objectives and to prepare students for success in subsequent courses.

New Mexico Higher Education General Education Core Competencies

New Mexico Tech teaches and assesses in compliance with the New Mexico Higher Education General Education Core Competencies established for Area 1: Communications; Area 2: Mathematics; Area 3: Basic Laboratory Sciences; Area 4: Social Sciences; and Area 5: Humanities.

Transfer Students

Transfer students are expected to meet these general requirements in principle but are not required to present the exact duplicates of these courses. Their transcripts will be evaluated by the Registrar.

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

GPA Requirements

Some department require that their students achieve a minimum GPA in required courses. This information is listed by individual department. Student should consult their advisors for specific criteria.

General Degree Requirements for a Master of Science Degree

The general requirements common to all M.S. degree curricula in the sciences and engineering fields are listed below. Additional requirements for specific curricula are listed under the appropriate department.

It is required that a student preparing for the M.S. degree:

1. Have competence in the subject matter of the standard introductory college courses in chemistry, physics, and one natural science,
2. Have a working knowledge of calculus and the content of one additional course in mathematics beyond calculus,
3. Have a minimum of six credit hours of approved upper-division or graduate course work from another department,
4. Declare a major with at least 12 credit hours of course work above the 500-level, exclusive of research credits, and
5. Complete a research project culminating in a thesis or independent study paper.

Note: These general requirements do not apply to students in the Master of Science for Teachers (MST) program. MST requirements are listed on page 57.

General Degree Requirements for a 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.

In addition to dissertation credits, course requirements for each specialty are listed under the programs and courses of instruction for each department.

General Education Core Curriculum Requirements for a Bachelor of Science Degree

Area 1– Communications (9 credit hours)

ENGL 111 (3) - ENGL 111 is waived for students who have a high enough ACT or SAT score (page 35). These students must take another course to replace the three credit hours; however, that course does not have to be an English course.

ENGL 112 (3) - Must meet prerequisites to enroll.

ENGL 341 (3) - Must meet prerequisites to enroll. Mechanical Engineering majors must use MENG 341.

Area 2 - Mathematics (8 credit hours)

MATH 131 (4) - Must meet prerequisites to enroll.

MATH 132 (4) - Must meet prerequisites to enroll.

Area 3 - Basic Laboratory Sciences (18 credit hours)

PHYS 121 & 121L (5) - Must meet prerequisites to enroll.

PHYS 122 & 122L (5) - Must meet prerequisites to enroll.

CHEM 121 & 121L (4) - Must meet prerequisites to enroll.

CHEM 122 & 122L (4) - Must meet prerequisites to enroll.

Area 4 - Social Sciences (6 credit hours)

Economics (ECON)

Political Science (PS)

Psychology (PSY)

Anthropology (ANTH)

Women's and Gender Studies (WGS)

Social Science (SS)

Area 5 - Humanities (6 credit hours)

English (ENGL), except ENGL 103, 111, 112, 341

Art History (ART)

Communication (COMM)

Music (MUS), except for performance ensembles

History (HIST)

Philosophy (PHIL)

Humanities (HUMA)

Technical Communication (TC) except TC 321, 420, 422

Theater (THEA)

Foreign Languages (SPAN, FREN, GERM)

Other languages may be counted only if they are listed or approved by the Communication, Liberal Arts, Social Sciences Department

Area 6 - Additional Courses from Area 4 or 5 (6 credit hours)

Arts & Sciences

Air Force ROTC
(AFROTC)

Professor Kleinschmidt
Assistant Professors Creel, Doane

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.

The Air Force ROTC commissioning program is open to qualified students in all academic majors. 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 USAF. Both the GMC and POC programs require students to enroll in an Aerospace Science Leadership Laboratory each semester.

Program Requirements

Qualified students may enroll in aerospace studies classes during normal college registration procedures. The student enrolls in the General Military Course (GMC) for the first two years. Prior to enrolling 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.

Financial Opportunities

The Air Force provides uniforms and textbooks for Air Force ROTC courses, as well as transportation expenses for the four-week summer training period. After successful completion of the training and entrance into the POC, participants will receive up to $500 a month (tax-free) subsistence for approximately 20 months (until graduation). Students who qualify may receive an AFROTC scholarship which will pay tuition and fees, up to $600 per year for books and up to $500.00 per month (tax-free) subsistence throughout the academic period that the scholarship is in effect. Scholarships are available for four, three and one-half, three, two and one-half, and two year periods. An additional year of scholarship benefits is available for most technical majors. Students who qualify for the POC and are not on AFROTC scholarships receive up to $500.00 per month. To retain this scholarship, the student must continue to meet retention standards.

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

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

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.

Three Phases of the AFROTC Program

General Military Course (GMC)

The GMC is an introduction to the 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 freshmen and sophomores. The GMC total 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 250 (spring semester). Sophomores may dual enroll in AFAS 120/121 and AFAS 250/251 to accomplish these requirements in two semesters instead of four.

Field Training

Field Training is a four 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 POC.

Professional Officer Course (POC)

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 in their junior and senior years. The POC totals approximately 300 hours, with 180 hours of academics and 120 hours of leadership laboratory over two years.

> NOTE: Leadership laboratory is a co requisite 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

General Military Courses

AFAS 120, The Foundation of the United States Air Force I, 1 cr
   A survey course designed to introduce students to the United States Air Force and provide an overview of the basic characteristics, missions and organization of the Air Force.

AFAS 120L, Leadership Laboratory, 1 cr
   Corequisite: AFAS 120
   Development of personal leadership and managerial abilities. Examination and demonstration of Air Force customs and courtesies, drill and ceremonies and standards of discipline and conduct. Graded S/U.

AFAS 121 The Foundation of the United States Air Force II, 1 cr
   A survey course designed to introduce students to the United States Air Force and provide an overview of the basic characteristics, missions and organization of the Air Force.

AFAS 121L, Leadership Laboratory
   Corequisite: AFAS 121
   Continuation of AFAS 120L. Graded S/U.

AFAS 250, The Evolution of USAF Air and Space Power I , 1 cr
   Introduces topics on Air Force heritage and leaders, introduction to air and space power through examination of competencies, functions and continued application of communication skills.

AFAS 250L, Leadership Laboratory
   Corequisite: AFAS 250
   Application of elements of personal leadership. Demonstration of command, effective communications, individual leadership instruction, physical fitness training and knowledge of Air Force requirements. Graded S/U.

AFAS 251, The Evolution of USAF Air and Space Power II, 1-2 credits
   Introduces topics on Air Force heritage and leaders, introduction to air and space power through examination of competencies, functions, and continued application of communication skills.

AFAS 251L, Leadership Laboratory, 1-2 cr
Corequisite: AFAS 251
Continuation of AFAS 250L. Graded S/U.

AFAS 300, Air Force Leadership Studies, 3 cr
Teaches cadets advanced skills and knowledge in management and leadership. Emphasis placed on enhancing leadership skills. Cadets have an opportunity to try out the leadership/management techniques in a supervised environment as juniors and seniors.

AFAS 300L, Air Force Leadership Laboratory
Corequisite: AFAS 300
Application of leadership and management theories and concerns through participation in advanced leadership experiences; weight and fitness training. Graded S/U.

AFAS 301, Air Force Leadership Studies, 3 cr
Teaches cadets advanced skills and knowledge in management and leadership. Emphasis placed on enhancing leadership skills. Cadets have an opportunity to try out the leadership/management techniques in a supervised environment as juniors and seniors.

AFAS 301L, Air Force Leadership Laboratory, 1 cr
Corequisite: AFAS 301
Continuation of AFAS 300L. Graded S/U.

AFAS 400, Natl Security Affairs/Prep for Active Duty, 3cr
A foundation for seniors to understand their role as military officers in American society. An overview of the complex social and political issues facing the military profession.

AFAS 400L, Air Force Leadership Laboratory, 1cr
Corequisite: AFAS 400
Application of leadership and management theories and concerns through participation in advanced leadership experiences; weight and fitness training.

AFAS 401, Natl Security Affairs/ Prep for Active Duty, 3cr
A foundation for seniors to understand their role as military officers in American society. An overview of the complex social and political issues facing the military profession.

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. Items required for the courses are provided by the AFROTC program.

Courses are taught on the main campus of UNM; students wishing to take these courses should contact the Aerospace Studies Department at 505.277.1838.

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

ERTH 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 88).

• 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 Kieft, Rogelj (Chair of the Department)
Associate Professor DeVeaux
Assistant Professors Duval, Waldrop, Watkins
Adjunct Faculty: Beers, Bell, Boston, Buelow, Calvert, Chain, Elliott, Frolova, Goncz, Markwell, Pias, Piyasena, Tartis, Thompson, Vuyisich, D. Wilkinson, P. Wilkinson, Wolberg
Emeritus Faculty: Reiss, Smoake

Degrees Offered: B.S. in Biology, Biology with Environmental Science Option, and Biology with Medical Technology Option; M.S. in Biology and M.S. in Biology with Specialization in Biochemistry

Program Offered: 5 year BS/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 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 231) 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 biophysical 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—130
In addition to the General Education Core Curriculum Requirements (page 88), the following courses are required:

- BIOL 111 (3), 111L (1), 112 (3), 112L (1), 311 (3), 311L (1), 331 (3), 333 (3) & 333L (1) or 341 (3) & 341L, and BIOL 471 (1)
- At least 6 additional credit hours from:
  BIOL 341 (3) & 341L (1) or 333(3) & 333L (1), 351 (3), 351L (1), 352 (3), 352L (1), 431 (3), 437 (3)
- At least 6 additional credit hours from:
  BIOL 343 (3), 343L (1), 344 (3), 344L (1), 444 (3), 446 (3), 455 (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 of the following: CHEM 311 (3–4), 331 (3–4), 333L (1), 334 (3), 334L (1), 441 (3–4)
- Computer Science or Mathematics: CSE 113 (4) or MATH 283 (3)
- Electives to complete 130 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 101 and BIOL 102. 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
4 BIOL 111 & 111L (intro)
4 CHEM 121 & 121L (general)
3 ENGL 111 (college English)
4 MATH 131 (calculus)
1 Physical Recreation
16 Total Credit Hours

Semester 2
4 BIOL 112 & 112L (intro)
4 CHEM 122 & 122L (general)
3 ENGL 112 (college English)
4 MATH 132 (calculus)
1 Physical Recreation
16 Total Credit hours

Semester 3
4 BIOL 311 & 311L (genetics)
3 BIOL 331 (cell)
3 Social Science
5 PHYS 121 & 121L (general)
3 CHEM 333 (organic)
18 Total credit hours

Semester 4
4 BIOL 333 & 333L (molecular)
3 Social Science
3 Humanities
5 PHYS 122 & 122L (general)
3 Chemistry Elective
18 Total credit hours

Semester 5
4 Biology Elective
3 Biology Elective
3 Chemistry Elective
3 Social Science
3 ENGL 341 (technical writing)
16 Total credit hours

Semester 6
4 Biology Elective
3 Biology Elective
3–4 CSE 113 (computer science) or
    MATH 283 (statistics)
3 Humanities
3 Electives
16-17 Total credit hours

Semester 7
4 Biology Elective
3 Biology Elective
1 BIOL 471 (seminar)
8 Electives
16 Total credit hours

Semester 8
4 Biology Elective
3 Biology Elective
3 Humanities/Social Science
6 Electives
16 Total credit hours

Bachelor of Science in Biology with Environmental Science Option

Minimum credit hours required—130
In addition to the General Degree Requirements (page 88), the following courses are required:

- BIOL 111 & 111L (4), 112 & 112L (4), 311 & 311L (4), 331 (3), 333 & 333L (4), or BIOL 343 & 343L, and BIOL 471 (1)
- At least 12 additional credit hours from: BIOL 343 (3), 343L (1), 344 (3), 344L (1), 444 (3), 446 (3), 455(3), 493 (4); CHEM 422 (3), 422L (1), ERTH 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 of 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 113 (4) or MATH 283 (3)
- Electives to complete 130 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 101 and BIOL 102. Prerequisites for a particular course may be waived only with the written permission of the course instructor and chair of the department.

Bachelor of Science in Biology with Medical Technology Option

Minimum credit hours required—130
In addition to the General Education Core Curriculum (page 88), the following courses are required:
- BIOL 111 & 111L (4), 112 & 112L (4), 341 & 341L (4), 437 (3),
  BIOL 351 (3), BIOL 352 (3)
- CHEM 311 & 311L (4), 333 & 333L (4)
- MATH 283 (3)
- Internship (63) at an approved school of medical technology

Minor in Biology

Minimum credit hours required—18
The following courses are required:
- BIOL 111 & 111L (4)
- BIOL 112 & 112L (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:
- ERTH 101 (3), ERTH 101L or 103L (1), ERTH 201 & 201L (4)
- BIOL 111 & 111L (4)
- Two classes from the following list: ERTH 450 (3), ERTH 390 (3), BIOL 341 (3), BIOL 344 (3), ERTH 449/BIOL 449 (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. Requirements for the Master of Science degree in Biology follow the M.S. with Thesis option (page 56). Additional requirements are the following:

- Completion of at least six credit hours of 500-level biology coursework other than thesis, directed study, or seminar.
- Completion of at least six credit hours of 500-level coursework other than thesis, directed study, or seminar in one or more disciplines outside of biology.
- Completion of two credit hours of BIOL 501, Graduate Seminar.

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. Requirements for the Master of Science degree in Biology with Specialization in Biochemistry follow the M.S. with Thesis option (page 56). Additional requirements are the following:
Completion of at least six credit hours of 500-level biology coursework other than thesis, directed study, or seminar.

- Completion of at least six credit hours of CHEM 521 (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.

Five Year Program: Biology B.S./Biology M.S.

Exceptionally qualified and motivated students may earn both BS and MS degrees in Biology in five years. The student fulfills the requirements for a BS degree in four years and for an MS degree the following year. A minimum of 160 credit hours are required to complete both degrees. The MS degree requires the completion of a thesis based on the student's own research.

Students may apply for the BS/MS program as early as the end of their 4th semester and no later than the end of the 6th semester. Admission is contingent on their having a GPA of at least 3.0, on the acceptability of their proposed course of study, and on the willingness of a Biology faculty member to be their graduate advisor. Students in the five-year program must apply for graduate standing, normally in their 6th semester. Once admitted to the graduate program, the student spends his or her 8th semester as a dually registered student. During their senior year, the student must select a graduate advisory committee and formalize his or her graduate research topic. Once admitted to the graduate program, a student may apply for financial support via research assistant or teaching assistant positions. Students are expected to make substantial progress on their graduate research project during their 4th year. Student progress will be evaluated by the Biology Department at the end of the 4th year; students making significant progress may continue in the program; others may be considered for the more standard Biology M.S. program (see above) or they may be dropped from the Biology M.S. program.

Biology Courses:

BIOL 101, Issues in Biological Science, 1 cr, 1 cl hr
Graded S/U
Introduction to modern topics in biotechnology, biodiversity, and biocomplexity. Discussion of career options in the biological sciences.

BIOL 111, 111L, General Biology, 4 cr, 3 cl hrs, 2 lab hrs
Corequisite: CHEM 109 or CHEM 121
A survey of life functions and associated structures at the cellular level. Energy fixation and utilization, growth and development through cell division, and gene action. [NMCCNS BIOL 1214: General Education Area III]

BIOL 112, 112L, General Biology II, 3-4 cr, 3 cl hrs, 3 lab hrs
Prerequisite: BIOL 111
Introduction to evolution, ecology, physiology, and development. Laboratory is a phylogenetic survey of the kingdoms of life. [NMCCNS BIOL 1224: General Education Area III]

BIOL 311, 311L, Genetics, 3–4 cr, 3 cl hrs, 3 lab hrs
Prerequisites: BIOL 111 & 111L; concurrent enrollment in 311R highly recommended.
An overview of the storage, transmission and expression of biological information. The lab emphasizes Mendelian analysis in model organisms and fluorescent analysis of human DNA.

BIOL 311R, Genetics Recitation, 1 cr, 1cl hrs
Corequisite: Biol 311

BIOL 331, Cell Biology, 3 cr, 3 cl hrs
Prerequisites: BIOL 111; CHEM 121
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 333, 333L, Molecular Biology, 3-4 cr, 3 cl hr, 3 lab hrs
Prerequisites: BIOL 331; CHEM 121
Principles of modern molecular biology. Laboratory emphasizes enzyme purification and recombinant DNA techniques, organized as a gene cloning project. BIOL 333 and BIOL 333L must be taken concurrently.

BIOL 341, 341L, Introductory Microbiology, 3–4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: CHEM 122

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 111

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 112; MATH 131

A study of the principles which govern the interactions between biological populations and the environment.

BIOL 351, Anatomy and Physiology I, 3 cr, 3 cl hrs

Prerequisite: BIOL 112; 331

Principles of human anatomy and physiology. Provides a general overview of the form and function of the following human systems: integumentary skeletal, muscular, nervous, endocrine, cardiovascular, lymphatic, immune, respiratory, digestive, urinary, and reproductive.

BIOL 351L, Anatomy and Physiology Lab I, 1 cr, 3 lab hrs

Corequisite: BIOL 351

An in-depth study of human anatomy and physiology, covering microanatomy and gross anatomy of multiple systems as well as physiological function. Focal systems will include: skeletal, muscular, gastrointestinal, cardiovascular, respiratory systems and the special senses.

BIOL 352, Anatomy and Physiology II, 3 cr, 3 cl hrs

Prerequisite: BIOL 351

A continuation of BIOL 351 with more in-depth study of human physiology. Topics will include a variety of physiology systems and expand on systems covered in BIOL 351 and human development.

BIOL 352L, Anatomy and Physiology Lab II, 1 cr, 3 lab hrs

Prerequisite: BIOL 351

Corequisite: BIOL 352

An in-depth study of human anatomy and physiology, covering microanatomy and gross anatomy of multiple systems as well as physiological function. Focal systems will include: skeletal, muscular, gastrointestinal, cardiovascular, respiratory systems and the special senses.

BIOL 362, Animal Behavior, 3 cr, 3 cl hrs

Prerequisites: PSY 121; BIOL 112; or consent of instructor

An overview of the study of animal behavior, focusing on presentation, adaptive advantage and mechanisms of specific behaviors. (Same as PSY 362)

BIOL 409, Cell and Molecular Neuroscience, 3 cr, 3 cl hrs

Prerequisite: PSY 121 or BIOL 111

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 333

A study of current topics in genetics, including the molecular basis of gene structure and action in eukaryotes and prokaryotes.

BIOL 435, 435D, Bioinformatics , 3 cr, 3 cl hrs

Prerequisite: BIOL 311 or consent of instructor

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 444, Evolutionary Biology, 3 cr, 3 cl hrs,

Prerequisite: BIOL 311, BIOL 344

The mechanisms and implications of biological evolution. Topics include population genetics, adaptation and natural selection, fossil evidence, and evolutionary medicine.

BIOL 446, Environmental Toxicology, 3 cr, 3 cl hrs

Prerequisite: CHEM 333

The fate and behavior of toxic pollutants in terrestrial and aquatic environments, from an ecosystem perspective.

BIOL 449 Astrobiology, 3 cr, 3 cl hours

Prerequisites: CHEM 121, 122, PHYSICS 121, 122, 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 ERTH 449.)

BIOL 455, Molecular Ecology, 3 cr, 3 cl hrs

Prerequisites: BIOL 311 and 344, or consent of instructor

Application of molecular biological techniques to ecological and environmental problems. Current research projects at Tech are emphasized.

BIOL 471, Life Sciences Seminar, 1 cr, 1 cl hr

Prerequisite: Upper-class standing in biology or consent of instructor

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 486, Cytogenetics, 3 cr, 3 cl hrs

Prerequisites: BIOL 311 and 333

Principles of chromosome structure and function with an emphasis on medical diagnostics. Course includes a field trip to a cytogenetics diagnostic laboratory.

BIOL 489, 489D, 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 or consent of instructor

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 509, Cell and Molecular Neuroscience, 3 cr, 3 cl hrs

Prerequisite: PSY 121 or BIOL 111

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: BIOL 311 and 333

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 535, 535D, Bioinformatics 3 cr, 3 cl hrs

Prerequisite: BIOL 311 or consent of instructor

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: BIOL 341

Study of human infectious disease and the immune system. Pathogenic microorganisms and mechanisms of pathogenicity. Innate and acquired immune responses. Immunochemistry, 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: BIOL 341 or consent of instructor

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 544, Evolutionary Biology, 3 cr, 3 cl hrs

Prerequisite: BIOL 311, BIOL 344; graduate standing or consent of instructor.

The mechanisms and implications of biological evolution. Topics include population genetics, adaptation and natural selection, fossil evidence, and evolutionary medicine. Shares lecture with BIOL 444, with additional expectations for graduate credit.

BIOL 549 Astrobiology, 3 cr, 3 cl hours

Prerequisites: Graduate status or 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 449, with additional expectations for graduate credit. (Same as GEOL 549.)

BIOL 560, Population and Community Ecology, 3 cr, 3 cl hrs

Prerequisites: BIOL 344; graduate standing or consent of instructor

Advanced study of demography, population dynamics, species interactions, and community structure.

BIOL 564, Molecular Ecology, 3 cr, 3 cl hrs

Prerequisite: BIOL 333 or consent of instructor

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 586 Cytogenetics, 3 cr, 3 cl hrs

Prerequisites: BIOL 311 and 333

Principles of chromosome structure and function with an emphasis on medical diagnostics. Course includes a field trip to a cytogenetics diagnostic laboratory. Shares lecture with BIOL 486, with additional expectations for graduate credit.

BIOL 591, Thesis (master's program), cr to be arranged

Faculty Professional and Research Interests

Bhasker—Medical Professions
Boston —Geomicrobiology
Chain— Bioinformatics, Metagenomics, Molecular Genetics
DeVeaux — Radiation Microbiology and Extremophilic Adaptations, Pathogenicity Gene Transfer
Duval — Biogeochemistry, Plant Ecology & Soil Science
Elliott — Neuroscience, Animal Communications, and Psycholinguistics
Frolova — Synthetic Organic Chemistry, Drug-Delivery, Organic-Inorganic Hybrid Materials
Goncz — Education, Education of Educators, Curriculum Development
Kieft— Microbiology, Environmental Biology
Kirk—Biology of Aging, Evolutionary Ecology
Markwell—Medical Professions
Pias— Biochemistry & Computer Simulations of Biological Phenomena
Piyasena— Analytical Tools for Environmental, Biological, and Chemical Analysis
Reiss—Molecular Genetics, Evolution
Rogelj—Anti-Cancer and Anti-Infectives, Drug Discovery, Anti-Microbial Materials
Tartis—Chemical Engineering of Drug Delivery Systems
Thompson—Cell and Molecular Neuroscience of Vision
Vuyisich—Genome Science & Technology Applications
Dean Wilkinson—Veterinary Professions
Pepita Wilkinson—Veterinary Professions
Smoake—Animal Physiology, Endocrinology
Vuyisich — Cancer Biology, Infectious Diseases, Antibiotic Resistance, Toxicology, Forensics
Waldrop — Comparative Biomechanics, Biological Fluid Dynamics, Invertebrate Physiology
Watkins — Bacteriophage Biology, Plant Microbiomics, Algal Biofuels
Wolberg — Education, Paleontology

Biomedical Sciences
(Transdisciplinary)

Biomedical Sciences Advisory Committee:
Snezna Rogelj, Biology
Sally Pias, Chemistry
Mark Samuels, Psychology
Michaelann Tartis, Chemical Engineering
Bhaskar Majumdar, Materials Engineering
David Grow, Mechanical Engineering
Ex Officio: Dean of Arts & Sciences, Dean of Engineering

Degrees Offered: B.S. in Biomedical Sciences, with options in Biology, Chemistry and Cognitive Neuroscience

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.

Undergraduate Program
Core requirements for the Bachelor of Science in Biomedical Sciences (all options)

Minimum credit hours required—127
In addition to the General Education Core Curriculum Requirements (page 88), the following core program is required of all Biomedical Sciences students. Note that courses marked with an asterisk (*) may also be used to satisfy General Education requirements:

- BMS 101 (1), BMS 300 & 300L (4)
- BIOL 111 & 111L (4), BIOL 112 & 112L (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 231 (4), MATH 335 (3), MATH 383 (3)
- PHIL 342 (3)*
- PSY 121 (3)*, PSY 205 & 205L (4)*
- BMS 495 (3)
- BMS 496 (3)
- One of the science options described below
- One of the engineering concentrations described below

Bachelor of Science in Biomedical Sciences with Biology Option

In addition to the General Education Core Curriculum Requirements (page 88), and the core Biomedical Sciences Requirements (above), the following courses are required (11 credits):

- BIOL 333 & 333L (4), BIOL 351 & 351L (4), BIOL 435 or BIOL 437 (3)
  OR
- BIOL 351 & 351L (4), BIOL 352 & 352L (4), BIOL 435 or BIOL 437 (3)

Bachelor of Science in Biomedical Sciences with Chemistry Option

In addition to the General Education Core Curriculum Requirements (page 88), and the core Biomedical Sciences Requirements (above), the following courses are required:

- CHEM 311 & 311L (4), CHEM 331 & 331L (4), CHEM 442 & 442L (4)

Bachelor of Science in Biomedical Sciences with Cognitive Neuroscience Option

In addition to the General Education Core Curriculum Requirements (page 88), and the core Biomedical Sciences Requirements (above), the following courses are required:

- PSY 212 (3)*, PSY 309 & 309L (3)*, PSY 314 (3)*, PSY 409 (3)*, PSY 410 (3)*

Engineering Concentrations

Biochemical Engineering

- ChE 326 (3)
- Two of ChE 476 (3), ChE 489 (Surfaces, Interfaces, Colloids), ChE 489 (Nanostructures & Nanomaterials), ChE 489 (Bioprocess Engineering)

Bioinformatics

- BIOL 311 & 311L (4), BIOL 333 & 333L (4), (part of Biology Option), BIOL 435 (3)
- CSE 122 (3), CSE 373 (3)

Biomaterials

- MATE 202 & 202L (4), MATE 310 (3), MATE 420 (3)

Biomechanics

- ES 201 (3), ES 216 (3), ES 303 (3)
- MENG 460 (3)

Biomedical Sciences Courses:

BMS 101, Introductory Biomedical Sciences, 1 cr, 1 cl hr

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.

BMS 300, 300L, Biotechnology and Lab, 3-4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: BMS 101, BIOL 111, CHEM 121

An overview of research in biomedicine, bioinformatics, bioprocesses, and biorobotics. Attention also given to moral and ethical issues. Lab projects are integral to the course.

BMS 495, 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 593, with additional expectations for graduate credit.

BMS 496, 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 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.

Biotechnology
(Transdisciplinary)

Faculty:
Biology - DeVeaux, Duval, Kieft, Rogelj, Waldrop, Watkins
Chemical Engineering - Calvert, Choudhury, Chowdhury, Lecerlc, Tartis
Chemistry - Frolova, Pias, Piyasena, Tello-Aburto
Computer Science & Engineering - Mazumdar
Earth & Environmental Science - Cadol
Environmental Engineering - Huang
Materials Engineering - Kalugin
Mathematics - Makhnin, Stone
Mechanical Engineering - Grow, 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 purse 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

    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

    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 a d 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 MATE 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 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

Professors Heagy (Chair)
Associate Professors Altig (Associate Chair), Wingenter
Assistant Professors Patidar, Pias, Piysena, Ranasinghe, Rubasinghege, Tello-Aburto
Research Faculty Frolova
Emeritus Professors Brandvold, Hatch, Popp

Degrees Offered: B.S. in Chemistry, B.S. in Chemistry with Environmental Science Option, and B.S. in Chemistry with Biochemistry Option; 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. Graduates receive a Bachelor of Science degree accredited by the American Chemical Society, and the chemistry 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 Core Curriculum Requirements (page 88), the following courses are required:
- MATH 231 (4), CSE 174 (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), 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).

This leaves a minimum of 14 credit hours of electives. The Chemistry Department promotes a diverse set of electives for a well-founded education. In addition to the above requirements, the Chemistry Department strongly recommends the following course be taken by students seeking a major in Chemistry:

Recommended Electives
- CHEM 442 (3), CHEM 442L (1)
- CHEM 343 (3)
- One or more of MATH 254 (3), 283 (3) or 382 (3), 335 (3)
- One or more of MGT 330 (3), 462 (3), 476 (3)
- BIOL 111 (3), 111L (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 *Preprofessional Programs* on page 231 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 121 & 121L (general)
3 ENGL 111 (college English)
4 MATH 131 (calculus)
4 BIOL 111 & 111L (general)
15 Total credit hours

Semester 2
4 CHEM 122 & 122L (general)
3 ENGL 112 (college English)
4 MATH 132 (calculus)
5 PHYS 121 & 121L (general)
16 Total credit hours

Semester 3
4 CHEM 311 & 311L (quantitative analysis)
4 CHEM 333 & 333L (organic)
4 MATH 231 (calculus)
5 PHYS 122 & 122L
17 Total credit hours

Semester 4
4 CHEM 334 & 334L (organic)
4 CSE 107 & 107L (programming)
3 Humanities
3 Social Science
3 CHEM 343 (inorganic)
17 Total credit hours

Semester 5
4 CHEM 331 & 331L (physical)
3 Humanities
3 Social Science
4 CHEM 441 & 441L (biochemistry)
3 Math Recommended
17 Total credit hours

Semester 6
4 CHEM 332 & 332L (physical)
3 ENGL 341 (technical writing)
3 Humanities/Social Science
4 CHEM 442 & 442L (biochemistry)
1 CHEM 301 (toolbox)
15 Total credit hours

Semester 7
4 CHEM 411 & 411L (instrumental)
3 CHEM 400/500 (directed research)
3 CHEM 446 (polymer)
1 CHEM 493 (senior thesis)
3 Humanities/Social Science
14 Total credit hours *

Semester 8
4 CHEM 443 & 443L (inorganic)
4 CHEM 400/500 (directed research)
2 CHEM 494 (senior thesis)
3 MGT 300 or 462 (management elective)
12 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 Core Curriculum Requirements (page 88), 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; ERTH 130, 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 254, 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 Core Curriculum Requirements (page 88), 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 254, 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)

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 recommended to consult the chemistry graduate handbook for details. Remedial coursework does not count toward degree requirements. The student's course of study must be approved by the student's 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 towards this requirement. Additionally students must take 6 credit hours at the 300, 400, or 500-level and above from other departments. The student should consult with their committee and advisor when developing a course plan.

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 521 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.

Five-Year BS/MS Program in Chemistry

Exceptionally well-motivated students may earn both BS and MS degrees in Chemistry in five years. The student fulfills the requirements for a BS in four years and for a MS degree the following year. To complete both degrees, a minimum of 150 credit hours are required, including 12 credit hours of 500-level chemistry courses, 6 credit hours of courses at the 300-level or above from other departments, and 1 credit hour of Graduate Seminar (CHEM 529/530). Three credit hours of 300-level or above may be applied to both the BS and MS degrees.

Students may express their intent to apply for the BS/MS program as early as the end of their 4th semester and must formalize their application no later than the end of their 6th semester. Prior research experience is required, along with a recommendation letter from the research advisor. Prospective BS/MS students are encouraged to begin research with their indeed master's advisor early in their academic career.

By the end of the 6th semester, applicants must have earned a grade of B or better in all of the following courses and their associated laboratories:

> General Chemistry (CHEM 121 and CHEM 122)
> Physical Chemistry (CHEM 331 and CHEM 332)
> Organic Chemistry (CHEM 333 and CHEM 334)
> Quantitative Analysis (CHEM 311)

Admission to the BS/MS program is contingent on the applicant's having a GPA of at least 3.0 at the time of application and at the end of the 7th semester. In addition, by the end of the 8th semester, students are required to complete CHEM 443, CHEM 411, CHEM 441, CHEM 442 and associated laboratories, earning a grade of B or better.

Students in the five-year program must apply for graduate standing, normally in the 6th semester. Once admitted to the graduate program, the student spends his or her 8th semester as s dually registered student.

Registration for Graduate Seminar (CHEM 529, 530) is required beginning with the 8th semester. Student must register for Graduate Seminar for a letter grade and give a presentation during the 9th semester. The MS degree requires completion of a master's thesis based on the student's research.

At the beginning of the 7th semester, the student must select a graduate advisory committee and formalize his or her graduate research topic. The BS/MS program, including the master's thesis defense, must be completed by the end of the 10th semester.

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. Prior to the beginning of the 9th semester, the suitability of the proposed master's level research will be judged by the student's graduate committee.

Upon completion of the requirements for earning the BS degree, a student in the 5-year BS/MS program becomes eligible for financial support via research assistantship or teaching assistantship positions. Financial support is contingent upon the availability of funds.

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 in Chemistry is focused on environmental and human health related topics. Interdisciplinary programs with other science departments, such as Physics, Biology, 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.

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 any substitute up to 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 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 109, Introduction to Chemistry, 3 cr, 2 cl hrs, 4 lab hrs
Prerequisite: MATH 101
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 121, General Chemistry I, 3 cr, 3 cl hrs, 1.5 recitation hours
Prerequisite: MATH 103 (or equivalent, passed with grade C- or better) or CHEM 109 (passed with C- or better)
Corequisite: CHEM 121L
Offered fall and spring semesters

Basic descriptive and quantitative principles of chemistry associated with the concepts of the mole, concentration, heat, atomic and molecular structure, periodicity, bonding, physical states, stoichiometry, and reactions.
[NMCCNS CHEM 1214: General Education Area III]

CHEM 121L, General Chemistry Laboratory I, 1 cr, 3 lab hrs
Corequisite: CHEM 121; a lab usage fee is charged
Offered fall and spring semesters

Laboratory experiments and techniques emphasizing principles from CHEM 121. [NMCCNS CHEM 1214: General Education Area III]

CHEM 122, General Chemistry II, 3 cr, 3 cl hrs, 1.5 recitation hours

Prerequisites: CHEM 121 and 121L

Corequisites: CHEM 122L and MATH 131 or equivalent

Offered fall and spring semesters

Continuation of CHEM 121. Emphasizes basic kinetics, thermodynamics, equilibria, electrochemistry, reactions of inorganic compounds, and an introduction to organic chemistry. [NMCCNS CHEM 1224: General Education Area III]

CHEM 122L, General Chemistry Laboratory II, 1 cr, 3 lab hrs

Corequisite: CHEM 122; a lab usage fee is charged

Offered fall and spring semesters

Laboratory experiments and techniques emphasizing principles from CHEM 122. [NMCCNS CHEM 1224: General Education Area III]

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 122 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 122 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 122 passed with grade C- or better; MATH 132; PHYS 122

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 122 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 343, Inorganic Chemistry, 3 cr, 3 cl hrs

Prerequisites: CHEM 122 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 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

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

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

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)

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

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

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

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

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

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 431, Chemistry of Aquatic Systems, 3 cr, 3 cl hrs

Prerequisite: CHEM 311 or consent of instructor

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 ERTH 407.)

CHEM 432, Atmospheric Chemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 331, 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 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

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

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

Offered spring semester

Atomic and molecular structure with relationships based on the periodic system; bonding theories; elements of group theory; chemistry in nonaqueous solvents; chemistry of the elements; coordination chemistry; ligand field theory.

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
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
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
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
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
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
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

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

This course may not be used to fulfill graduate degree requirements.

CHEM 501 Applied Molecular Quantum Mechanics, 3 cr, 3 cl hrs

Prerequisites: CHEM 332, 334, and 443

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: CHEM 411 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: CHEM 331 and 411, 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

Prerequisites: Any two of the following: CHEM 311, 331, or 333 (or consent of instructor)

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 422, with additional expectations for graduate credit.

CHEM 522L, 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 422L, with additional expectations for graduate credit.

CHEM 523, Applied Spectroscopy, 3 cr, 3 cl hrs

Prerequisite: CHEM 332 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: CHEM 331 or equivalent, 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: CHEM 332 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: CHEM 332 or equivalent, 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: CHEM 332 or equivalent, 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: CHEM 331 and 332 or equivalent, 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

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: CHEM 311 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: CHEM 331 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: CHEM 311 or 331, 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: CHEM 331 and 333, 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: CHEM 334 or equivalent, 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: CHEM 334 or equivalent, or consent of instructor

Principles and practices of organic synthesis.

CHEM 546, Polymer Chemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 332 and 334 or equivalent, 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: CHEM 334 or equivalent, 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: CHEM 334 or equivalent, 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: CHEM 334 or equivalent, 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: CHEM 334 or equivalent, 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: CHEM 443 or equivalent, 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

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: CHEM 442 or consent of instructor

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 lectures. Shares lectures with CHEM 461, with additional expectations for graduate credit.

CHEM 581, 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 589 Special Topics in Chemistry, cr to be arranged

CHEM 591, Thesis (master's program), cr to be arranged

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
Frolova—Organic and Medicinal Chemistry
Heagy—Organic Chemistry, Organic Synthesis, Physical Organic Chemistry
Patidar - Biochemistry, DNA Repair Pathways and Carcinogenesis
Pias—Computational Chemistry and Biochemistry
Piyasena—Bioanalytical Chemistry
Ranasinghe - Photonic Nanomaterials, Time-Resolved Ultrafast Laser Spectroscopy, Non-Linear Spectroscopy
Tello Aburto—Organic Synthesis, Medicinal Chemistry
Wingenter—Atmospheric and Ocean Chemistry, Climate Change

Emeritus Faculty Research Interests

Brandvold—Biophysical Chemistry, Enzyme Mechanisms, Environmental Chemistry, Atmospheric Chemistry
Hatch—Organic Chemistry, Polymer Chemistry
Popp—Environmental Chemistry, Geochemistry

Communication, Liberal Arts, Social Sciences (CLASS)

Professors Dezember, D. Dunston, Lara-Martínez, Prusin
Associate Professor Simpson (Chair of the Department)
Assistant Professors Dotson, Durão, Higgins, Kramer-Simpson, Mikhailova, Priest
Instructors Henneke, Kieffer, Rowe
Adjunct Faculty Barrientos, Henneke, Phillips, Pick-Baca, Stewart-Langley
Emeritus Professors Campbell, Corey, Deming, S. Dunston, Olsen, Wilson, Yee
Music Director Benalil

Degree Offered: B.S. in Technical Communication, B.G.S., A.G.S.
Minors Offered: Hispanic Studies, History, Literature, Music, Philosophy, Science & Technology Stuides, Technical Communication

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 three of the five 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 Public Speaking);
Area 4 — Social Sciences (Cultural Anthropology, Political Science, Women's and Gender Studies);
Area 5 — Humanities/Liberal Arts (Art History, Communication, Creative Writing, Hispanic History, History, Languages, Literature, Media Studies, Music, Philosophy, Popular Culture, Technical Communication, Visual Art).

The Department offers three degrees: an industry-endorsed Bachelor of Science in Technical Communication, 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.

Degrees and Curricula:
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 TC courses introduce students to document design, graphics, and computer documentation, created online and for multimedia. The TC 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.

Minimum credit hours required—120

In addition to the General Education Core Curriculum (page 88), the following courses are required:

- Technical Communication—35 credit hours of technical communication courses including TC 100 (1), 101 (1), 151 (3), 202 (3), 211 (3), 321 (3), 411 (3), 420 (3), 421 (3), 422 (3), and nine credit hours of technical communication electives. MGT 330 is an approved TC elective. All technical communication courses must be completed with grade C or better. Students may use these TC courses to fulfill Area 5 of the General Education Core Curriculum Requirements (page 88) with the exception of TC 321, TC 421, and TC 422.
- Humanities: 12 credit hours in excess of the General Education Core Curriculum Requirements and excluding TC 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

Sample Curriculum for the Bachelor of Science in Technical Communication

Semester 1
1	TC 101 (orientation)
3	ENGL 111 (college English)
4	MATH 131 (calculus)
4	CHEM 121 & 121L (general)
3	Foreign Language
15	Total credit hours

Semester 2
3	TC 151 (visual communication)
3	ENGL 112 (college English)
4	MATH 132 (calculus)
4	CHEM 122 & 122L (general)
3	Foreign Language
17	Total credit hours

Semester 3
3	TC 202 (elements of editing)
5	PHYS 121 & 121L (general)
3	Humanities
3	Social Science
1	Elective
15	Total credit hours

Semester 4
3	TC 211 (media studies)
5	PHYS 122 & 122L (general)
3	Humanities
3	Social Science
1	Elective
15	Total credit hours

Semester 5
1	TC 100 (community service)
3	ENGL 341 (technical writing)
6	Humanities
3	Humanities/Social Science
3	Science or Engineering
16	Total credit hours

Semester 6
3	TC 421 (professional writing workshop)
3	Technical Communication Elective
6	Humanities
3	Social Science
3	Science or Engineering
18	Total credit hours

Semester 7
3	TC 321 (internship)
3	TC 411 (persuasive writing)
3	TC 420 (senior seminar)
3	TC Elective
3	Science or Engineering
15	Total credit hours

Semester 8
3	Technical Communication Elective
3	TC 422 (senior thesis)
3	Science or Engineering
6	Electives
15	Total credit 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 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 for the Bachelor of General Studies (BGS)

Area 1: Communications (9 credit hours)
- ENGL 111 — ENGL 111 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 112, ENGL 242 and ENGL 341 to fulfill the 9 credit hours in this area.
- ENGL 112
- COMM 242 or ENGL 341

Area 2: Mathematics (3 credit hours)
- MATH 101
- MATH 103
- MATH 104
- MATH 105
- MATH 131

Area 3: Laboratory Sciences (8 credit hours with associated labs)
- BIOL 111 & Lab
- BIOL 112 & Lab
- CHEM 109
- CHEM 121 & Lab
- CHEM 122 & Lab
- PHYS 121 & Lab
- PHYS 122 & Lab
- ES 110 & Lab
- ES 111 & Lab
- CSE 113
- Engineering with lab (ChE, CE, EE, ENVE, MATE, METE, ES, MENG, ME, PETR)

Area 4: Social Sciences (6 credit hours)
- Anthropology (ANTH)
- Economics (ECON)
- Political Science (PS)
- Psychology (PSY)
- Social Sciences (SS)
- Women's and Gender Studies (WGS)

Area 5: Humanities (6 credit hours)
- English (ENGL), except 103, 111, 112, 341. If ENGL 242 is used to fulfill credits in Area 1, it cannot also count in Area 5.
- Art History (ART)
- History (HIST)
- Humanities (HUMA)
- Music (MUS) except for performance ensembles
- Technical Communication (TC) except TC 321, 420, 422
- Foreign Languages (SPAN, FREN, GERM). Other languages may be counted only if they are listed or approved by the CLASS Department.

Area 6: Additional Courses from Area 4 or Area 5 (6 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—65

A two-year certificate, Associate of General Studies, may be awarded after completion of 65 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 111 — ENGL 111 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 112, ENGL 242 and ENGL 341 to fulfill the 9 credit hours in this area.
- ENGL 112
- COMM 242 or ENGL 341

Area 2: Mathematics (3 credit hours)
- MATH 101
- MATH 103
- MATH 104
- MATH 105
- MATH 131

Area 3: Laboratory Sciences (8 credit hours with associated labs)
- BIOL 111 & Lab
- BIOL 112 & Lab
- CHEM 109
- CHEM 121 & Lab
- CHEM 122 & Lab
- PHYS 121 & Lab
- PHYS 122 & Lab
- ES 110 & Lab
- ES 111 & Lab
- CSE 113
- Engineering with lab (ChE, CE, EE, ENVE, MATE, METE, ES, MENG, ME, PETR)

Area 4: Social Sciences (6 credit hours)
- Anthropology (ANTH)
- Economics (ECON)
- Political Science (PS)
- Psychology (PSY)
- Social Sciences (SS)
- Women's and Gender Studies (WGS)

Area 5: Humanities (6 credit hours)
- English (ENGL), except 103, 111, 112, 341. If ENGL 242 is used to fulfill credits in Area 1, it cannot also count in Area 5.
- Art History (ART)
- History (HIST)
- Humanities (HUMA)
- Music (MUS) except for performance ensembles
- Technical Communication (TC) except TC 321, 420, 422
- Foreign Languages (SPAN, FREN, GERM). Other languages may be counted only if they are listed or approved by the CLASS Department.

Area 6: Additional Courses from Area 4 or Area 5 (6 credit hours)

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 professionals an opportunity to build and strengthen their professional communication abilities for academic and professional work. The 14 hours of coursework required for the Certificate brings the student from a general foundation (ENGL 501 and TC 511) to specific media of presentation (COMM 560), while elective courses are available to students with specific interests; for example professionals who work in the Americas will benefit from SPAN 520, engineers may be interested in a course specifically designed for Engineering Communication (COMM 570). Requirements for this degree include the following:

- COMM 575 (3) or TC 505 (3), TC 511 (3)
- Six credits from the following: COMM 575 (3) or TC 505 (3) (whichever was not used for the requirement above), TC 561 (3), ENGL 511 (3), SPAN 520 (3), TC 521 (3), TC 512 (3), COMM 560 (3).
- Community Service/Internship - TC 501 (2)

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).

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 Hispanic Studies

The following courses are required:
- One of the following sequences (6)
  — SPAN 113 and 114, Elementary Spanish I and II
  — SPAN 113N and 114N, 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

STOP

Anthropology Courses:

The following courses may be used to fulfill Area 4: Social Sciences of the General Education Core Curriculum (page 88).

ANTH 101, 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 5: Humanities of the General Education Core Curriculum (page 88).

ART 272, Art History, 3 cr, 3 cl hrs

Survey of art of the western hemisphere from prehistory to the 21st century. May incorporate an interdisciplinary approach. [NMCCNS ARTS 2113: General Education Area V]

ART 372, Issues in Art History, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 or consent of instructor

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; Literature inspired by Art; Modern Art, Sci Fi, and Film.

Communication Courses:

The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 88).

COMM 242, 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. [NMCCNS COMM 1113: General Education Area I]

COMM 360, Advanced Public Speaking, 3 cr, 3 cl hrs

Prerequisites: COMM 242 or consent of instructor

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.

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.

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.

COMM 575, Communication in the Sciences 3 cr, 3 cl hrs

Prerequisites: Graduate Standing

Advanced communication/writing courses linked to science 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.

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 distraction-free writing environment and have opportunities for feedback from the instructor or available writing consultants.

English Courses:

The following courses (except ENGL 103, 111, 112, 341) may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 88).

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 111. *(Does not fulfill the English portion of the General Education Core Curriculum, page 88.)*

ENGL 105, 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 106, 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 111, College Writing: Exposition, 3 cr, 3 cl hrs

The essentials of academic prose; techniques and mechanics of writing well; rhetorical strategies. [NMCCNS ENGL 1113: General Education Area I]

ENGL 112, College Writing: Argument and Analysis, 3 cr, 3 cl hrs

Prerequisite: ENGL 111 or equivalent course passed with a C or better

A continuation of ENGL 111 with critical reading and writing; writing arguments; library research paper. [NMCCNS ENGL 1123: General Education Area I]

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 111 and 112 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.

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.

Literature Courses:

ENGL 120, 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. [NMCCNS ENGL 1013: General Education Area V]

ENGL 311, Creative Writing, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 or consent of instructor

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 112 or consent of instructor

Concentrated study of major works of short fiction written in English and in translation.

ENGL 321, American Literature, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 or consent of instructor

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. [NMCCNS ENGL 2513: General Education Area V]

ENGL 322, American Literature, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 or consent of instructor

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. [NMCCNS ENGL 2523: General Education Area V]

ENGL 323, American Nature Writing, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 or consent of instructor

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, inter-disciplinary, 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 112 or consent of instructor

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 112 or consent of instructor
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 112 or consent of instructor
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 112 or consent of instructor
A survey of British literature from its origin through the Age of Enlightenment. Major authors studied include the Beowulf poet, Chaucer, Shakespeare, and Milton. [NMCCNS ENGL 2413: General Education Area V]

ENGL 332, British Literature, 3 cr, 3 cl hrs
Prerequisite: ENGL 112 or consent of instructor
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 112 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 112 or consent of instructor
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 112 or consent of instructor
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 112 or consent of instructor
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 112 or consent of instructor

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 112 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 112 or consent of instructor

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.

ENGL 524, Ecotopia: The Intersection of Science and Literature, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing or consent of instructor

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.

French Courses:

The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 88).

FREN 113, 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 114, Elementary French II, 3 cr, 3 cl hrs

Prerequisite: FREN 113 or equivalent

Continuation of FREN 113. [NMCCNS FREN 1123: General Education Area V]

FREN 215, Intermediate French I, 3 cr, 3 cl hrs

Prerequisite: FREN 114 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 216, Intermediate French II, 3 cr, 3 cl hrs

Prerequisite: FREN 215 or equivalent

Continuation of FREN 215.

German Courses:

The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 88).

GERM 113, 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.

GERM 114, Elementary German II, 3 cr, 3 cl hrs
Prerequisite: GERM 113 or equivalent
Continuation of GERM 113.

History Courses:

The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 88).

HIST 121, Full STEAM Ahead, Part 1, 3 cr, 3 cl hrs
Corequisite: HIST 121L
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. This course is offered to the members of the Learning and Living Community and fulfills a General Education Core requirement.

HIST 121L, Full STEAM Ahead Lab, 1 cr, 1 lab hrs
Corequisite: HIST 121
This lab accompanies the Full STEAM Ahead class and explores class concepts in a hands-on, collaborative environment.

HIST 131, 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 132, 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 141, 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. [NMCCNS HIST 1113: General Education Area V]

HIST 142, American History since 1865, 3 cr, 3 cl hrs
A continuation of HIST 141, 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. [NMCCNS HIST 1123: General Education Area V]

HIST 151, 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 152, World History II, 3 cr, 3 cl hrs
A continuation of HIST 151, emphasizing social, political, and cultural developments in Eurasian civilization from 1500 to the present.

HIST 161, 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 162, 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 345, The Rise and Fall of the Soviet Union, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 or consent of instructor

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 348, War and Society, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 or consent of instructor

The political, economic, social, and ideological implications of warfare.

HIST 349, Crime and Society, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 or consent of instructor

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 350, Revolutions in World History, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 or consent of instructor

This course examines the political, economic, social, and psychological impact of the major revolutionary movements between the 17th century and today. Students will study the causes of revolutions, the ideologies that inspired the revolutionaries, and revolutionary methods of state creation and state control, and evaluate how revolutions shape contemporary politics.

HIST 366, Historical Fiction, 3 cr, 3 cl hrs

Prerequisites: ENGL 112 or consent of instructor

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 112 or consent of instructor

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 376, Mass Violence through the Ages, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 or consent of instructor

This course examines mass violence in theoretical and historical contexts as well as a range of psychological, sociological, and political perspectives on its causes, varieties, and mechanisms in different geographic areas. Utilizing various sources, students will explore mass violence through its ideological patterns, religious and political institutions, social engineering projects as well as legal aspects of war crimes.

HIST 385, Latin American Cultural History, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 or consent of instructor

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 386, Introduction to The Middle East, 3 cr, 3 cl hrs

Prerequisite: At least one 100-level history course or equivalent; ENGL 112

The course is a general introduction to the history of the area known as the Fertile Crescent, with a focus on the political, ethnic, religious, and socio-economic policies of the principal states of the region.

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

Humanities Courses:

The following course may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 88).

HUMA 120, Film Genres, 3 cr, 3 cl hrs
An exploration of one or more genres of film with critical analysis of each work for its significance in understanding historical, cultural, aesthetic and contemporary issues and the diversity of human experience.

HUMA 121, 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 301, Practical Creativity, 3 cr, 3 cl hrs
Prerequisites: ENGL 112 or consent of instructor.
May be applied by philosophy minors toward the requirement for 18 credit hours in philosophy.
An investigation of factors impacting creativity (discipline, time-pressure, constraints), conceptions of creativity (play, inspiration, complex adaptive systems), and applications of creativity (problem solving, negotiation, art).

HUMA 303, Failure, Change, and Integrity, 3 cr, 3 cl hrs
Prerequisites: ENGL 112 or consent of instructor.
Philosophical and practical approaches to personal and organizational failure. Implications of uncertainty, loss, and change for goal setting and self-evaluation.

HUMA 309, Song and Society, 3 cr, 3 cl hrs
Prerequisites: ENGL 112 or consent of instructor.
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 112 or consent of instructor.
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.

Music & Music Performance Courses:

The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 88).

MUS 105, Fundamentals of Music, 3 cr, 3 cl hrs
An introduction to the basic materials of music: tones, rhythm, notation, singing, and composition. [NMCCNS MUSI 1113: General Education Area V]

MUS 110, 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. [NMCCNS MUSI 1113: General Education V]

MUS 201, Comprehensive Musicianship I, 3 cr, 3 cl hrs, 1 lab hr

Prerequisite: MUS 105 or consent of instructor

A detailed study of notation, keys, scales, intervals, chords, clefs, and transpositions. Practical application to keyboard, instruments, and voice.

MUS 301, Composition, 3 cr, 3 cl hrs

Prerequisite: ENGL 112

An introduction to the structural principles of music composition. Students will use software tools to study patterns in existing compositions and then create several computer-based compositions within specific design constraints. Final project compositions will be presented in public performance. Prior music background not required.

MUS 309, Song and Society, 3 cr, 3 cl hrs

Prerequisites: ENGL 112 or consent of instructor.

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)

MUS 311, Opera, 3 cr, 3 cl hrs

Prerequisite: MUS 105, or consent of instructor

A musical and socio-historical exploration of selected great operatic works.

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 88).

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

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 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

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 88).

PHIL 120, 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 231, 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 323, American Nature Writing, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 or consent of instructor

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, inter-disciplinary, 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 112 or consent of instructor

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 112 or consent of instructor

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 112 or consent of instructor

Ethical theories and their applications in business, research, and engineering.

PHIL 342, Philosophy of Bioethics, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 or consent of instructor

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 112 or consent of instructor

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 112 or consent of instructor

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 112 or consent of instructor

Study of a single philosopher's work or a philosophical school.

PHIL 440, Philosophical Novels, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 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 112 or consent of instructor

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.

PHIL 521, 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.

Political Science Courses:

The following courses may be used to fulfill Area 4: Social Sciences of the General Education Core Curriculum (page 88).

PS 151, 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.

PS 171, American 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]

PS 361, 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.

PS 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.

Social Science Courses:

The following courses may be used to fulfill Area 4: Social Sciences of the General Education Core Curriculum (page 88).

SS 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 and ANTH 120 and WGS 120)

SS 130, 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.

SS 132, 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.

SS 201, 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.

SS 211, Environment, Science, and Technology, 3 cr, 3 cl hrs

This science and technology studies course challenges students to think more carefully and critically about environmental problems and controversies, examining the cognitive, cultural, economic, political, and communicative roots of disagreements over climate change, genetically-modified organisms, and other issues. Students will also explore the extent to which contemporary efforts, including "green" consumerism and renewable energy technologies, can solve the problem of environmental and ecological degradation.

SS 301, Interdisciplinary Problem Solving, 3 cr, 3 cl hrs

Prerequisites: ENGL 112 or consent of instructor

An introduction to the Theory of Inventive Problem Solving (TRIZ), including techniques for problem definition, functional modeling, and concept generation. Emphasis on qualitative, interdisciplinary approaches to technical problems.

SS 311, The Digital Age and Its Discontents, 3 cr, 3 cl hrs

Prerequisites: ENGL 112 or consent of instructor

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 modernities.

SS 501, Creative Problem Solving, 3 cr, 3 cl hrs

Prerequisites: Graduate Standing or consent of instructor

Techniques for defining problems and generating solution concepts, using Theory of Inventive Problem Solving (TRIZ) methods and incorporating additional tools that provide clarity and flexibility when approaching challenges creatively. Emphasis on qualitative, interdisciplinary approaches to technical problems. Application of these methods to graduate students' own-and peers'-design and/or experimental problems.

Spanish Courses:

The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 88).

SPAN 113, 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. [NMCCNS SPAN 1113: General Education Area V]

SPAN 113N, 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 114, Elementary Spanish II, 3 cr, 3 cl hrs

Prerequisite: SPAN 113 or equivalent

Continuation of SPAN 113. [NMCCNS SPAN 1123: General Education Area V]

SPAN 215, Intermediate Spanish I, 3 cr, 3 cl hrs

Prerequisite: SPAN 114 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 216, Intermediate Spanish II, 3 cr, 3 cl hrs

Prerequisite: SPAN 215 or equivalent

Continuation of SPAN 215; readings in Spanish literature.

SPAN 352, Contemporary Latin American Novel, 3 cr, 3 cl hrs

Prerequisite: SPAN 215 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, 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 ANTH 370)

SPAN 385, Latin American Cultural History, 3 cr, 3 cl hrs

Prerequisite: SPAN 215 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, toreo, music, painting, literature, graffiti—in their political, economic, and historical background. All readings and reports to be in Spanish. (Same as HIST 385)

SPAN 520, 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.

Technical Communication Courses:

TC 100, 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.

TC 101, Orientation to Technical Communication, 1 cr, 1 cl hr

Guest speakers introduce students to the myriad activities and career paths of technical communicators.

TC 151, Visual Communication, 3 cr, 3 cl hrs

Students are introduced to the significance of visual symbols in human communication. They learn fundamental graphic and document design principles, develop a vocabulary for analyzing the rhetoric, ethics, and politics of images, and apply this knowledge to the production of effective technical visuals.

TC 202, Elements of Editing, 3 cr, 3 cl hrs

Prerequisite: ENGL 112

Grammar review. Description of types and levels of editing. Responsibilities of editors. Use of editing and proofreading symbols, usage guides, style guides, and style sheets. Production aspects of editing. Practice in online and hardcopy editing of short manuscripts.

TC 211, Media Studies, 3 cr, 3 cl hrs

Prerequisites: ENGL 112

Survey of media of mass communication, including print, television, film, and internet. Emphasis on social impact of media and on developing tools to examine media messages. Students will form research groups to present on and analyze selected media events.

TC 301, Writing Theory and Practice, 3 cr, 3 cl hrs

Prerequisites: ENGL 112 or consent of instructor

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.

TC 305, Science Writing, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 and at least junior standing or consent of instructor

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 TC 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.

TC 315, Philosophy of Digital Communication, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 or consent of instructor

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 PHIL 315.)

TC 316, International Professional Communication, 3 cr, 3 cl hrs

Prerequisite: ENGL 112 or consent of instructor

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 TC 512, with additional expectations for graduate credit.

TC 321, Internship, 3 cr

Prerequisites: TC 202 and 211; ENGL 341; and consent of TC 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 TC faculty. Students produce a report about their internship program.

TC 351, Web Design, 3 cr, 3 cl hrs

Prerequisites: TC 151

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.

TC 361, Advanced Visual Communication: Data Visualization, 3 cr, 3 cl hrs

Prerequisites: ENGL 112 or consent of instructor

STEM professionals constantly visualize data both mentally and physically. Understanding how different professionals and fields visualize data is critical to improving professional communication. In this course, students learn how to observe STEM professionals at work, analyze and interpret the results, and apply them in their own work. Shares lecture with TC 561, with additional expectations for graduate credit.

TC 371, Publications Management, 3 cr, 3 cl hrs

Prerequisites: TC 202 and 211 or consent of instructor

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.

TC 411, Persuasive Communication, 3 cr, 3 cl hrs

Prerequisites: ENGL 112 and at least junior standing, or consent of instructor

Theory and practice of producing proposals, sales literature, application letters, résumés, and other documents and media that promote the interest of individuals or organizations in industry and government. Topics in psychology, rhetoric, and advertising may be considered. Students gain practical experience in design, writing, and illustrating promotional texts, particularly technical proposals.

TC 420, Senior Seminar, 3 cr, 3 cl hrs

Prerequisites: TC 211 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 TC 422, Senior Thesis.

TC 421, Professional Writing Workshop, 3 cr, 3 cl hrs

Prerequisites: TC 202 and 211, 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.

TC 422, Senior Thesis, 3 cr, 3 cl hrs

Prerequisite: TC 420

Initiation, production, and presentation (oral and written) of an original research project in technical communication.

TC 491, Directed Studies, 1–3 cr, as arranged

Prerequisites: TC 202 and 211, or consent of instructor

TC 501, 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.)

TC 505, 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 an 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.

TC 511, Persuasive Communication, 3 cr, 3 cl hrs

Prerequisites: 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.

TC 512, 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, Professional Writing Workshop, 3 cr, 3 cl hrs

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.

TC 561, Data Visualization, 3 cr, 3 cl hrs

Prerequisites: Graduate Standing or Consent of Instructor

STEM professionals constantly visualize data both mentally and physically. Understanding how different professionals and fields visualize data is critical to improving professional communication. In this course, students learn how to observe STEM professionals at work, analyze and interpret the results, and apply them in their own work. Shares lecture with TC 361, with additional expectations for graduate credit.

TC 589, Special Topics, 3 cr, 3 cl hrs

Theater Courses:

The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 88).

THEA 314, 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.

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.

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 88).

WGS 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.

WGS 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.

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.

COMM 575, Communication in the Sciences 3 cr, 3 cl hrs

Prerequisites: Graduate Enrollment in Sciences

Advanced communication/writing courses linked to science 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.

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.

ENGL 524, Ecotopia: The Intersection of Science and Literature, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing or consent of instructor

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.

PHIL 521, 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.

SS 501, Creative Problem Solving, 3 cr, 3 cl hrs

Prerequisites: Graduate Standing or consent of instructor

Techniques for defining problems and generating solution concepts, using Theory of Inventive Problem Solving (TRIZ) methods and incorporating additional tools that provide clarity and flexibility when approaching challenges creatively. Emphasis on qualitative, interdisciplinary approaches to technical problems. Application of these methods to graduate students' own-and peers'-design and/or experimental problems.

SPAN 520, 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.

TC 501, 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.)

TC 505, 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 an 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.

TC 511, Persuasive Communication, 3 cr, 3 cl hrs

Prerequisites: 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.

TC 512, 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, Professional Writing Workshop, 3 cr, 3 cl hrs

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.

TC 561, Data Visualization, 3 cr, 3 cl hrs

Prerequisites: Graduate Standing or Consent of Instructor

STEM professionals constantly visualize data both mentally and physically. Understanding how different professionals and fields visualize data is critical to improving professional communication. In this course, students learn how to observe STEM professionals at work, analyze and interpret the results, and apply them in their own work. Shares lecture with TC 361, with additional expectations for graduate credit.

TC 589, Special Topics, 3 cr, 3 cl hrs

Faculty Research Interests

Dezember—Poetry, the Visual Arts and Poetry, American Literature

Dotson—Science and technology studies

Durão—Visual Communication with an emphasis on Data Visualization, Science and Technology Studies, International professional communication

D. Dunston—Conducting, Music and Science, Creativity and Innovation

S. Dunston—American Literature, Philosophy

Higgins —American Literature, Ethnic Studies, Cultural Studies, American English Language Learning

Kramer-Simpson— Feedback, Transitioning from college to the workforce, Students developing research interests

Lara-Martínez—Latin American Cultural History, Psychoanalysis

Mikhailova — Medieval History, Gender, Russian History, History of Science

Priest —Writing Center Studies, Science Rhetoric and Outreach, Composition Pedagogy

Prusin—Russia, Eastern Europe, Nationalism, Genocide

Simpson—ESL Writing, Graduate Student Writing, Technical and Scientific Communication

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 Axen, Bilek, Mozley, Person, Spinelli (Chair of the Department)
Associate Professors Cadol, Harrison, Van Wijk
Assistant Professors Bonamici, Gomez-Velez, Grapenthin, Luhmann, Maher, Mao,
Research Professors Murray, Reusch, Ulmer-Scholle
Emeritus Professors Budding, Campbell, Condie, Gross, Hendrickx, D. Johnson, Kyle, Lattman, Phillips, Schlue , Wilson
Adjunct Faculty Balch, Bauer, Blamey, Broadhead, Cather, Chamberlin, Chapin, Cohen, Conley, Creech-Eakman, Dewars,
    Dunbar, Fernald, Frey, Frisbee, Goff, Hawley, Heath, Heizler, Ingate, Kelley, Kieft, Koning, Land, Love, Lueth, Martin,
    McLemore, Newton, Ross, Rowe, Stephens, Stone, Tidwell, Timmons, Underwood, Vrolijk, Will, Zimmerer

Degrees Offered: B.S. in Earth Science with options in Geology, Geophysics, Hydrology, and Mineral Resources and B.S. in Earth Science ; 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 or 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 with or without options
Minimum credit hours required—130
Courses taken to fulfill mathematics and basic science requirements of the General Degree Requirements, and courses in Earth Science, taken to fulfill departmental requirements must be taken for a letter grade.

All degree options in the Bachelor of Science in Earth Science program share the following common core curriculum. Students may therefore immediately begin coursework for the major before choosing a specific option track.

Earth Science Core Curriculum
ERTH 200 (4), ERTH 202 (4), ERTH 203 (3), ERTH 204 (4), ERTH 390 (3), ERTH 325 (3), ERTH 340 (3)

Bachelor of Science in Earth Science with Geology Option

In addition to the General Education Core Curriculum Requirements (page 88), the following courses are required:

- A 100-level ERTH course and associated lab (4)
- Earth Science core [ERTH 200 (4), ERTH 202 (4), ERTH 203 (3), ERTH 204 (4), ERTH 325 (3), ERTH 340 (3), ERTH 390 (3)]
- ERTH 380 (4), ERTH 385 (3), ERTH 453 (4), ERTH 468 (3), either ERTH 483 (2), ERTH 484 (2), and ERTH 485 (2) or ERTH 480 (6)
- Earth science electives, minimum 12 credit hours in courses numbered 300 and above
- MATH 283 or 382 (3)
- Total of 3 credit hours 200-level or above from chemistry, mathematics, or physics
- Technical electives, minimum 9 credit hours from courses numbered 300 or above from the following fields: mathematics, biology, computer science, physics, chemistry, engineering, or courses numbered 500 or above from GEOL, GEOP, GEOC and HYD

Bachelor of Science in Earth Science with Geophysics Option

In addition to the General Education Core Curriculum Requirements (page 88), the following courses are required:

- A 100-level ERTH course and associated lab (4)
- Earth Science core [ERTH 200 (4), ERTH 202 (4), ERTH 203 (3), ERTH 204 (4), ERTH 325 (3), ERTH 340 (3), ERTH 390 (3)]
- ERTH 380 (4) or ERTH 385 (3), ERTH 448 (3)
- Two of the following: ERTH 434 (3), ERTH 445 (3), ERTH 453 (3), ERTH 454 (3), ERTH 455 (3), ERTH 456 (3), ERTH 459 (3), ERTH 460 (3), ERTH 468 (3), any GEOP (3), PETR 370 (3), ERTH Technical Elective (3-4)
- ERTH 483 (2) and ERTH 484 (2), or approved geophysics field experience (4)
- MATH 231 (4), MATH 254 (3), MATH 332 (3), MATH 335 (3), MATH 283 or 382 (3)
- PHYS 241 (3), PHYS 242 (3), PHYS 333 (3)
- Technical electives, minimum 3 credit hours from courses numbered 300 or above from the following fields: mathematics, biology, computer science, physics, chemistry, and engineering.
- Earth science elective in courses numbered 300 and above (3)

Bachelor of Science in Earth Science with Hydrology Option

In addition to the General Education Core Curriculum Requirements, (page 88) the following courses are required:

- A 100-level ERTH course and associated lab (4)
- Earth Science core [ERTH 200 (4), ERTH 202 (4), ERTH 203 (3), ERTH 204 (4), ERTH 325 (3), ERTH 340 (3), ERTH 390 (3)
- ERTH 384 (1), ERTH 440 (3) and 440L (1), ERTH 483 (2), ERTH 484 (2), ERTH 486 (2)
- One of the following: ERTH 411 (3), ERTH 413 (3), or ERTH 414 (3)
- Math 231 (4), Math 283 (3), Math 335 (3)
- Earth science electives, minimum 9 credit hours in courses numbered 300 and above
- CHEM 311 & 311L (4), ENVS 412 (3), CSE 107 & 107L (4)

Bachelor of Science in Earth Science with Mineral Resources Option

In addition to the General Education Core Curriculum Requirements (page 88), the following courses are required:

- ERTH 101 with associated lab (4)
- Earth Science core [ERTH 200 (4), ERTH 202 (4), ERTH 203 (3), ERTH 204 (4), ERTH 325 (3), ERTH 340 (3), ERTH 390 (3)]
- ERTH 380 (4), ERTH 431 (3), ERTH 453 (4), ERTH 462 (3), ERTH 480 (6), ERTH 4xx (3) [Environmental Geochemistry of Mining Activities]
- ME 320 (2), ME 340 (3)
- Technical electives, minimum 3 credit hours from courses numbered 300 or above from the following fields: mathematics, biology, computer science, physics, chemistry, and engineering.
- Earth science and mineral engineering electives, 12 credit hours from the following classes: ERTH 360 (2), ERTH 407/ GEOC 507 (3), GEOC 565 (3), ME 522 (3), ME523 (3), ME 551 (3)
- Earth science elective in course numbered 300 and above (3)

Bachelor of Science in Earth Science

In addition to the General Education Core Curriculum Requirements (page 88), the following courses are required:

- A 100-level ERTH course and associated lab (4)
- Earth Science core [ERTH 200 (4), ERTH 202 (4), ERTH 203 (3), ERTH 204 (4), ERTH 325 (3), ERTH 340 (3), ERTH 390 (3)]
- ERTH 384 (1), ERTH 483 (2), ERTH 484 (2)
- Earth science electives, minimum 24 credit hours in courses numbered 300 and above
- MATH 283 (3) or 382 (3)
- Total of 3 credit hours 200-level or above from chemistry, mathematics, or physics
- Technical electives, minimum 9 credit hours from courses numbered 300 or above from the following fields: mathematics, biology, computer science, physics, chemistry, and engineering.

Minor in Earth Science

Minimum credit hours required — 18
The following courses are required:
- One 100-level ERTH class and associated lab (4 hrs)
- Two classes from the following list: ERTH 200, 201, 202, 203, or 204
- 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:
- ERTH 101 (3), ERTH 101L or 103L (1), ERTH 201 & 201L (4)
- BIOL 111 & 111L (4)
- Two classes from the following list: ERTH 450 (3), ERTH 390 (3), BIOL 341 (3), BIOL 344 (3), ERTH 449/BIOL 449 (3)

Minor in Geophysics

Minimum credit hours required — 19-20
The following courses are required:
- ERTH 101 (3), ERTH 101L, ERTH 204 (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:
- ERTH 101 (3), ERTH 101L (1), 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:
- ERTH 101 (3), ERTH 101L or 103L (1), ERTH 412 (3), ERTH 200 (4), ERTH 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:
- ERTH 101 (3), ERTH 101L (1), ERTH 203 (3), ERTH 460 (3)
- Three classes from the following list: ERTH 445(3), ERTH 447 (3), ERTH 453 (4), ERTH 461 (3)

Earth Science Courses:

ERTH 101, 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 ERTH 101L or ERTH 103L.   [NMCCNS GEOL 1114: General Education Area III]

ERTH 101L, Earth Processes Laboratory, 1 cr, 3 lab hrs

Corequisite: ERTH 101

Laboratory to accompany ERTH 101. Identification of rocks and minerals, maps and map reading, and measurement and interpretation of geologic features. Field trips. [NMCNNS GEOL 1114: General Education Area III]

ERTH 120, Introductory Oceanography, 3 cr, 3 cl hrs

Offered spring semester, odd-numbered years

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.

ERTH 120L, Oceanography Laboratory, 1 cr, 3 lab hrs

Corequisite: ERTH 120

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**.**

ERTH 130, 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.

ERTH 130L, Spaceship Earth Laboratory, 1cr, 3 lab hrs

Corequisite: ERTH 130

Laboratory and field demonstrations of principles of global biogeochemical cycles and the interaction of life with its planetary home.

ERTH 140 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.

ERTH 140L, Water in the Rise and Fall of Civilizations Laboratory, 1 cr, 3 lab hrs

Corequisite: ERTH 140

Offered on demand

Laboratory and field exercises in hydrologic processes including flood forecasting, erosion, salinization, and groundwater overdraft.

ERTH 150, The Catastrophic Earth: An Introduction to Natural Hazards, 3 cr, 3 cl hrs

Offered spring semester, even-numbered years

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.

ERTH 150L, Catastrophic Earth Laboratory, 1 cr, 3 lab hrs

Corequisite: ERTH 150

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.

ERTH 200, Introduction to Mineralogy, 4 cr, 3 cls hrs, 3 lab hrs

Prerequisite: a 100-level ERTH course, ERTH 101L, CHEM 121, CHEM 121L

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 201, Geobiology, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: a 100-level ERTH course

Corequisite: ERTH 101L

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.

ERTH 202, Earth Surface Processes and Landforms, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: Any ERTH 100 level class

Corequisite: ERTH 101L

Offered fall semester, odd-numbered years

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.

ERTH 203, Earth's Crust: Materials, Processes, and Dynamics, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: a 100-level ERTH course and ERTH 101L

Offered spring semester

Overview of the evolution of the crust of the Earth, the major rock types and processes that form it, and the main methods used to study it. Topics include sedimentology, petrology, structural geology, geochronology, subsurface fluid flow, and petroleum geology. Field trips.

ERTH 204, Introduction to Whole Earth Structure and Composition, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: a 100-level ERTH course

Corequisite: ERTH 101L

Offered fall semester, even-numbered years

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 325, Near-Surface Geophysics, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: PHYS 121; a 100-level ERTH course and associated lab

Offered spring semester, even-numbered years.

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.

ERTH 340, Global Climate Change: Origins and Impacts, 3 cr, 3 cl hrs

Prerequisites: MATH 132, PHYS 122

Offered spring semester, even-numbered years

How is global warming affecting the occurrence of floods and droughts, and human development influencing their severity and extent? This class will provide an introduction to the global hydrologic cycle and the potential changes caused by global climate change in the presence of a growing human population. Examples of recent research pointing to an accelerated hydrologic cycle will be discussed, including remote sensing and numerical modeling studies. Implications for sustainable human development and ecosystems will be explored, especially for the semiarid Southwest.

ERTH 360, Earth Resources and Environmental Issues, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: Any 100-level ERTH 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: ERTH 200, 203, CHEM 121, CHEM 122

Offered spring semesters, odd-numbered years

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 384, Stratigraphy, 1 cr, 2 cl hrs, 3 lab hrs

Prerequisite: ERTH 203

Offered spring semester, even-numbered years

Survey of lithostratigraphic, biostratigraphic and chronostratigraphic principles. Topics include seismic and sequence stratigraphy and stratigraphic modeling. Weekend field trip required. Meets with ERTH 385 for the first third of the semester.

ERTH 385, Stratigraphy and Paleontology, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: ERTH 203

Offered spring semester, even-numbered years

Continuation of paleontologic and stratigraphic principles; survey of geologically important invertebrate biota preserved as fossils; their modes of preservation, collection techniques, taxonomy, evolution, paleobiology and paleoecology; overview of the late Precambrian and Phanerozoic biotic and stratigraphic histories in the context of North American tectonics. Weekend field trips required.

ERTH 390, Principles of Geochemistry, 3 cr, 3 cl hrs

Prerequisites: CHEM 122 and ERTH 200

Offered fall semester

Application of chemical principles to geologic processes. Topics include mineral and rock chemistry, aqueous geochemistry and geochronology.

ERTH 401, Computational Methods for Geoscientists, 2 cr, 1 cl hr, 1 lab hr

Prerequisites: Any ERTH 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 lecture with GEOL 501/GEOP 501 with additional expectations for graduate credit.

ERTH 403, Introduction to Soils, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite or Corequisite: ERTH 202

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 122

Pre- or Corequisite: ERTH 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: ERTH 202 and 403; or consent of instructor

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: ERTH 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 ENVS 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 pules, hazardous waste migration soil moisture controls on evapotranspiration and vegetation growth. Shares lecture with HYD 514, with additional expectations for graduate credit.

ERTH 424, Sedimentary Petrography, 3 cr, 4 lab hrs

Prerequisite: ERTH 200, 202, 203 or consent of instructor

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: ERTH 200, 202 and 203 or consent of instructor

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 427, Carbon Sequestration Science, 3 cr, 3 cl hrs

Prerequisite: Math 132, Chem 122, Phys 122, one 100-level ERTH course

Offered on demand

Overview of geological carbon sequestration. Topics include: Earth's changing climate, sources and sinks of greenhouse gases, carbon capture, reservoirs and caprocks, physical and aqueous chemistry of CO_2. Field trips.

ERTH 430, Active Tectonics, 3 cr hrs

Prerequisites: ERTH 202, 203

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: ERTH 380; ERTH 462

Pre- or Corequisite: ERTH 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 122 or 132 or consent of instructor
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: ERTH 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 132, PHYS 132 122
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.

ERTH440L, Hydrological Theory and Field Methods Laboratory, 1 cr, 3 lab hrs.
Prerequisites: MATH 132, PHYS 122 132; Co- or prerequisite: ERTH 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 122; ERTH 203
Offered spring semester
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 121 or equivalent; a 100-level ERTH 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/GEOP 545 with additional expectations for graduate credit.

ERTH 447, Depositional Systems and Basin Analysis, 3 cr, 3 cl hrs
Prerequisites: ERTH 202 and ERTH 203
Offered fall semester
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 122; a 100-level ERTH course and associated lab; upper-class standing

Offered fall, even-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 122, PHYSICS 122, 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 121 & 122; and either a 100-level ERTH course with associated lab, or BIOL 111

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: ERTH 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 453 Intermediate Structural Geology, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: ERTH 203; PHYS 121; MATH 131

Offered fall semester, odd-numbered years.

Builds on basics of structural geology taught in ERTH 203. Elements of fault, fold, and rock mechanics; strain analysis and inference of stress in Earth's crust; construction of balanced, kinematically viable cross sections; brittle and ductile shear-sense indicators in faults and shear zones. Shares lecture and lab with GEOL 553 with additional expectations for graduate credit.

ERTH 454 Tectonics, 3 cr, 3 cl hrs

Prerequisites: ERTH 101 and 101L, ERTH 203 and ERTH 204 (or equivalents) or consent of instructor

Recommended: ERTH 380, ERTH 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 254
Corequisite: ERTH 401 or GEOP 501 or consent of instructor
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: ERTH 380 or consent of instructor
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: ERTH 203 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: ERTH 203
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: ERTH 202 and ERTH 203 or consent of instructor
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.

ERTH 462, Mineral Deposits, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: ERTH 200
Offered fall semester

Geologic and geochemical characteristics of metallic mineral deposits; theories of origin and classification.

ERTH 468, Evolution of the Earth, 3 cr, 3 cl hrs

Prerequisites: ERTH 203, 204
Offered spring semester, even years

Origin of the solar system and of the Earth; the evolution of continents, atmosphere, and oceans; comparative planetary evolution; tectonic regimes in geologic history.

ERTH 480, Field Methods in Earth Science, 6 cr

Prerequisites: ERTH 200, 203, 380 and 384 or 385. ERTH 202 and 453 recommended.

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: ERTH 200, 203, 384 or 385

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: ERTH 483; ERTH 202 or equivalent recommended

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: ERTH 380, 483; ERTH 453 recommended

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: ERTH 440 and one of ERTH 411, ERTH 413 or ERTH 414, or 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.

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.

Geology

The Geology program offers an undergraduate degree in Earth Science with Geology option. See page 151.

Graduate Program

Master of Science in Geology

The master's candidate must demonstrate competence in mathematics, chemistry, and physics comparable to the requirements for the Bachelor of Science degree in Geology. The Master of Science degree in Geology may be earned under either of the following plans:

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 ERTH 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 ERTH 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 58-59.

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 ERTH 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 ERTH 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: ERTH 202 or 203; or consent of instructor

Offered fall semester

Introduction to soil formation, pedogenic processes, and soil description and mapping techniques. Shares lecture/ lab with ERTH 405 with additional expectations for graduate credit.

GEOL 509, Soil Geomorphology, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: ERTH 202 and 403; or consent of instructor

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 ERTH 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 ERTH/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 ERTH 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 instructors

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 ERTH 425 with additional expectations for graduate credit.

GEOL 530, Active Tectonics, 3 cr hrs

Prerequisites: ERTH 202, 203, or consent of instructor

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 ERTH 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 ERTH 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 122 or consent of instructor

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 ERTH 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: ERTH 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 ERTH 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

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 121 or equivalent; a 100-level ERTH 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 ERTH 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

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.

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 ERTH/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 121 & 122; and either any 100 level ERTH or BIOL 111

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 ERTH 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 ERTH 450L, with additional expectations for graduate credit.

GEOL 551, Industrial Minerals, 3 cr, 3 cl hrs

Prerequisites: Graduate standing or consent of instructor

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 553 Intermediate Structural Geology, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: ERTH 203; PHYS 121; MATH 131 or consent of instructor.

Offered alternate years.

For entering graduate students lacking undergraduate structural geology background. Elements of fault, fold, and rock mechanics; strain analysis and inference of stress in Earth's crust; construction of balanced, kinematically viable cross sections; brittle and ductile shear-sense indicators in faults and shear zones. Shares lecture and lab with ERTH 453, with additional expectations for graduate credit.

GEOL 554 Tectonics, 3 cr, 3 cl hrs

Prerequisites: ERTH 101 and 101L, ERTH 203 and ERTH 204 (or equivalents) or consent of instructor

Recommended: ERTH 380, ERTH 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 ERTH 454, with additional expectations for graduate credit.

GEOL 556, Volcanology, 3 cr, 2-3 cl hrs, 1-3 lab hrs

Prerequisite: ERTH 380 or consent of instructor

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 ERTH 456, with additional expectations for graduate credit.

GEOL 558, Mechanics of Earthquakes and Faulting, 3 cr, 3 cl hrs

Prerequisites: ERTH 453 or equivalent and graduate standing; or consent of instructor

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

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 ERTH 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*

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 ERTH 461, with additional expectations for graduate credit.

GEOL 562, Fluvial Geomorphology, 3 cr, 3 cl hrs

Prerequisites: ERTH 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

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 58-59.

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: ERTH 201, CHEM 121, CHEM 122, BIOL 111, BIOL 112, or consent of instructor

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 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 in accordance with the general requirements of the Graduate Program.

The master's candidate must demonstrate competence in chemistry, geology, mathematics, and physics comparable to the requirements for the Bachelor of Science degree in either chemistry, one of the engineering sciences, or one of the geological sciences.

A program of study for the master's degree must be approved by the student's advisory committee and must satisfy the general requirements for the degree, including GEOC 590 (at least three credit hours) or GEOC 591 (at least six credit hours). Students must complete two credit hours of GEOC 592, at least four credit hours of GEOC 593 (unless the degree is completed in a shorter time), 12 credit hours in geochemistry, (which can also include ERTH 390 (Principles of Geochemistry)) and six credit hours in upper- division or graduate chemistry courses. As part of the degree requirements, students must have completed CHEM 331; GEOC 507, GEOC 544, ERTH 200 (mineralogy); or their equivalents.

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 58-59.

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 122
  Corequisite: ERTH 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 ERTH 407, with additional expectations for graduate credit.

GEOC 516, ^{40}Ar/^{39}Ar Geochronology, 3 cr, 3 cl hrs

Prerequisite: ERTH 444 or consent of instructor

Offered fall semester

Principles and applications of ^{40}Ar/^{39}Ar geochronology and thermochronology, with applications to geologic systems.

GEOC 517, Advanced 40Ar/39Ar Geochronology, 3 cr, 3 cl hrs

Advanced topics, specialized applications, and current research in ^{40}Ar/^{39}Ar geochronology.

GEOC 531, Exploration Geochemistry, 3 cr, 3 cl hrs

Pre- or Corequisite: ERTH 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 ERTH 431, with additional expectations for graduate credit.

GEOC 544, Principles of Isotope Geochemistry, 3 cr, 3 cl hrs

Prerequisite: CHEM 122; ERTH 200; ERTH 203

Offered spring semester

Principles of radiogenic isotope geochemistry and applications to geologic dating and to the petrogenesis of rock suites. Shares lecture with ERTH , with additional expectations for graduate credit.

GEOC 546, Contaminant Hydrology, 3 cr, 3 cl hrs

Prerequisite: ERTH 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.

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 ERTH 449, with additional expectations for graduate credit. (Same as GEOL 549)

GEOC 550, Cave and Karst Systems, 3 cr, 3 cl hrs

Prerequisites: CHEM 121 & 122; and either any 100 level ERTH or BIOL 111

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 ERTH 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 ERTH 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

Offered spring semester

Theory and application of noble gas mass spectronmetyr. 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, 1 cr

Prerequisites: ERTH 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)

The Geophysics program offers an undergraduate degree in Earth Science with Geophysics option. See page 151.

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): ERTH 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): ERTH 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, Computational Methods for Geoscientists, 2 cr, 1 cl hrs, 1 lab hrs
  Prerequisite: Any ERTH 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 ERTH 401, with additional expectations for graduate credit. Same as GEOL 501.

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 283 or 382 and MATH 335 or consent of instructor

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 a 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 122 or consent of instructor

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. ERTH 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 121 or equivalent; a 100-level ERTH 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 ERTH 445 with additional expectations for graduate credit.

GEOP 555 Geodetic Methods and Modeling, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: MATH 254
Corequisite: ERTH 401 or GEOP 501 or GEOL 501 or consent of instructor
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 ERTH 455, with additional expectations for graduate credit.

GEOP 558, Mechanics of Earthquakes and Faulting, 3 cr, 3 cl hrs

Prerequisites: ERTH 453 or equivalent and graduate standing; or consent of instructor
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
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 ERTH 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

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

The Hydrology program offers an undergraduate degree in Earth Science with Hydrology option. See page 151.

Graduate Program

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:

· ERTH 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.
· ERTH 202 or equivalent
· MATH 283, 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; ERTH 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:

- ERTH 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 122
Pre- or Corequisite: ERTH 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 ERTH 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: ERTH 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 231; Pre or Corequisite ERTH 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: ERTH 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 ERTH 411, with additional expectations for graduate credit.

HYD 513, 513D, 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 ERTH 413, with additional expectations for graduate credit.

HYD 514, 514D, 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 pules, hazardous waste migration soil moisture controls on evapotranspiration and vegetation growth. Shares lecture with ERTH 414, with additional expectations for graduate credit.

HYD 516, 516D, Geofluids, 3 cr, 3 cl hrs

Corequisites: ERTH 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 283 or 382 and MATH 335 or consent of instructor

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 a GEOP 520)

HYD 534, 534D, Introduction to Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: PHYS 122 or consent of instructor

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 ERTH 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: ERTH 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 ERTH 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: ERTH 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: ERTH 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: ERTH 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 121 & 122; and either a 100-level ERTH course with associated lab, or BIOL 111

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 ERTH 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 ERTH 450L, with additional expectations for graduate credit.

HYD 558, Tracers in Hydrology, 3 cr, 3 cl hrs

Prerequisites: ERTH 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, 14C, 36Cl , 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: ERTH 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 an 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

Bonamici—Petrology, Solid-Earth Geochemistry, Isotope Geochemistry, Tectonics, Geochemical Microanalysis

Cadol—Surface Water Hydrology, Ecohydrology, Fluvial Geomorphology

Gomez-Velez—Environmental Flow and Transport, Groundwater-surface water interactions, Hydrogeology, Watershed hydrology, Analytical and numerical modeling, data mining and assimilation

Grapenthin— Geodesy, Active Tectonics, Volcanology, Inverse Methods, Real-time Hazard Analysis and Warning

Harrison—Soil Properties, Recurrence Intervals of Earthquakes, Soil Salinization in Arid Environments, Soil Stability

Luhmann—Karst Hydrogeology, Fluid-Rock Interaction, Aqueous Geochemistry, Geologic Carbon Sequestration

Maher—Geochemistry and mineralogy of ore deposits, distal expressions of hydrothermal systems, copper isotope systematics

Mao—Inverse Modeling, Hydrogeophysics, Contaminant Hydrology, High Performance Computing, Stochastic Hydrology

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.

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

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

Creech-Eakman—Characterization of Exoplanet Atmospheres and Associated Planetary Properties (NESSI—New Mexico Tech Extrasolar Spectroscopic Survey Instrument); Mid-infrared Imaging, Spectroscopy and Optical Interferometry; Pulsation and Dust Production in Mira Variables

Dunbar—Igneous Petrology, Volcanology, Trace Element Behavior in High- and Low-Temperature Aqueous Systems, Microprobe Geochemical Analysis

Hawley—Geomorphology, Quaternary Stratigraphy, Environmental Geology, Hydrogeology

Heizler—40Ar/39Ar Thermochronology

Kelley—Fission-Trace Thermochronology, Tectonics, Thermal Studies

Kieft—Geomicrobiology of Soils and Subsurface Environments

Land—Cave and Karst Hydrology, Hydrogeology

Love—Environmental Geology, Quaternary Geology, Sedimentology

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, and Instrumentation and Measurements

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 additionally 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 discipline, should they choose.

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 Core Curriculum Requirements (page 88) 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 100-level ERTH course and associated lab (4)
- ERTH 201 & 201L (4), ERTH 202 & 202L (4), ERTH 440 (4)
- MATH 231 (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—135
In addition to the General Degree Requirements (page 88), and the core Environmental Science Requirements (above), the following courses are required:
- BIOL 112 & 112L (4), 311 & 311L (4), 333 & 333L (4)
- Technical Electives (12)—Technical electives to be approved by the Advisory Committee

Bachelor of Science in Environmental Science with Chemistry Option

Minimum credit hours required—135

In addition to the General Degree Requirements (page 88), and the core Environmental Science Requirements (above), the following courses are required:

- CHEM 331 & 331L (4), 334 & 334L (4), 411 & 411L (4)
- Technical Electives (14)—Recommended technical electives, which must be approved by the advisory committee, include CHEM 332, 441, 442

Bachelor of Science in Environmental Science with Geology Option

Minimum credit hours required—135

In addition to the General Degree Requirements (page 88), and the core Environmental Science Requirements above), the following courses are required:

- ERTH 203 & 203L (4), ERTH 204 & 204L (4), ERTH 380 (3), ERTH 385 (3), ERTH 405 (3)
- Electives to meet minimum credit hours required.

Bachelor of Science in Environmental Science with Hydrology Option

Minimum credit hours required—135

In addition to the General Degree Requirements (page 88), and the core Environmental Science Requirements (above), the following courses are required:

- ERTH 204 & 204L (4), ERTH 340 (3), ERTH 440 (4), ERTH 441 (1), ERTH 442 (1), ERTH 443 (1)
- MATH 335 (3)
- Electives to meet minimum credit hours required.

Bachelor of Science in Environmental Science with Instrumentation and Measurements Option

Minimum credit hours required—135

In addition to the General Degree Requirements (page 88), 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)
- ERTH 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 ERTH 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.

F A 130C Intro to New Mexico Tin Punching 1 cr, 2 cl hrs
Fundamental tools and processes in creating traditional Hispanic folk art.

F A 140C 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 cameral 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.

F A 145C 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.

F A 150C Drawing and Painting 1 cr, 2 cl hrs
Survey of introductory skills and techniques using a variety of drawing and painting media

F A 151C Technical and Industrial Drawing 1 cr, 2 cl hrs
Free hand three dimensional and industrial drawing techniques

F A 152C 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.

F A 153C Painting in Acrylics 1 cr, 2 cl hrs
Basic methods and skills in acrylic painting

F A 160C Stained Glass and Mosaics 1 cr, 2 cl hrs
Introduction to materials and construction techniques of stained glass panels and mosaic objects

F A 240C Photography 1 cr, 3 cl hrs
Technical and aesthetics process in Photography as an art form

F A 260C Stained Glass I 1 cr, 3 cl hrs
Investigation of tools and techniques in creating inspired stained glass compositions.

F A 261C Glass Fusing/Slumping 1 cr, 3 cl hrs
Fundamental tools and processes in creation of glass objects; mold making and slumping processes used in basic kiln forming.

F A 262C Glass Bead Making 1 cr, 3 cl hrs
Exploration of flame working methods and techniques used in creating wearable art

F A 263C Stained Glass II 1 cr, 3 cl hrs
Prerequisite: FA 260C or consent of instructor
Students will investigate more complex designs, tools and equipment in stained glass, including three dimensional and sculptural designs.

F A 264C Stained Glass Design 1 cr, 3 cl hrs

Students will learn to design stained glass, and will explore design elements, pattern making, and pattern alignment.

F A 265C Stained Glass Interpretation 1 cr, 3 cl hrs

Students will study art masterpieces in other media and recreate them in stained glass.

F A 266C Dimensional Stained Glass 1 cr, 3 cl hrs

Students will learn how to create three-dimensional stained glass artwork.

F A 267C Fused Glass Jewelry 1 cr, 3 cl hrs

Learn to create stunning original jewelry in fused glass.

F A 270C Hand Building in Clay 1 cr, 3 cl hrs

Studio arts survey of hand forming techniques used in creating diverse utilitarian and sculptural ceramics. Accommodates all skill levels

F A 271C Wheel Thrown Ceramics I 1 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

F A 272C Sculptural Ceramics 1 cr, 3 cl hrs

Studio art class in three dimensional construction of abstract and figurative sculpture. Accommodates all skill levels

F A 273C Wheel Thrown Ceramics II 1 cr, 3 cl hrs

Prerequisite: FA 270C, Hand Building in Clay

Students will learn and practice advanced wheel and decorative techniques.

F A 280C Beginning Enameling 1 cr, 3 cl hrs

The art of fusing glass to metal, safe handling of equipment and chemicals in beginning techniques

F A 281C Enameling II 1 cr, 3 cl hrs

Prerequisite: FA 280C, Beginning Enameling

The art of fusing glass to metal using advanced techniques and methods

F A 282C 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.

F A 283C 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

F A 284C 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

F A 285C 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

F A 286C Armor Making 1 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 Liebrock, Soliman, Sueyoshi, Wedeward
Associate Professors Anselmo (Program Coordinator), Mazumdar, Shin (Chair of the Department), Zheng
Assistant Professors Ramyaa, Rezgui

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 will be 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 & Engineering* and *Management* departments. 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 12 hours of technical electives to broaden or deepen their knowledge in an IT area of their interest. Graduates of the IT program will be well prepared for immediate industry employment or graduate study in an IT-related discipline.

Undergraduate Program

Bachelor of Science in Information Technology

Minimum credit hours required—120
In addition to the General Education Core Curriculum (page 88), the following courses are required:

- IT 101 (2), IT 113 (4), 122 (3), 213 (3), 221 (3), 263 (3), 321 (3), 326 (3), 330 (3), 353 (3), 373 (3), 382 (3), 462 (3), 466 (3), 481 (3), 482 (3)
- CSE 222 (3), 241 (3)
- MATH 283 (3)
- PSY 121 (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 131 (calculus)
  1 IT 101 (intro to comp sci & information tech)
  4 IT 113 (intro to programming)
  4 CHEM 121 & 121L (general chemistry I)
  3 ENGL 111 (college English)
17 Total credit hours

Semester 2
  4 MATH 132 (calculus)
  3 IT 122 (algorithms and data structures)
  4 CHEM 122 & 122L (general chemistry II)
  3 ENGL 112 (college English)
14 Total credit hours

Semester 2.5 (Summer)
  4 Chem 122 & 122L (general chemistry II)
  4 Total credit hours

Semester 3

    3 IT 221 (computer and network organization)
    3 IT 263 (information protection and security)
    3 CSE 241 (foundations for computer science)
    5 PHYS 121 & 121L (general physics I)
    3 PSY 121 (general psychology)
   17 Total credit hours

Semester 4

    3 CSE 222 (systems programming)
    3 IT 213 (intro to object oriented programming)
    3 MATH 283 (introduction to applied statistics)
    3 Humanities
    5 PHYS 122 & 122L (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 IT 382 (legal and ethical info technology issues)
    3 IT 492 (systems, risk and decision analysis)
    3 IT 466 (project management)
    3 Social Science
   15 Total credit hours

Semester 7

    3 Technical Electives
    3 IT 481 (senior secure system design project)
    4 Biology/Earth Science/Engineering with Lab
    3 Humanities
   13 Total credit hours

Semester 8

    3 Technical Electives
    3 IT 482 (senior secure system design project)
    6 Humanities/Social Science
   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

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, data structures, 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 103

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, Introduction to Programming, 4 cr, 3 cl hrs, 3 lab hrs

Co-requisite: MATH 131

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 132

Fundamental data structures including linked lists, tress, 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 of computers, operating systems, and computer networks. Memories, buses, interrupts, input and output, and instruction set architecture. Basics of assembly language programming. (Same as CSE 221.)

IT 263, Information Protection and Security, 3 cr, 3 cl hrs

Prerequisite: IT 101, 113 each with a grade of C or higher
Corequisite: IT 221

Concepts of information, message and data. Storage and transmission, retrieval and communications. Authorized users and penetrators. Threats to information confidentiality, integrity, availability, and accountability. Attacks. Degrees of security and costs. Protection mechanisms and security precautions. Authentication and authorization. Encryption. Secure operating systems, communications and networks. Defenses against viruses, worms, and hostile code.

IT 311, 311D, Human Information Processing and Decision Making, 3 cr, 3 cl

Prerequisite: PSY 121 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

Prerequisite: IT 213 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 developments, 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

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, 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 112 and upper-class standing or consent of instructor

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 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 CSE 353.)

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; design theory for relational databases. Database integrity. Physical data organization. Introduction to problems of concurrency control, recovery, security, and distributed databases. Course work includes a project using SQL and the Oracle Database Management System. (Same as CSE 373.)

IT 382, 382D, Ethical and Social Implications of Information Technology, 3 cr, 3 cl hrs

Prerequisite: IT 326 with a grade of C or higher

Philosophy of ethics. Social and ethical issues associated with computing and information technologies. Ethics and the responsibilities of computing professionals. Legal ramification will be explored whenever possible. (Same as CSE 382.)

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: CSE 122 or 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: CSE 353 with a grade of C or higher

In depts. 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 283 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

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 CSE 463.)

IT 466, 466D, Project Management, 3 cr, 3 cl hrs

Prerequisite: MATH 283, MGT 472 each with a grade of C or higher, or consent of instructor

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. (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

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—Agent-Based Financial System Modeling and Simulation, Non-Financial Risk Modeling and Analysis

Liebrock—Computer Forensics, Information Assurance, Parallel Processing, Well Posedness Analysis, Visualization

Mazumdar—Mobile and distributed databases: Integrity, Privacy, Security; Information Systems, Software Integrity

Rezgui —Cloud Computing, Service-based computing, Energy-aware cellular networks

Shin— System security, Usable Security, Applied Cryptography, Software Engineering

Soliman—Computer Networks — fiber/wireless modern technologies and protocols, Sensor Networks — modern technologies and protocols, Computer/Sensor Networks Security, Programming Languages, Neural Networks — applications in image compression, cloud computing management, and sensor networks

Sueyoshi—Management Science, Data Envelopment Analysis, Risk and Policy Analysis

Wedeward—Adaptive Control, Robotic Systems

Zheng—Mobile Computing, Computer and Network Security, Machine Learning and its Applications

Management

Professor Sueyoshi
Associate Professors Anselmo, Reinow (Chair of the Department)
Assistant Professor Wang
Visiting Professor Ryu
Adjunct Faculty: Lentz, Mazumdar, Parveen, Stephenson, Udell

Degrees offered: A.S. in Business; B.S. in Management and B.S. in Management of Technology

The Department of Management provides undergraduate degree programs that draw heavily on Tech's strengths in science, engineering, and technology. The aim of the department is to develop in students substantive decision-making skills and tools, as well as the functional knowledge required to effectively manage complex technology-based organizations in today's competitive global economy. Management students take the same basic science and math courses required of every Tech student—two semesters each of chemistry, physics, calculus, and another lab science such as biology, engineering, or geology. Added to this foundation are courses in accounting, business computer systems, economics, human resources, finance, management, marketing, operations research, and statistics.

New Mexico Tech offers bachelor's degrees in management and management of technology. The B.S. in Management is appropriate for those planning to enter the fields of human resources management, production management, project management, finance, marketing, accounting, or general management. In addition, the B.S. in Management prepares potential entrepreneurs to start their own companies. The B.S. in Management of Technology integrates management course work with study in an engineering field of the student's choice. This degree focuses on the application of quantitative methods to solve complex management problems. In accordance with the overall mission of New Mexico Tech, it is expected that problems addressed will be primarily within engineering and applied science disciplines, including natural resource, energy, manufacturing, and environmental management problems. 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 Department of Management also offers an Associate of Science degree in Business. This program is designed for students seeking to complete a two-year degree in business, and/or those who may wish to transfer to a four-year bachelor's program in business administration or management. Required courses are often transferable among participating New Mexico institutions.

Undergraduate Program

Associate of Science in Business

Minimum credit hours required—65
The following courses are required:

- ACCT 201 (3), 202 (3), 371 (3)
- ECON 251 (3), 252 (3)
- ENGL 111 (3), 112 (3)
- MGT 330 (3)
- Mathematics: Six credit hours chosen from MATH 103 (3), 104 (3), 105 (5), 131 (4)
- TC 151 (3)
- Business 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 88)
- A total of eight credit hours in courses with associated laboratories from the disciplines of biology, chemistry, earth science, or physics
- Electives to complete 65 credit hours

Sample Curriculum for the Associate of Science in Business

Summer
    5 Mathematics
    5 Total credit hours

Semester 1
    3 ENGL 111 (college English)
    3 Mathematics
    3 ACCT 201 (fundamentals I)
    3 ECON 251 (macroeconomics)
  12 Total credit hours

Semester 2
    3 ENGL 112 (college English)
    4 Science with lab (biol, chem, earth science, or physics)
    3 ACCT 202 (fundamentals II)
    3 ECON 252 (microeconomics)
  13 Total credit hours

Semester 3
    3 BA 315 (business law I)
    3 ACCT 371 (financial accounting)
    4 Science with lab (biol, chem, earth science, or physics)
    3 TC 151 (intro to visual communication)
    3 Humanities/Social Science
  16 Total credit hours

Semester 4
    3 BA 317 (business law II)
    9 Business Electives
    4 Electives
  16 Total credit hours

Students must achieve a minimum GPA of 2.0 in required courses in order to graduate.

Core Requirements for the Bachelor of Science in Management

In addition to the General Education Core Curriculum (page 88), the following core of business and economics courses is required of all Management students:

• ACCT 201 (3), 202 (3); ACCT 350 is recommended
• BCS 283 (3)
• CSE 113 (4) or ES 111 (3)
• MGT 101 (1), 302 (3), 330 (3) 335(3), 462 (3), 472 (3), 476 (3), 481 (3), 486 (3)
• ECON 251 (3), 252 (3). *These courses may be used to fulfill the Area 4 of the General Education Core Curriculum, page 88.*
• 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 required courses in order to graduate.

Bachelor of Science in Management

Minimum credit hours required—120
In addition to the General Education Core Curriculum (page 88) and the core business 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.
• ACCT 350 (3) is recommended

Sample Curriculum for the Bachelor of Science in Management

Semester 1
  1 MGT 101 (modern management issues)
  3 ENGL 111 (college English)
  4 CHEM 121 & 121L (general)
  4 MATH 131 (calculus)
  4 CSE 113 or ES 111
16 Total credit hours

Semester 2
  3 ENGL 112 (college English)
  4 CHEM 122 & 122L (general)
  4 MATH 132 (calculus)
  4 Biology/Earth Science/Engineering with lab
15 Total credit hours

Semester 3
  5 PHYS 121 & 121L (general)
  3 ACCT 201 (fundamentals 1)
  3 ECON 251 (macroeconomics)
  3 Elective
  3 Social Science
17 Total credit hours

Semester 4
  5 PHYS 122 & 122L (general)
  3 ACCT 202 (fundamentals II)
  3 BCS 283 (applied statistics)
  3 ECON 252 (microeconomics)
  3 Humanities/Social Science
17 Total credit hours

Semester 5
  3 ACCT 350 (managerial accounting)
  3 BA 315 (business law I)
  3 MGT 330 (organizational behavior)
  3 MKT 335 (principles)
  3 Management Elective
18 Total credits

Semester 6
  3 FIN 302 (principles)
  3 MGT 462 (decision analysis)
  3 ENGL 341 (technical writing)
  3 Management Elective
  6 Electives
18 Total credit hours

Semester 7
  3 MGT 451 (leadership & motivation)
  3 MGT 472 (production & operations)
  3 Humanities
  3 Management Elective
  3 Elective
15 Total credit hours

Semester 8
  3 BA 490 (business policy)
  3 MGT 473 (production and operations II)
  3 MGT 481 (senior seminar)
  3 Humanities
  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 Core Curriculum (page 88) and the core business requirements (page 191), the following courses are required:
- ES 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
- MATH 231 (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 MGT 101 (modern management issues)
  3 ACCT 201 (fundamentals I)
  3 ENGL 111 (college English)
  4 CHEM 121 & 121L (general)
  4 MATH 131 (calculus)
 12 Total credit hours

Semester 2
  3 ACCT 202 (fundamentals II)
  3 ENGL 112 (college English)
  4 CHEM 122 & 122L (general)
  4 MATH 132 (calculus)
  3 ES 111 or CSE 113 (4 cr)
 17 or 18 Total credit hours

Semester 3
  5 PHYS 121 & 121L (general)
  3 ECON 251 (macroeconomics)
  4 MATH 231 (calculus)
  3 ES 201 (statics)
 16 Total credit hours

Semester 4
  5 PHYS 122 & 122L (general)
  3 BCS 283 (applied statistics)
  3 ECON 252 (microeconomics)
  3 ES 216 (fluid mechanics)
  4 Biology/Earth Science/Engineering with lab
 18 Total credit hours

Semester 5
  3 ACCT 350 (managerial accounting)
  3 BA 315 (business law I)
  3 MGT 330 (organizational behavior)
  3 MKT 335 (principles)
  3 Engineering prerequisite or elective
 15 Total credit hours

Semester 6
  3 FIN 302 (principles)
  3 ENGL 341 (technical writing)
  3 Humanities
  3 Social Science
  6 Engineering prerequisite or Elective
 18 Total credit hours

Semester 7
  3 MGT 462 (decision analysis)
  3 MGT 472 (production & operations I)
  3 Humanities
  6 Engineering prerequisite or Elective
 15 Total credit hours

Semester 8
  3 BA 490 (business policy)
  3 MGT 481 (senior seminar)
  3 Engineering Elective
  3 Humanities/Social Science
  3 Management or Engineering Elective
 15 Total credit hours

Minor in Management

Minimum credit hours required—18

The following courses are required:
- MGT 302 (3), 330 (3), 335 (3) 472 (3)
- Six (6) credit hours of Management Department courses numbered 300 or above.

  Note: ECON 252 and BCS/MATH 283 are prerequisites for MGT 302 and MGT 335. Non-majors must obtain instructor consent in lieu of the ACCT 202 prerequisite for MGT 302.

Accounting Courses:

ACCT 201, 201D, Fundamentals of Accounting I, 3 cr, 3 cl hrs
  Financial accounting procedures, concepts, and reports for sole proprietorships.

ACCT 202, Fundamentals of Accounting II, 3 cr, 3 cl hrs
  Prerequisite: ACCT 201
  Financial accounting for partnerships and corporations, an introduction to managerial accounting concepts.

ACCT 350, 350D, Managerial Accounting, 3 cr, 3 cl hrs

Prerequisite: ACCT 202 or consent of instructor

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, 353D, Cost Accounting, 3 cr, 3 cl hrs

Prerequisite: ACCT 202 or consent of instructor

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 202

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

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

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 202; FIN 302; ECON 251, 252; MGT 330; BCS 283; 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

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 88.

ECON 251, Principles of Macroeconomics, 3 cr, 3 cl hrs

Macroeconomic theory and policy analysis. Economic aggregates; fiscal and monetary policy; productivity and economic growth; banking system; national debt. Policy innovation: crisis and response; Keynesian, monetarist and supply-side models. Free trade, protectionist and mercantilist strategies. Exchange rate systems and macroeconomic management. [NMCCNS ECON 2113: General Education Area IV]

ECON 252, Principles of Microeconomics, 3 cr, 3 cl hrs

Microeconomic theory and applications. Market allocation of resources; supply and demand; theory of marginal analysis; market types; market failure; regulation and antitrust; economic growth and innovation; business finance; economic globalization; and cultures of capitalism. [NMCCNS ECON 2123: General Education Area IV]

ECON 362, Managerial Economics, 3 cr, 3 cl hrs

Prerequisites: ECON 251, 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

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

Current topics in economics.

ECON 491, Directed Study, 1–3 cr, 1–3 cl hrs

Prerequisite: Upper-class standing or consent of instructor

Finance Courses

FIN 410, Theory of Financial Decisions, 3 cr, 3 cl hrs

Prerequisites: FIN 302; BCS 283; or consent of instructor

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: BCS 283; FIN 302 or ES 316; or consent of instructor

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

Current topics in finance.

FIN 491, Directed Study, 1–3 cr, 1–3 cl hrs

Prerequisite: Upper-class standing or consent of instructor

Management Courses:

MGT 101, 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 302, Introduction to Financial Economics 3 cr, 3 cl hrs

Prerequisites: ACCT 202, BCS 283, ECON 252, or consent of instructor

Introduction to costa analyses, financial management and planning, introduction to financial investments including debt, and capital budgeting models with examples of applications.

MGT 330, Management and Organizational Behavior, 3 cr, 3 cl hrs

Prerequisites: ENGL 112 and upper-class standing or consent of instructor

Classical and contemporary organization theories, interpersonal and organization behavior, motivation, communication, leadership, decision process in organizations.

MGT 331, 331D, Human Resource Management, 3 cr, 3 cl hrs

Managing human resources in technology and engineering organizations including employee recruitment and retention, leading teams, managing employee performance, an analyzing organizational productivity, among other critical topics.

MGT 335, 335D, Marketing of New Products and Innovations, 3 cr, 3 cl hrs

Prerequisites: ECON 252; BCS 283; 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: BCS 283; 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: any two of the following course: ECON 251, ECON 252, MGT 335, MGT 302

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: BCS 283 or MATH 283 or MATH 382 and upper-class standing or consent of instructor. Management majors should enroll in BCS 283.

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: BCS 283 and upper-class standing or consent of instructor

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

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 283, MGT 472 or consent of instructor

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: upper-class standing and consent of instructor

MGT 488, Technology Entrepreneur Workshop, 3 cr, 3 cl hrs

Prerequisites: FIN 302; MGT 381; ACCT 202; senior standing; or consent of instructor

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 486, Business Policy/Corporate Strategy, 3 cr, 3 cl hrs

Prerequisites: ACCT 202; FIN 302; ECON 251, 252; MGT 330; BCS 283; MKT 335; senior standing

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 490, 490D, Selected Topics, 1–3 cr, 1–3 cl hrs

Prerequisite: Upper-class standing or consent of instructor

Current topics in management.

Faculty Research Interests

Anselmo—Decision Analysis and Risk Management, Computational Finance, Electronic Commerce

Mazumdar—Database Systems, Massive Storage Systems, Computational Logic

Reinow - Strategic Management, Leadership

Sueyoshi—Management Science, Data Envelopment Analysis, Risk and Policy Analysis

Yuan - Finance and Economics

Mathematics

Professors Avramidi, Borchers, Hossain (Chair of the Department), Stone (Dean of Arts & Sciences), Wang
Associate Professors Aitbayev, Kerr, Makhnin
Assistant Professors Gonzalez-Parra, He, Zhang
Instructors Ballou, Phillips
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 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, and computer. 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 Core Curriculum (page 88), the following courses are required:

- *Introduction to Computer Science*: CSE 113 (4) or ES 111 (3)
- *Basic Mathematics*: MATH 231 (4), 254 (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:
    1. Applied Mathematics: 410 (3), 411 (3), 435 (3), 436 (3), 437 (3), 438 (3)
    2. Pure Mathematics: 442 (3), 455 (3), 456 (3), 461 (3), 471 (3), 472 (3)
    3. Operations Research and Statistics: 415 (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.
- *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 131 (calculus)
4	CHEM 121, 121L, 121 R (general chemistry)
4	Science/Engineering Elective
3	ENGL 111 (college English)
15	Total credit hours

Semester 2

4	MATH 132 (calculus)
4	CHEM 122, 122L, & 122R (general chemistry)
4	Science/Engineering Elective
3	ENGL 112 (college English)
15	Total credit hours

Semester 3

3	MATH 254 (intro to linear algebra)
4	MATH 231 (calculus)
5	Phys 121 & 121L
3	Humanities
15	Total credit hours

Semester 4

3	MATH 335 (ordinary differential equations)
3	MATH 352 (basic concepts)
5	PHYS 122 & 122L (general)
4	CSE 113 or ES 111
15	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	Social Science
3	Electives*
16	Total credit hours

Semester 6

3	MATH 454 (linear algebra)
3	ENGL 341 (technical writing)
3	Math Elective
6	Electives*
15	Total credit hours

Semester 7

3	MATH 430 (mathematical modeling)
3	Math Elective
3	Social Science
6	Electives*
15	Total credit hours

Semester 8

3	Math Elective
3	Math Elective
3	Humanities/Social Science
6	Electives*
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 254 (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. There is no foreign language requirement for either program. 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.

Five-Year Bachelor's/Master's Degree Program in Mathematics

The five-year mathematics B.S./M.S. program provides the student the opportunity to obtain both a bachelor's degree and a master's degree in mathematics in five years. A minimum of 150 total credit hours are required to complete the dual degree program.

Students should apply to the program before their seventh semester. Admission is contingent on academic performance and acceptance of a proposed course of study. Graduate status is granted upon completion of the general requirements for the bachelor's degree in mathematics or one of its options with a 3.0 minimum cumulative grade point average. The master's degree is granted upon completion of the requirements of the master's degree program.

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

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 (6 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 another 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 Industrial Mathematics group.

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 Industrial Mathematics group and should involve mathematical modeling, computation and analysis.

Master of Science in Mathematics with Specialization in Operations Research and Statistics

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 or 488, or the equivalent.

Graduate work would consist of:

1) A minimum of 12 credit hours from MATH 515, 516, 517, 518, 519, 582, 583, 586, 587, 588, 589. 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; MATH 384, 386, 410, 411, 484, 505, and 521.

Master of Science in Mathematics with Specialization in Analysis

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, 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 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:
    - All of the following, if not already taken: MATH 410, 411, 435, 437, 438, 471
    - 500-level MATH courses (30 credit hours) consisting of:
        1. MATH 530 (3), 532 (3)
        2. Six (6) credit hours of core classes: MATH 511, 535, 538, 539, 577
        3. Four or more of the remaining classes are to be additional core classes (above), courses from the list of recommended classes (below) or other classes approved in advance by the student's committee. Students are strongly encouraged to include MATH 509, Graduate Internship, in their program. *Recommended classes: MATH 509, 510, 512, 518, 519, 531, 533, 536, 537, 587 or other*
- 12 hours of upper-division or graduate-level courses from outside the math department
- Dissertation (24 credit hours): MATH 595
- Preliminary exams in differential equations, analysis, and numerical analysis (usually taken in the third semester, or in the second semester for students who already have a master's degree). Students may, if necessary, repeat one or more exams the following semester. Students who do not receive satisfactory scores after two attempts will not be accepted into 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, 582, 583, 586, 587, 588, 589
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:

Tech's mathematics department offers courses in eight sub-fields of mathematics. The middle digit of each mathematics course number specifies the sub-field in which that course belongs. The middle digits and the sub-fields they represent are:

1—operations research and numerical methods
2—discrete mathematics
3—applied analysis
4—geometry
5—modern algebra
6—topology
7—real analysis (theory)
8—probability, statistics, stochastic processes

Thus, 415 is a course in operations research, etc. The middle digit 0 is used for the basic mathematics courses. The only exception to this system is MATH 581, the standard college number for directed studies.

MATH 101, College Algebra, 3 cr, 2 cl hrs, 3 lab hrs

The fundamental algebraic operations—factoring, fractions, linear equations and inequalities, quadratic equations, ratio, proportion, variation, functions and their graphs, systems of equations. [NMCCNS MATH 1113: General Education Area II]

MATH 103, 103D, Pre-Calculus, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: ACT Math score of at least 21 or SAT Math score of at least 500 or SAT Redesign Math score of at least 530 or a score of 24 or higher on the algebra portion of the math placement test, or MATH 101 passed with grade C- or better

Functions and relations, equations and inequalities, determinants and matrices, simultaneous equations, algebra of polynomials, complex numbers. [NMCCNS MATH 1613: General Education Area II]

MATH 104, 104D, Trigonometry, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: MATH 103 passed with a grade of C– or better, or ACT Math score of at least 26 or SAT Math score of at least 590 or SAT Redesign Math score of at least 610 or a score of 20 or higher on the advanced algebra portion of the math placement test.

Trigonometric functions, identities, related angles, radian measure, graphs, inverse functions, trigonometric equations, logarithms, solution of plane triangles. [NMCCNS MATH 1114: General Education Area II]

MATH 131, Calculus and Analytic Geometry I, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: MATH 103 and 104 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 104 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.

First course in calculus and analytic geometry. Includes introductory concepts in analytic geometry, limits, continuity, differentiation, applications of the derivative, the mean value theorem, the definite and indefinite integral, and applications of integration. [NMCCNS MATH 1614: General Education Area II]

MATH 132, Calculus and Analytic Geometry II, 4 cr, 4 cl hrs

Prerequisite: MATH 131 passed with grade C- or better

Continuation of MATH 131. Transcendental functions, techniques of integration, polar coordinates, infinite series, and applications. [NMCCNS MATH 1623: General Education Area II]

MATH 221, Formal Logic and Discrete Mathematics, 3 cr, 3 cl hrs

Prerequisite: MATH 132 passed with a grade C- or better

Analytical reasoning and critical thinking skills. Induction and recursion. Mathematical proofs. Propositional calculus and predicate calculus. Discrete and combinatorial mathematics: sets, functions, relations, trees, and graphs, permutations and combinations.

MATH 231, Calculus and Analytic Geometry III, 4 cr, 4 cl hrs

Prerequisite: MATH 132 passed with grade C- or better

Vectors in the plane and 3-space, vector calculus in two dimensions, partial differentiation, multiple integration, topics in vector calculus, and complex numbers and functions.

MATH 254, Introduction to Applied Linear Algebra, 3 cr, 3 cl hrs, 1.5 lab hrs

Prerequisite: MATH 131 passed with grade C- or better

Linear systems, matrix algebra, determinants, vector spaces, linear transformations, eigenvalues and eigenvectors, inner products and orthogonality, least squares problems.

MATH 283, Introduction to Applied Statistics, 3 cr, 3 cl hrs, 1.5 lab hrs

Corequisite: MATH 132

Exploratory data analysis. Introduction to probability and random variables. Concepts of population and sample. Estimation and hypothesis testing. Simple linear regression and one-way analysis of variance. Techniques in data analysis using statistical computer packages.

MATH 332, Vector Analysis, 3 cr, 3 cl hrs

Prerequisite: MATH 231 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 132 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 231, 335, and one of MATH 254 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 231
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 132 passed with grade C- or better

Mathematical proofs, set theory, mathematical induction and recursion, binary relations, 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, Reimann integral.

MATH 382, Probability and Statistics, 3 cr, 3 cl hrs

Prerequisite: MATH 132 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: Math382 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 132 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 384, Applied Regression and Design of Experiments, 3 cr, 3 cl hrs

Prerequisite: MATH 283 or 382 passed with grade C- or better

Design of experiments, analysis of variance and covariance, linear and nonlinear curve fitting. Applications taken from metallurgy, mining and petroleum engineering, hydrology, and other disciplines.

MATH 386, Nonparametric Statistics, 3 cr, 3 cl hrs

Prerequisite: MATH 283 or 382 passed with grade C- or better

Tests based on ranks for one-sample and two-sample problems, nonparametric estimates, multiple comparisons, nonparametric methods in regression. Applications in science and engineering.

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 for Scientists and Engineers I, 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, numerical differentiation and integration, numerical solution of ordinary differential equations.

MATH 411, Numerical Linear Algebra, 3 cr, 3 cl hrs

Prerequisites: MATH 254; CSE 113 or ES 111

Direct and iterative methods for solving linear systems, conditioning and stability, methods for computing eigenvalues and eigenvectors, linear least squares problems, applications, performance, software.

MATH 414, Introduction to High Performance Computing,3 cr, 3 cl hrs

Prerequisite: MATH 410 passed with grade C- or better

Solving scientific problems in high-performance computing systems. Topics include: numerical methods, using software libraries and packages such as MATLAB, Mathematica, NAG, LAPACK, etc., matching algorithms to machines, measuring performance and scientific visualization. A number of computing architectures—such as high-performance workstations, the Cray Y-MP, and the Connection Machine—will be used to solve a small set of prototype problems.

MATH 415, Introduction to Operations Research: Deterministic Methods, 3 cr, 3 cl hrs

Prerequisite: MATH 254 passed with grade C- or better

A survey of operations research techniques including linear programming, nonlinear models, and graph theoretical models.

MATH 430, Mathematical Modeling, 3 cr, 3 cl hrs

Prerequisites: MATH 335; one of MATH 254 or MATH 337; MATH 382, each 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.

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 254 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 442, Introduction to Differential Geometry, 3 cr, 3 cl hrs

Prerequisite: MATH 254 passed with grade C- or better

Introduction to the theory of manifolds, vector fields, tensors and differential forms.

MATH 454, Linear Algebra, 3 cr, 3 cl hrs

Prerequisites: MATH 254 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, 456, 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 458, Introduction to Theory of Numbers, 3 cr, 3 cl hrs

Prerequisite: MATH 352 passed with grade C- or better

Properties of integers, primes, congruences, related topics.

MATH 461, Introduction to Topology, 3 cr, 3 cl hrs

Prerequisite: MATH 372 passed with grade C- or better

Fundamental concepts of point-set topology, abstract topological spaces, metric spaces, continuous mappings, separation axioms, compactness, connectedness.

MATH 464, Knot Theory, 3cr, 3 cl hrs

Prerequisite: MATH 335 and MATH 352 passed with grade C- or better

General survey of knot theory concentrating on knot invariants, including numerical, polynomial and invariants of finite type, theory of braids, the Artin braid group, elementary template theory, applications to physics and biology.

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 254 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 505, Neural Nets, 3 cr, 3 cl hrs

Prerequisites: CS 344; MATH 254 and 382; or consent of instructor

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. (Same as CSE 565)

MATH 509 Graduate Internship, credit to be arranged

Prerequisite: Graduate standing

MATH 510 Computational Fluid Dynamics, 3 cr, 3 cl hrs

Prerequisite: MATH 254, 336, 410 or equivalent

Equations of fluid dynamics, flow models, discretization techniques, analysis of numerical schemes, numerical methods for solving linear and nonlinear systems of 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 consent of instructor

Finite difference or finite element methods for parabolic and elliptic partial differential equations; approximation, stability, and convergence; applications.

MATH 512, Numerical Methods for Wave Propagation, 3 cr, 3 cl hrs

Prerequisite: MATH 410 or consent of instructor

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 consent of instructor

Topics chosen from areas in numerical analysis, numerical partial differential equations, multigrid and domain decomposition methods, 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

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

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

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, Methods of Nonlinear Programming, 3 cr, 3 cl hrs

Prerequisite: MATH 410 or 415 or consent of instructor

Theory of constrained and unconstrained optimization. Methods for nonlinear programming, including quasi-Newton methods, conjugate direction methods, Levenberg-Marquardt methods, sequential quadratic programming, and sequential unconstrained minimization techniques.

MATH 519, 519D, Inverse Problems, 3cr, 3 cl hrs

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 521, Advanced Combinatorics, 3 cr, 3 cl hrs

Prerequisite: MATH 221

Graph theory and applications. Graphs, trees, connectivity, Euler tours and Hamiltonian cycles, matchings, planar graphs, directed graphs, networks, cycle space, and bond space.

MATH 530, Modeling Case Studies, 3 cr, 3 cl hrs

Prerequisite: MATH 430 or equivalent

Open-ended modeling projects from actual applications.

MATH 531, 531D, Topics in Ordinary Differential Equations, 3 cr, 3 cl hrs each semester

Prerequisite: MATH 437 or equivalent

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

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

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 436
Advanced topics selected from asymptotic expansions of integrals and ordinary differential equations, integral equations, singular integral equations, Wiener-Hopf technique, generalized functions.

MATH 537, 537D, Bifurcation Theory, 3 cr, 3 cl hrs
Prerequisite: MATH 437 or equivalent
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
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
The Navier-Stokes equations, inviscid flow, irrotational fluids, viscosity, and turbulence. Other topics as time and interest permit.

MATH 542, Topics in Differential Geometry, 3 cr, 3 cl hrs
Prerequisite: MATH 442 or consent of instructor
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 561, 562, Topology, 3 cr, 3 cl hrs each semester
Prerequisites: MATH 471, 472; or MATH 461
Point-set topology, abstract topological spaces, generalized convergence, product and quotient spaces, metric spaces, uniform spaces; elementary concepts of algebraic topology.

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
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
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
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 384 or 483; MATH 486 or consent of instructor
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 585, Statistics for Technology Managers, 3 cr, 3 cl hrs

Prerequisite: Enrollment in the Engineering Management program

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.

MATH 586, 586D, Spatial Variability and Geostatistics, 3 cr, 3 cl hrs

Prerequisite: MATH 382

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

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

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 589, Applied Multivariate Analysis, 3 cr, 3 cl hrs

Prerequisite: MATH 382; MATH 283 or 384 recommended

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 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

Gonzales-Parra —Applied Mathematics, Mathematical Biology, Dynamical Systems, Numerical Analysis

He—Uncertainty Quantification, Approximation Theory, Fuzzy Set Theory and Fuzzy Measure Theory

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

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 333 (3); MATE 447 (3)
- Two of: EE 308 (3), EE 324 (3), EE 434 (3); MATE 441 (3),
  MATE 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 122 or 132; MATH 231
    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; MATH 254
    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.
    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.

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.

P R 100C Weight Lifting 1 cr, 2 cl hrs
> Introduction to basic principles and techniques of weight training

P R 101C Weight Lifting for Women 1 cr, 2 cl hrs
> Introduction to basic principles and techniques of weight training as related to women

P R 102C Physical Conditioning 1 cr, 2 cl hrs
> Physical fitness, stress management, weight management, nutrition and muscular strength and endurance

P R 103C Beginning Racquetball 1 cr, 2 cl hrs
> Basic fundamentals of all strokes and strategies used in the game of racquetball

P R 203C Intermediate Racquetball 1 cr, 2 cl hrs
Prerequisite: PR 103C or consent of instructor.
> Perfection of all strokes and strategies used in the game of racquetball

P R 104C Beginning Tennis 1 cr, 2 cl hrs
> Fundamentals skills in footwork, forehand, back hand, volleys, and servings

P R 105C Badminton 1 cr, 2 cl hrs
> Instruction in basic skills such as serving, volleys, forehand and backhands

P R 106C Beginning Golf 1 cr, 2 cl hrs
> Instruction in the basic skills, equipment, rules, etiquette and shot-making and use of irons and woods.

P R 206C Intermediate Golf   1 cr, 2 cl hrs
Prerequisite: PR 106C or consent of instructor.
> Instruction emphasizing actual play

P R 110C Beginning Volleyball   1 cr, 2 cl hrs
> Introduction to basic skills, rules, and strategies

P R 210C Intermediate Volleyball   1 cr, 2 cl hrs
Prerequisite: Prior experience is required.
> Improve individual skill levels and apply more tactics and strategies

P R 111C Basketball 1 cr, 2 cl hrs
> Instruction and practice of game skills in a team setting

P R 112C Indoor Soccer 1 cr, 2 cl hrs
> Instruction and practice of basic skills in an indoor setting

P R 113C Flag Football 1 cr, 2 cl hrs
> Instruction and practice of basic skills, rules, field positions in a team setting

P R 120C Beginning Yoga 1 cr, 2 cl hrs
> Introductory practices focus on alignment, strength, breath relaxation, and restoration

P R 121C Gentle Yoga 1 cr, 2 cl hrs

Focus on stress reduction, body/breath awareness and flexibility

P R 122C Slow Flow Yoga 1 cr, 2 cl hrs

Instruction supports structural integrity of spine, back and abdominals

P R 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

P R 124C Stretch and Relaxation 1 cr, 2 cl hrs

Instruction emphasizes stretch and relaxation techniques

P R 125C Massage/Thai Massage 1 cr, 2 cl hrs

This course teaches basic techniques to ease muscle pain, improve circulation and create a better sense of well being.

P R 130C Aerobics 1 cr, 2 cl hrs

Instruction in continuous movement using basic steps for improved cardio respiratory endurance.

P R 131C Salsa Aerobics 1 cr, 2 cl hrs

Instruction emphasizes exercise and cardiovascular endurance with the use of Latin music

P R 132C Zumba 1 cr, 2 cl hrs

The trademark name for Salsa Aerobics instruction emphasizing exercise and cardiovascular endurance with the use of Latin music

P R 133C Indoor Cycling 1 cr, 2 cl hrs

Designed to progressively build strength and endurance while improving cardio respiratory function

P R 134C Spinning 1 cr, 2 cl hrs

The trademark name for Indoor Cycling designed to progressively build strength and endurance while improving cardio respiratory function

P R 140C Beginning Kung Fu 1 cr, 2 cl hrs

Foundations of Chinese martial arts, self defense, and health systems with special emphasis on the Northern Longfist style.

P R 141C Karate 1 cr, 2 cl hrs

Instruction in the basic skills, blocks, strikes, and kicks of Japanese karate

P R 142C Taijutsu 1 cr, 2 cl hrs

Instruction in the basic techniques of punching, falling, rolling and kicking in Taijutsu

P R 143C Tai Chi Chuan 1 cr, 2cl hrs

Instruction and practice in techniques to enhance body awareness, reduces stress, improve balance and increase strength.

P R 150C Beginning Belly Dance 1 cr, 2 cl hrs

Instruction in the basic moving steps and rhythms of the belly dance

P R 151C Irish Step Dance 1 cr, 2 cl hrs

Introduction to the traditional Irish step dance

P R 152C Ballroom Dance 1 cr, 2 cl hrs

Introduction to ballroom dance such as the lindy, foxtrot, waltz, tango, cha-cha and rumba

P R 153C Swing Dance 1 cr, 2 cl hrs

Introduction to swing dancing including East Coast Swing, Lindy Hop and Charleston.

P R 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

P R 161C Beginning Rock Climbing 1 cr, 2 cl hrs

Introduction to basic climbing technique with an emphasis on safety, safe knot and belay

P R 170C Aquatic Fitness 1 cr, 2 cl hrs

Prerequisite: Swimsuits and Aqua shoes recommended
Designed to enhance the level of muscular development, and cardiovascular endurance through exercise in water

P R 220C Intermediate Yoga 1 cr, 2 cl hrs

Prerequisite: PR 120C or consent of instructor.
Intermediate training and skill techniques in Yoga

P R 250C 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

P R 261C Intermediate Rock Climbing 1 cr, 2 cl hrs

Prerequisite: PR 161C or consent of instructor
Continuation of safety, rope set-up, belaying lead climb, rappelling and anchor set-up

Physics

Professors Creech-Eakman, Hofner, Minschwaner, Romero, Sonnenfeld (Chair of the Department), Wells, Westpfahl, Young
Associate Professors Eack, Meier, Morales-Juberias, Sessions
Assistant Professors Arendt, da Silva, Edens, Lopez Carrillo
Adjunct Faculty Avramidi, Buscher, Butler, Carilli, Dubey, Elias, Elvis, Fuchs, Goss, Haniff, Haertel, Jurgenson, Manney, Myers, Ott, Owen, Rison, Swain, Teare, Thomas, Wozniak
Emeritus Professors Eilek, Hankins, Klinglesmith, Krehbiel, LeFebre, Meason, Raymond, Schery, Winn

Degrees Offered: B.S. in Physics and in Physics with options in Astrophysics, Atmospheric Physics; M.S. in Physics; M.S. in Physics with Specialization in Instrumentation; Ph.D. in Physics; Ph.D. in Physics with dissertation in Astrophysics, Atmospheric Physics, or Mathematical Physics

Departmental web site: *http://www.physics.nmt.edu*

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, and the photochemistry of the middle to upper atmosphere 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-mill 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, the 2.4-meter optical telescope at New Mexico Tech's Magdalena Ridge Observatory (MRO) is now in operation, and the MRO optical/infrared interferometer 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 88), physics majors must choose PHYS 121 and 122 and labs. In addition, the following courses are required:

- PHYS 221 (4), 221L (1), 222 (4), 222L (1), 241 (3), 242 (3), 321 (3), 333 (3), 334 (3), 336L (1), 340 (3), 380 (1), 411 (3), 443 (3), 451 (2)
- MATH 231 (4), 254 (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 (ERTH), Engineering (ChE, CE, EE, ENVE, MATE, METE, ES, MENG, ME, PETR), Computer Science Engineering (CSE), or PHYS 189 (Introductory Astronomy or 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—six 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 121 & 121L
- 4 MATH 131 (calculus)
- 4 CHEM 121 & 121L (general)
- 3 ENGL 111 (college English)
- 16 Total credit hours

Semester 2
- 5 PHYS 122 & 122L
- 4 MATH 132 (calculus)
- 4 CHEM 122 & 122L (general)
- 3 ENGL 112 (college English)
- 16 Total credit hours

Semester 3
- 5   PHYS 221 & 221L
- 3 PHYS 241 (computational)
- 4 MATH 231 (calculus)
- 3 MATH 254 (linear algebra)
- 15 Total credit hours

Semester 4
- 5 PHYS 222 & 222L
- 3 PHYS 242 (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
- 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 88), physics majors must choose PHYS 121 and 122 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 121 & 121L
   4 MATH 131 (calculus)
   4 CHEM 121 & 121L (general)
   3 ENGL 111 (college English)
  16 Total credit hours

Semester 2
   5   PHYS 122 & 122L
   4 MATH 132 (calculus)
   4 CHEM 122 & 122L (general)
   3 ENGL 112
  16 Total credit hours

Semester 3
   5 PHYS 221 & 221L
   3 PHYS 241 (computational)
   4 MATH 231 (calculus)
   3 MATH 254 (linear algebra)
   3 Humanities/Language
  18 Total credit hours

Semester 4
   5 PHYS 222 & 222L
   3 PHYS 242 (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 88), physics majors must choose PHYS 121 and 122 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 121 & 121L
   4 MATH 131 (calculus)
   4 CHEM 121 & 121L (general)
   3 ENGL 111 (college English)
  16 Total credit hours

Semester 2
   5 PHYS 122 & 122L
   4 MATH 132 (calculus)
   4 CHEM 122 & 122L (general)
   3 ENGL 112 (college English)
  16 Total credit hours

Semester 3
   5 PHYS 221 & 221L
   3 PHYS 241 (computational)
   4 MATH 231 (calculus)
   3 MATH 254 (linear algebra)
   3 Humanities/Language
  18 Total credit hours

Semester 4
   5 PHYS 222 & 222L
   3 PHYS 242 (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 241 (3), 242 (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 Specialization 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.

Five-Year B.S./M.S. in Physics

The student must complete all the requirements for an M.S. in Physics, as outlined on page 219. The candidate for the program should apply for admission no later than the end of his/her 5th 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.

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 semester s 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 four 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 Mathematical Physics
> 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 wit ha 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 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.

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
Corequisite: MATH 101

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 121 Laboratory requirement.

PHYS 121, General Physics I, 4 cr, 3 cl hrs, 2 recitation hrs
Corequisites: PHYS 121L; MATH 131

Introductory concepts. Mechanics, including Newton's Laws of force, linear and angular momentum, energy, gravitation, heat and thermodynamics, and applications. [NMCCNS PHYS 1215: General Education Area III]

PHYS 121L, General Physics Laboratory I, 1 cr, 3 lab hrs
Corequisite: PHYS 121

Experiments from the subject matter of PHYS 121. [NMCCNS PHYS 1215: General Education Area III]

PHYS 122, General Physics II, 4 cr, 3 cl hrs, 2 recitation hrs
Prerequisite: PHYS 121
Corequisites: MATH 132; PHYS 122L

Continuation of PHYS 121 including electricity, magnetism and optics. [NMCCNS PHYS 1225: General Education Area III]

PHYS 122L, General Physics Laboratory II, 1 cr, 3 lab hrs
Corequisite: PHYS 122

Experiments from the subject matter of PHYS 122. [NMCCNS PHYS 1225: General Education Area III]

PHYS 221, Comprehensive Physics I, 4 cr, 3 cl hrs, 2 recitation hrs
Prerequisites: PHYS 121; MATH 131
Corequisite: PHYS 221L

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 1215: General Education Area III]

PHYS 221L, Comprehensive Physics Laboratory I, 1 cr, 2 lab hrs
Corequisite: PHYS 221
Laboratory experiments from the subject matter of PHYS 221. [NMCCNS PHYS 1215: General Education Area III]

PHYS 222, Comprehensive Physics II, 4 cr, 3 cl hrs, 2 recitation hrs
Prerequisites: PHYS 221; MATH 131
Corequisites: PHYS 222L; MATH 132, PHYS 122
Continuation of PHYS 221. 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 1225: General Education Area III]

PHYS 222L, Comprehensive Physics Laboratory II, 1 cr, 2 lab hrs
Corequisite: PHYS 222
Laboratory experiments from the subject matter of PHYS 222. [NMCCNS PHYS 1225: General Education Area III}

PHYS 241, Computational Physics I, 3 cr, 2 cl hrs, 2 hr recitation/computer lab
Prerequisite: PHYS 122
Corequisite: MATH 254
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 242, Computational Physics II, 3 cr, 2 cl hrs, 2 hr recitation/computer lab
Prerequisite: PHYS 241
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 122 or 222; 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 242, MATH 254
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 242
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

PHYS 328L: Prerequisite: PHYS 327L; or consent of instructor

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 122 or PHYS 222; PHYS 242; MATH 332

Corequisite: MATH 335

Maxwell's four short equations use the language of vector calculus to describe problems involing 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. Maxwell's equations in conductors and conductivity of metals, semiconductors and gasses will be considered.

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 254, 335, or consent of instructor

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

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 122 or PHYS 222; 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 122 or 222; or consent of instructor
Offered alternate years

Covers dry and moist thermodynamics, radiative transfer, some microphysics, and dynamics (including hydrostatic balance, geostraphic 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 122 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

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 222 and PHYS 340, or consent of instructor

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 121 & 122, PHYS 121 & 122, 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 ERTH 449)

PHYS 451, Senior Laboratory, 1 or 2 cr, 3 or 6 lab hrs

Prerequisites: Senior status or consent of instructor

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

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

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 254, 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 magnetostatic 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

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

Offered 2010 and alternate years

Basic equations, potential and viscous flow, scaling. Compressible flow including characteristics and shock waves. Magnetohydrodyamics, 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

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

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
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

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.

PHYS 546L, Electrical and Magnetic Measurements Graduate Lab, 1 cr, 3 lab hrs

Prerequisite: Graduate standing or consent of instructor

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 222 and PHYS 340, or consent of instructor

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. 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

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

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 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.*

Physics 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 111, 112, 331, 333; CHEM 121, 122, 333, 334; MATH 131, 132; PHYS 121, 122; PSY 121; and social science (two semesters).

Predental, Prephysical Therapy, and Preoptometry Programs

Most accredited schools of these specialties require a minimum of two years of college work. However, most schools give preference to students with three or four years of preparation. Courses should include those listed above for the first two years.

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. Most premedical students major in biology, however, 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.

Preveterinary Medicine Program

A minimum of two years of acceptable college work is required for admission to a college of veterinary medicine. However, most students complete a bachelor's degree before entering veterinary school. Courses to be included in a two-year program should be those described above. Students should add as many additional courses from those listed under the premedical program. A four-year program should include the remaining biology and chemistry courses of the premedical program and be planned to meet the degree requirements for the Bachelor of Science degree in biology, chemistry, or basic sciences.

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 111, 112, 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 111 and 112; CHEM 121 and 122; BIOL 111; and MATH 131 (MATH 132 recommended).

Prelaw Program

The usual requirement for admission to an accredited school of law is a baccalaureate degree from an accredited college.

Law schools often look for successful completion of English and writing courses as evidence of writing ability, and successful completion of mathematics and science courses as evidence of logical reasoning ability.

Many Tech degrees are suitable background for the field of patent law. Students interested in patent law should consult with an advisor early in their college career, to ensure they take appropriate courses. Contact Academic Affairs for further information and academic advising.

Psychology

Associate Professor Samuels (Chair of the Department)
Assistant Professors Elliott, Thompson
Adjunct Instructors Thomas, Wilkinson
Emeritus Professors Etscorn, Holson

Degree Offered: B.S. in Psychology

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.

Undergraduate Program

Bachelor of Science in Psychology

Minimum credit hours required—120
In addition to the General Education Core Curriculum (page 88), the following courses are required:

- PSY 121 (3); 205 (3) and 205L (1), 472 (1)
- Two courses (with associated labs) chosen from among PSY 301 (3) and PSY 301L (1), PSY 305 (3) and PSY 305L (1), PSY 309 (3) and PSY 309L (1)
- 15 additional credit hours in psychology
- BIOL 111 (4), 112 (4), and at least six (6) upper-division credits in Biology, exclusive of BIOL 471 or 472
- MATH 283 (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 PSY 121 and 205 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 PSY 121 (general)
    3 ENGL 111 (college English)
    4 MATH 131 (calculus)
    4 CHEM 121 & 121L (general)
    1 Elective
    15 Total credit hours

Semester 2
    4 PSY 205 (experimental)
    3 ENGL 112 (college English)
    4 MATH 132 (calculus)
    4 CHEM 122 & 122L (general)
    15 Total credit hours

Semester 3
    3 PSY 212 (drugs and behavior)
    3 PSY 323 (developmental)
    5 PHYS 121 & 121L (general)
    4 BIOL 111 (general)
    15 Total credit hours

Semester 4
    3 PSY 209 (social)
    3 MATH 283 (statistics)
    5 PHYS 122 & 122L (general)
    4 BIOL 112 (general)
    15 Total credit hours

Semester 5

    4 PSY 301 (perception)
    3 HIST 151 (world history I)
    3 BIOL 331 (cell biology)
    3 PHIL 231 (introduction)
    <u>5</u> Electives
  15 Total credit hours

Semester 6

    4 PSY 305 (cognitive psychology)
    3 HIST 152 (world history II)
    4 BIOL 351 (physiology)
    3 ENGL 341 (technical writing)
    <u>1</u> Elective
  15 Total credit hours

Semester 7

    4 PSY 309 (behavioral neuroscience)
    3 PSY 330 (abnormal)
    4 BIOL 311 (genetics)
    <u>4</u> Electives
  15 Total credit hours

Semester 8

    1 PSY 472 (seminar)
    3 PSY 362 (animal behavior)
  <u>11</u> Electives
  15 Total credit hours

Minor in Psychology

Minimum credit hours required—20

The following courses are required:

- PSY 121 (3), 205 (4)
- PSY 301 (4) or PSY 305 (4) or PSY 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 (see page 234).

Psychology Courses

The following courses may be used to fulfill Area 4: Social Sciences portion of the General Education Core Curriculum, page 88.

PSY 121, General Psychology, 3 cr, 3 cl hrs

    The study of behavior. Includes perception, motivation, learning, personality, social processes, and physiological processes. [NMCCNS PSYC 1113: General Education Area IV]

PSY 131, 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.

PSY 151, 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.

PSY 205, Experimental Psychology, 3 cr, 3 cl hrs

    Prerequisite: PSY 121
    Corequisite: PSY 205L

    Basic concepts and research methodology in the study of behavior; emphasis on experimental design, control, and methods in Experimental Psychology.

PSY 205L, Experimental Psychology Laboratory, 1 cr, 2 lab hrs

Prerequisite: PSY 121
Corequisite: PSY 205
A lab usage fee is charged.

Laboratory methods and experiments investigating behavior, cognitive processes and neuropsychology.

PSY 209, Social Psychology, 3 cr, 3 cl hrs

Prerequisite: PSY 121

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.

PSY 212, Drugs and Behavior, 3 cr, 3 cl hrs

Prerequisite: PSY 121

An overview of how drugs affect brain and behavior, with an emphasis on self-administered drugs, addiction and treatment.

PSY 301, Sensation and Perception, 3 cr, 3 cl hrs

Prerequisite: PSY 205
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.

PSY 301L, Sensation and Perception Lab, 1 cr, 2 lab hrs

Prerequisite: PSY 205
Corequisite: PSY 301
A lab usage fee is charged

Laboratory methods and experiments in Sensation and Perception.

PSY 305, Cognitive Psychology, 3 cr, 3 cl hrs

Prerequisite: Psychology 205 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.

PSY 305L, Cognitive Psychology Lab, 1 cr, 2 lab hrs

Prerequisite: Psychology 205 passed with a C- or better
Corequisite: PSY 305
A lab usage fee is charged

Laboratory methods and experiments investigating cognitive processes.

PSY 309, Behavioral Neuroscience, 3 cr, 3 cl hrs

Prerequisites: Psychology 205 passed with a C- or better; Biology 111, 112
Corequisite: PSY 309L

Study of the neural and other physiological bases of behavior. Functional neuroanatomy of sensory and motor systems, motivation and drives, learning and emotion.

PSY 309L, Behavioral Neuroscience Lab, 1 cr, 2 lab hrs

Prerequisites: Psychology 205 passed with a C- or better; Biology 111, 112
Corequisite: PSY 309
A lab usage fee is charged

Laboratory includes neuroanatomy and neurophysiology, either *in vivo* and/or in computer simulations.

PSY 311, Tests and Measurements, 3 cr, 3 cl hrs

Prerequisite: PSY 121

Design, administration, interpretation, and evaluation of psychological and educational tests. Includes measurement theory as well as practical techniques.

PSY 314, Psychotherapeutics, 3 cr, 3 cl hrs

Prerequisites: PSY 212, BIOL 111, 112

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 320, Psychology of Language, 3 cr, 3 cl hrs

Prerequisites: PSY 121

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.

PSY 323, Psychology of Child and Adolescent Development, 3 cr, 3 cl hrs

Prerequisite: PSY 121

The development of human behavior from conception to adolescence. Includes cognitive, social, behavioral, and physical development.

PSY 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.

PSY 324, Psychology of Adult Development and Aging, 3 cr, 3 cl hrs

Prerequisite: PSY 121

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, Abnormal Psychology, 3 cr, 3 cl hrs

Prerequisite: PSY 121

A psychobiological investigation of the cause, presentation, diagnosis, treatment and prognosis of behavioral issues.

PSY 350, Psychobiology of Sex, 3 cr, 3 cl hrs

Prerequisite: PSY 121 or consent of instructor

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.

PSY 362, Animal Behavior, 3 cr, 3 cl hrs

Prerequisites: PSY 121 or consent of instructor

An overview of the study of animal behavior, focusing on presentation, adaptive advantage and mechanisms of specific behaviors. (Same as BIOL 362)

PSY 389, Special Topics in Psychology, cr and hrs to be arranged

PSY 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.

PSY 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.

PSY 409, Cell and Molecular Neuroscience, 3 cr, 3 cl hrs
Prerequisite: PSY 121 or BIOL 111
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: PSY 121 or BIOL 111
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.

PSY 472, Senior Seminar, 1 cr, 1 cl hr each semester
Prerequisite: Upper-division standing or consent of instructor
Review and discussion of current research in psychology.

Education Courses:

EDUC 340, Concepts in Education, 2 cr, 2 cl hrs
Brief survey of the history (especially modern history) of education together with the professional requirements and structure of educational systems. Understanding standards-based education and how to address the needs of culturally diverse school populations.

EDUC 341, Matching Teaching Strategies to Student Learning, 3 cr, 2.5 cl hrs, 1.5 lab hrs
How students learn and develop; including cognitive, social, emotional and physical development as it relates to students individual needs and strengths. How to teach in a classroom of diverse learners; including differentiating instruction, modifying for special needs students, and motivating student learning. Lab hours will be spent observing and working in public school classrooms.

EDUC 343, Classroom Management and Discipline, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: Permission of the Alternative Licensure Program Coordinator, enrollment in Alternative Licensure Program.
Principles of classroom management and discipline, student and teacher rights and responsibilities. Lab involves study, observation and participation in the public schools. Includes interviewing and evaluation.

EDUC 401, Assessing and Teaching Reading in Content Areas, 3 cr, 3 cl hrs
Prerequisites: Permission of the Alternative Licensure Program Coordinator, enrollment in Alternative Licensure Program.
Concepts, methods and materials for the teaching of reading in the context of the secondary curriculum. Topics include measurement of reading achievement and ability, reading training, motivation for reading, and reading disabilities.

EDUC 403 Methods and Practices of Secondary School Teaching, 4 cr, 3 cl hrs, 3 lab hrs*
Prerequisites: eight (8) credit hours of upper-division education courses, permission of the Alternative Licensure Program Coordinator, enrollment in Alternative Licensure Program.
A study of essential teaching principles including: instructional planning and implementation; assessment of student learning, appropriate feedback, and subsequent lesson modification; effective questioning to encourage student participation and to promote individual thinking and problem solving. The implementation of a variety of instructional strategies to meet the needs of all learners. The use of various resource materials and technology. Lab hours will be spent observing and working in public school classrooms.

EDUC 411 Directed Teaching*, 3 cr
Prerequisites: Senior or graduate standing; permission of the Alternative Licensure Program Coordinator, enrollment in the Alternative Licensure Program, education minor added, EDUC 403, and consent of a public school principal. Lab fee may be assessed for teaching outside of Socorro.
Practice teaching in a local secondary school. Students will experience all aspects of teaching. It involves a commitment of 2 hours per day, five days a week, in the classroom. Expect to spend an equal number of hours in preparation. Student teachers will also meet one hour per week with the Education Instructor.

Faculty Research Interests

Elliott—Neuroethology, Systems Neuroscience, Language, Music Cognition, Auditory Perception

Samuels—Cognitive Development, Reasoning and Problem Solving, Memory, Brain Injury and Rehabilitation

Thompson—Animal behavior, Neuroscience, Eye Disease, Gene and Cell Replacement Therapy

Master of Science for Teachers (MST)
Interdepartmental Program within the Department of Psychology and Education *(Mark Samuels, Department Chair; George Becker, Coordinator)*

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, Vice President for Student and University Relations, Director of Professional Development, Registrar, Vice President for Academic Affairs.

Adjunct Faculty: Lynne Kurilovitch and Don Wolberg

Degree Offered: Master of Science for Teachers

Program Description

The MST program is designed to provide graduate-level classroom and laboratory instruction for teachers of science, mathematics, engineering, and/or technology. The emphasis of the courses is on content, rather than pedagogy. MST students are encouraged to develop laboratory exercises, demonstrations, and teaching methods from the course content 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 taught 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 instruction and as live courses on the New Mexico Tech campus and around the state.

Program Prerequisites

An individual with at least one year of teaching experience may apply for admittance into the MST Program. The Program encourages individuals to hold a valid teaching certificate when appropriate. To be accepted into the MST Program, an individual must pass the Survey Courses (ST 523D, ST 524D, ST 525, ST 526, ST 550AD, and ST 550BD) 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.

Application for Admission

Application forms may be obtained from the internet at www.nmt.edu/~grad/. Printed forms or more information can be requested by e-mail from graduate@nmt.edu or by mail from:

> Master of Science for Teachers
> Graduate Office
> 801 Leroy Place, New Mexico Tech,
> Socorro, NM 87801

MST Fellowships

The MST Office maintains a list of available fellowships.

Endorsement Policy

Information regarding certification 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, or 550. 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.

Thesis or Independent Study Requirement

The candidate for the MST degree 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. The candidate must satisfy the thesis requirements of the department of his/her 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 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 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. Three credit hours will be allowed for the IS (ST 590).

Graduate Advisory Committee

Each MST student will be assigned a temporary advisor at the time of first registration. The student will select an advisor and an advisory committee by the completion of 12 credits or within one year of first enrollment (whichever comes first). The student's academic advisor must be a regular faculty member of the Institute. The advisory committee consists of at least the academic advisor and two other members with regular faculty members not being a minority. The academic advisor serves as chair of the advisory committee. The Psychology and Education Chair and the Graduate Dean must approve the advisor and members of the advisory committee. The student should have contact with his/her 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. The approved Course Program must be on file in the Graduate Office for full-time students no later than the end of the second semester of residency. Part-time and distance education students must formalize their course program by the time they complete 12 credits. The course program is reported on the committee report form, available online and from the Graduate Office.

Program Requirements

All incoming MST students must demonstrate competence in science and mathematics by either:

1. 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 (2)

   Credits are awarded for these courses but these credits DO NOT count towards the 30 credits needed for a MST Degree.

2. Passing the appropriate placement exams (see above). No credits are awarded for passing a placement exam.

These courses or the appropriate placement exams are prerequisites for most other ST courses.

Master of Science for Teacher students must take the following core of 21 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 depth, 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), or 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.

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 501 Special Topics
   These courses are offered on a request basis:
      Charles Darwin, "The Origin of Species", and Evolution,
      Vertebrate Paleontology,
      Earth Environments Through Time,
      Environmental Case Histories,
      Great Ideas in Natural History,
      Critical Thinking Skills

ST 502D Archaeology for Teachers, 2cr
   Prerequisites: ST 525/525D or departmental waiver
      A general introduction to the study of the past through material remains and the relationship of archaeology to the sciences. Four major topics are covered: archaeological field and lab method and theory; human evolution; the basic structure of world prehistory; archaeological careers and application of archaeology in the public sphere. Assignments include papers, archaeological analysis problems and classroom lesson plans.

ST 503D Ancestor's Tale, 2cr

Prerequisites: ST 523/523D and ST 525/525D or departmental waiver

Evolution is a theory, a process and a narrative of biological and geological science that elucidates the history of life and its amazing diversity and abundance on Earth. *The Ancestor's Tale* is a course that takes its name from the book (used as the text), written by noted evolutionary biologist Richard Dawkins, and is at once metaphor and narrative of life's journey through almost 4 billion years. The journey of these evolutionary pilgrims begins now, in the present, with our own species *Homo sapiens*, and moves ever deeper back through the evolutionary branchings of organisms in time. The course investigates the unity of all life on Earth through all of time.

ST 505D Human Evolution, 2 cr

Prerequisites: ST 523/523D or departmental waiver

We live on a planet populated by several billion members of a single species, Homo sapiens, different from all other species by a unique set of characters and behaviors not seen in any other animal species. This course is concerned with the origin and evolution of who we are and how we got here. The course will trace the origin of the great group to which we belong, the Primates, as well as our distant and not too distant cousins. We will review those traits that make us Primates, along with such interesting animals as the lemurs of Madagascar, the Old World Monkeys, and the Great Apes of Africa.

ST 506D Dinosaurs and Their World, 2 cr

Prerequisites: ST 523/523D and ST 525/525D; or departmental waiver

This course means to do what its title advertises. Together, we will go on an adventure to look at dinosaurs and their world, a world at once with similarities to our own, and many differences. We will explore a world about which we know a great deal, but also a world that still has many more unanswered questions. We will take a journey back through so much time that the reality of time's distance is reduced to numbers without a sense of the actual enormity of the journey. And yet even that journey is but a small fraction of a still greater timescale of our planet and the universe.

ST 508D Worms, Bugs, and Shells, 2cr

Prerequisite: ST 523/523D or departmental waiver

This course provides an introduction to the major groups of living invertebrate animals. The vast majority of living organisms are animals and fewer than 5% of these are animals with backbones; the majority of the rest are invertebrates, the "worms, bugs and shells" of this course. This course will acquaint students with the main ideas about the classification, anatomy, evolutionary relationships, ecology, behavior, geographical distribution and other aspects of the natural history of the major groups of living invertebrates. Special emphasis will be placed on species found in New Mexico and the Southwest. Technical terminology will be kept to a minimum and the primary focus will be on big ideas.

ST 509D Human Genetics, 2cr

Prerequisites: ST 523/523D and ST550/550BD, or departmental waiver

Human genetics covers the basic principles of transmission and molecular genetics and the application of genetics to human health and reproduction. Lecture topics include forensic DNA analysis, genetic testing for diseases, cancer pre-disposition, *in vitro* fertilization, pre-implantation genetics, evolutionary medicine, and epigenetics. Bioethical issues raised by the development of new genetic tests, including whole-genome sequencing are considered. Participants are required to develop educational modules that can be used in their classes.

ST 510D Vertebrate Zoology: An Introduction to Animals with Backbones, 2cr

Prerequisites: ST 523/523D or departmental waiver

Vertebrate Zoology provides an introduction to the major groups of living vertebrate animals: fishes, amphibians, reptiles, birds and mammals. Vertebrates comprise a small fraction of all the animals that now exist on Earth, but are the most familiar and attract the most interest, in part because we ourselves are vertebrates. Vertebrates are diverse and abundant, although an increasing number of species are endangered. This course includes the classification, anatomy, evolutionary relationships, ecology, behavior, geographical distribution and other aspects of the natural history of the world's living vertebrates. Special emphasis will be placed on species found in New Mexico and issues of threatened and endangered species, habitat destruction and protection.

ST 517 Environmental Studies, 2 cr

Prerequisites: ST 523/523D and ST 550/550BD; or departmental waiver

This course is a study of the interrelationships of organisms with their physical and chemical environment including the biological interactions among populations, communities, ecosystems, and pollutants.

ST 518D Water as a Resource, 2cr

Prerequisites: ST 523/523D and ST 524/524D: or departmental waiver

This asynchronous web course covers one of our most precious resources in New Mexico and beyond. This course covers interesting and timely topics such as drinking water quality and supplies, water-generated energy, water conservation, desalination, ocean currents, weather patterns, water reservoirs, the hydrologic cycle, climate change, and drought, in the same flexible online format as Renewable Energy ST577d. Students view course material in weekly modules, participate in online discussions, complete two projects, and view virtual field trips. The web format allows you to view the course material whenever you want to during that module week. The scope of this course encompasses both local and global water issues and politics plus the biology and chemistry of water systems and supplies. The goal is to give a good understanding of the way water systems work and how they are connected to the other Earth systems, and to prepare students to teach water resources in their classrooms.

ST 519 Modern Genetics, 2 cr

Prerequisites: ST 523/523D and ST 550/550BD and ST 509 (recommended); or departmental waiver

This lab course is an introduction to techniques used to study Mendelian and molecular genetics, including forensic DNA.

ST 523D Survey of Biology, 1 cr

A survey of life functions at the cellular level including the structure of organic molecules, membrane structure and function, energy metabolism, cellular reproduction, and gene action. Also includes an introduction to evolution and phylogenetic survey of the kingdoms of 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 529/529D Research and Documentation, 2 cr

Prerequisites: None

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 529/529D 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 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).

ST 537 Supercomputer Challenge, 1cr

Prerequisite: departmental waiver

Teachers will learn how to sponsor a Supercomputing Challenge team and how to help students complete an appropriate computational science project in keeping with the Challenge mission statement (described at http://www.challenge.nm.org/). The computational project incorporates four components, Project Management, Structured Programming and Design, Mathematical and Agent Based Modeling, and Internet Research and Resources This is a twelve month project and terminates with the final competition at LANL in May.

ST 540 Rockin' 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.

ST 541 Geology and Mining Engineering for Teachers I, 2 cr

Prerequisites: ST 525 and ST 550/550BD; 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 542D Timescapes: Momentous, World Altering Events, 2 cr

Prerequisites: ST 525 or departmental waiver

This course is designed for science majors interested in discovering the great events occurring over the last 4.5 billion years of Earth history. Churchill said, "History is just one thing after another," but the history of planet Earth can be viewed as having been shaped by momentous, world-altering events, millions of years apart. These will form the basis of this course. The course will meet distribution requirements for science majors.

ST 543D Forensic Geology, 2 cr

Prerequisites: ST 525 or departmental waiver

Forensic Geology is a discipline with an ever-expanding role in criminology, environment concerns, and even the war against global terror – geologists have made claims they can tell the locations of terrorist leaders by studying the rocks visible behind them in videotapes. This discipline, a specialty of the geosciences, collects and studies earth materials and their associations, including rocks, sediments, soils, water, and any man-made products that they contain, with attention toward their significance in regulatory and legal areas. The margins of Forensic Geology overlap with other sciences, including biology, chemistry, physics, anthropology, and archeology.

ST 547 Field Techniques in Geology for Teachers, 2 cr

Prerequisites: ST 525 and ST 550/550BD; 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.

ST 548 Geology of the Southwest—National Parks and Natural Resources, 2 cr

Prerequisites: ST 525 and ST 550/550BD; 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.

ST 550AD Mathematics for Teachers, 1 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 550BD Mathematics for Teachers, 1 cr

Prerequisites: ST 550AD or departmental waiver

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 550 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 551AD Concepts in Mathematics for Teachers, 1 cr

Prerequisites: ST 550/550BD or departmental waiver

The development of some of the great ideas in Mathematics through history, from the concept of number to abstract mathematics, is discussed. Students develop class projects using the covered concepts and history in their own classes.

ST 551BD Concepts in Mathematics for Teachers, 1 cr

Prerequisites: ST 551AD or departmental waiver

The development of some of the great ideas in Mathematics through history, from the concept of number to abstract mathematics, is discussed. Students develop class projects using the covered concepts and history in their own classes.

ST 552AD Calculus on a Computer, 1 cr

Prerequisites: ST 550/550BD 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 552AD 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 553 Problem Solving and Recreational Mathematics, 2 cr

Prerequisites: ST 550/550BD or departmental waiver

This course covers problem solving techniques, logic and mathematical arguments, logic puzzles, word problems in algebra, games of strategy for two players, geometrical dissections, tiling puzzles, and basic combinatorics.

ST 554 Mathematical Modeling, 2 cr

Prerequisites: ST 550/550BD; or departmental waiver

Students learn the process of going from a real world problem to a mathematical model and back to an interpretation of results. Students will work in small groups on a wide variety of applications. Projects suitable for classroom use will be developed.

ST 556 Mobile Computing and Science Teaching, 1 cr

This is a course about hot 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 557 Fractals and Chaos, 2 cr

Prerequisites: ST 550/550BD or departmental waiver

This course covers the development of the basic geometry of fractals, using both deterministic and random methods, the mathematical ideas behind chaos, the connections between the ideas of chaos and fractals, and applications.

ST 558/558D Probability and Statistics, 2 cr

Prerequisites: ST 550/550BD or 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.

ST 560 Space Science: Hazardous Asteroids, 2 cr

Prerequisites: ST 526 and ST 550/550BD; 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 561 Weather and Climate, 2cr

Prerequisites: ST 526 and ST 550/550BD; or departmental waiver

In this course, students will study the physical and chemical processes that are important for understanding weather and climate: thermodynamics and the flow of energy in the atmosphere, cloud formation and precipitation, solar and thermal radiation, the greenhouse effect, and the photochemistry of ozone.

ST 562 Radio Astronomy for Teachers, 2 cr

Prerequisites: ST 526 and ST 550/550BD; or departmental waiver

This course is an introduction to observational radio astronomy. It covers some general concepts of astronomy including electromagnetic radiation, motions of astronomical bodies, coordinate systems, as well as small radio telescope operation and data collection. The format will include lectures, field trips, hands on use of optical and radio telescopes, independent team research, documentation, and research presentations. Students must be willing to explore independently and work in teams. Class hours vary during the week to accommodate observing sessions.

ST 563 Optical Astronomy for Teachers, 2 cr

Prerequisites: ST 526 and ST 550/550BD; or departmental waiver

This course exposes the student to the techniques of optical observational astronomy. The emphasis is on correct use of digital cameras and analysis of digital images. In addition, the course covers basic aspects of finding celestial objects in the night sky. Students must be willing to explore independently and work in teams. Class hours vary during the week to accommodate observing sessions.

ST 564/564D Great Concepts in Physics, 2 cr

Prerequisites: ST 526 and ST 550/550BD; 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.

ST 565 Physics of Aviation, 2 cr

Prerequisites: ST 526 and ST 5550/550BD; 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.

ST 567 Mission to Mars, 2cr

Prerequisites: ST 526 and ST 550/550BD; or departmental waiver

The STARBASE® La Luz Academy Mars Missions Flight, for fifth graders, involves students in planning and preparing for a simulated manned mission to Mars. Teachers guide their students through a series of Base Operations (including creating a mission patch, writing a saga, learning Mars facts, and designing a life support system) in the classroom and then bring students to the culminating Link-Up Day activity in the spring. The goal of the Mars Missions Flight is to increase student interest and motivation for studying science, technology, engineering, and mathematics. Participating teachers can earn graduate credit by submitting the following items: complete lesson plans developed for implementing each of the Base Operation activities in their classroom; a list of resources used in the classroom to accomplish the required Base Operations; and a lessons-learned report based on their participation in this activity.

ST 568 AFRL La Luz Summer Teacher Institute, 1cr

Prerequisites: ST526 and ST 550/550BD; or departmental waiver

This is a hands-on, inquiry-based course that focuses on science, technology, engineering, and mathematics (STEM) activities from the AFRL La Luz Academy. Students will earn one credit hour by completing a specified team STEM project, using a systems engineering approach, during the weeklong course. Opportunities to collaborate with scientists and engineers, as well as tours of AFRL facilities, will be incorporated into the course, as available. An additional credit hour is available the following summer for those students who develop and implement STEM lesson plans as Teacher Institute Fellows during the school year and present these lesson plans at the AFRL La Luz Academy Teacher Institute Symposium.

ST 569 Optics for Teachers, 2cr

Prerequisites: ST 526 and ST 550/550BD; or departmental waiver

This course considers the characteristics and behavior of light. Drawings and a few algebraic equations provide complementary means – concrete and abstract – for predicting the position, orientation, size and type of images created in a variety of optical instruments and natural circumstances. Participants receive an Introductory Optics System kit, and individual projects and class activities insure familiarity and the ability to adapt the kit for a range of classroom levels. The study of light introduces various "action at a distance" phenomena. While this course affirms that many observed phenomena require a considerably more sophisticated model for optics, a solid grounding in geometric optics is sufficient for the design of state of the art instruments.

ST 570/570D Electricity, 1 cr

Prerequisites: ST 526 and ST 550/550BD; or departmental waiver

Electricity and Magnetism are behind almost all modern technologies. This first course in electricity covers what you would need to teach electricity and circuits for grades 6-12. We will cover forces on charges, electric fields, voltage, current, power and electrical circuits. You will be sent a lab kit so that you can demonstrate static electric effects and build and test simple circuits. This course will introduce new mathematics (vectors) to describe electric fields and you will learn to calculate fields of multiple charges. It will also review the trigonometry and fractions that were introduced in ST550, and apply them to electric forces and circuit analysis.

ST 571/571D Electromagnetism and Light, 1 cr

Prerequisites: ST 570 or departmental waiver

This follow-on course to Electricity (ST570) introduces magnetic fields and forces and how they interact with electric currents. Dipole moment and magnetic strength are also introduced. The vector cross product is used to calculate the direction of magnetic forces. The mathematics of sine waves is reviewed and then applied to understanding wavelength, frequency, refraction, interference and diffraction. Your lab kit will allow you to demonstrate image formation by lenses and diffraction of a laser, to build a simple motor, and to build a galvanometer. This course should lead to increased confidence in physics, applied math, and basic engineering skills.

ST 572D, New Mexico Science and Scientists I, II, III, 2 cr each

Prerequisites: none

New Mexico is unique in the U.S. in its concentration of scientists and in the range of science being done here. Much of the research is on the cutting edge, be it deep-space radio astronomy, New World archeology, or the newest computer chips. New Mexico scientists are at work in universities, colleges, museums, institutes, national laboratories, the state and federal government, regional entities such as the Middle Rio Grande Conservancy, and in mining and other private industries. The course will introduce students to many of these scientists in an informal, conversational setting. This course is designed for both science and non-science majors.

Section I: Earth, Mars, and Meteors
Section II: Biology and Evolution
Section III: Energy, Environment and Materials

ST 577 Renewable Energy (extensive use of field trips), 2 cr

Prerequisites: ST 524/524D and ST 526; or departmental waiver

This is a survey course that explores the state of energy use, production, economics and environmental issues by field trips, lectures and readings. Topics explored in this course include sources of energy, impacts of energy production and use, methods of production and delivery as well as environmental, economic and political issues. Field trips will allow students to see firsthand alternative energy facilities, sites where alternative energy is in use, traditional mines and power plants. Students will meet with personnel at these facilities. A goal of the course is to enable teachers to present information in their classroom from the perspective of real experience.

ST 577D Renewable Energy (web based, no field trips), 2 cr

Prerequisites: ST 524/524D and ST 526; or departmental waiver

Energy and the energy crisis and their association with non-renewable sources are covered and renewable sources and new technologies are then covered for a contrasting perspective. Weekly course modules explain fossil fuel origins, uses, and abuses, plus the renewable energy sources wind, solar, biomass, hydroelectric, ocean/tidal, and geothermal plus virtual field trips. The scope of this course encompasses both local and global energy issues and politics plus new technology and innovations. The goal is to give a good understanding of the alternatives to fossil fuel use and ways to reuse and conserve resources. Taking this course will prepare the student to teach energy generation and conservation in his or her own classroom.

ST 578D The Chemistry of Natural Products, 2cr

Prerequisites: ST 524/524D 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.

ST 579D Concepts in Chemistry: Development of Atomic Theory, 2cr
Prerequisites: ST 524/524D 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.

ST 580D Introduction to Biochemistry, 2 cr.
Prerequisites: ST 524/524D or departmental waiver

This course will consider the structure and function of the four basic classes of biomolecules. These are proteins, carbohydrates, lipids and nucleic acids. A discussion of enzyme function, membrane construction, metabolism and photosynthesis will also be included. Finally, the role of nucleic acids in protein synthesis will be considered. Special topics to be taken up are vitamins, neurotransmitters and viruses.

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.

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.

Engineering

Accreditation

The undergraduate 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, *http://www.abet.org*.

The undergraduate program in Computer Science is accredited by the Computing Accreditation Commission of ABET, *http://www.abet.org*.

Professional Examinations

Undergraduate engineering majors in Chemical, Civil, Environmental, 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 a professional engineer status. 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

Electrical Engineering

Environmental Engineering

Explosives Engineering

Materials Engineering

Mechanical Engineering

Mineral Engineering

Optical Science and Engineering

Petroleum Engineering

Polymer Science Engineering

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 103

Students will be introduced to the profession of engineering and gain fundamental engineering skills with an emphasis on engineering design and problem solving. Topics covered include: problem definition and presentation of 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 design project.

ES 111, Computer Programming for Engineers, 3 cr, 2 cl hrs, 3 lab hrs

Corequisite: MATH 131

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

Prerequisites: PHYS 121
Corequisite: MATH 231

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: ES 201
Corequisite: MATH 231

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

Prerequisite: ES 201 passed with grade C- or better; MATH 231

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

Prerequisite: ES 201 passed with grade C- or better; MATH 335

Kinematics and kinetics of particles, systems of particles, and rigid bodies; momentum and energy methods; and problem solution by computer.

ES 305, Engineering Analysis, 3 cr, 3 cl hrs

Prerequisites: ES 216, 302; MATH 335; or consent of instructor

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: Junior Standing

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 122; MATH 335

Analysis of steady state linear circuits, balanced three-phase power, transformers. Electromechanical energy conversion. Semiconductor devices and applications.

ES 347, Thermodynamics, 3 cr, 3 cl hrs

Prerequisites: CHEM 122; MATH 132
Corequisites: ES 216; PHYS 122; MATH 231

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

Prerequisite: ES 216, ES 347
Corequisite: 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

Prerequisite: ES 111 or ChE 327; PHYS 122

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)

Associate Professors Choudhury, Leclerc (Chair of the Department), Tartis
Assistant Professor Chowdhury
Adjunct Faculty Bickel, Dunston, Lee, McCoy
Visiting Professor Calvert
Laboratory Associate Price
Emeritus Professor Bretz

Degree Offered: B.S. in Chemical 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.

Undergraduate Program

Bachelor of Science in Chemical Engineering

Minimum credit hours required—136

In addition to the General Education Core Curriculum (page 88), the following courses are required:

- ChE 110 (1), 110L (1), 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 231 (4), 335 (3)

- MATE 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 & 110L (intro to chemical engineering)
- 3 ENGL 111 (college English)
- 4 MATH 131 (calculus I)
- 4 CHEM 121 & 121L (general)
- 3 Social Science
- 16 Total credit hours

Semester 2
- 3 ENGL 112 (college English II)
- 4 MATH 132 (calculus II)
- 4 CHEM 122 & 122L (general)
- 5 PHYS 121 & 121L (general)
- 16 Total credit hours

Semester 3
- 3 ChE 326 (principles of chemical engineering I)
- 4 MATH 231 (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 122 & 122L (general)
- 3 ChE 327 (principles of chemical engineering II)
- 17 Total credit hours

Semester 5
- 3 ChE 349 (ChE thermodynamics)
- 3 ChE 371 (chemical engineering analysis)
- 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 MATE 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 ChE 443 & 443L (process control & lab)
- 4 CHEM 333 & 333L (organic)
- 3 Engineering/Technical Elective
- 3 Humanities/Social Science
- 18 Total credit hours

Semester 8
- 3 ChE 462 (plant design II)
- 3 ES 302 (strength of materials)
- 3 EE 211 (circuits) or 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—19

The following courses are required:

- ChE 326 (3),
- Three of: ES 216 (3), ES 347 (3), ES 350 (3), ChE 349 (3), ChE 371 (3)
- One of: ChE 351 (3), ChE 352 (3), ChE 443 & L (2+1)
- 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)
- MATE 202 & 202L (4) or 235 & 235L (4)
- MATE 351 (3)
- Approved Technical Electives (6)

Chemical Engineering Courses:

ChE 110, Introduction to Chemical Engineering, 1 cr, 1 cl 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.

ChE 110L, Introduction to Chemical Engineering Lab, 1 cr, 1 lab hr

This 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 121
Corequisite: MATH 132
Offered fall semester

Introduction to stoichiometric computations. Calculations of energy and material balance. Elementary process analysis and reactor design. Single and multi-phase systems. (Same as METE 326)

ChE 327, Principles of Chemical Engineering II, 3 cr, 3 cl hrs

Prerequisite: ChE 326
Corequisite: MATH 231
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 231; CHEM 121, PHYS 121; ES 347 is recommended

Offered fall semester

The theory and engineering applications of the properties of mixtures, phase and chemical reaction equilibria. (Same as MATE 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

Corequisites: MATH 335, ES 350

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.

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). (Same as MATE 430)

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 MATE 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 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 MATE 314 or consent of instructor
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: MATE 202 or consent of instructor
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.

ChE 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. (Same as MATE 474.)

ChE 475, 475D, Explosives Surety, 3 cr, 3 cl hrs

Prerequisite: Upper-class standing or consent of instructor

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*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 MATE 576 with additional expectations for graduate credit.

ChE 485, Senior Seminar, 1 cr, 3 lab hrs

Prerequisite: Senior standing or consent of instructor

Offered fall semester

Student and outside speaker presentations of topics of current interest. Peer and video review of each student's work. Career planning.

ChE 491, Independent Study, hrs and crs to be arranged

Prerequisite: Consent of instructor

Individual study of chemical engineering problems of special interest.

Faculty Research Interests

Calvert—Biomaterials, 3-D Printing, Bioprinting,   Hydrogels, Gel-Based Drug Delivery, Gel Sensors

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 CO_2 Reduction

Chowdhury—Plasmonic nanomaterials, Nanoparticle-Bioparticle Interactions, Single Molecule Microscopy, Proton Transport Membranes, Plasmon Enhanced Photocatalysis

Leclerc—Catalysis, Reactor Design, Alternative Fuels, Biofineries, Hydrogen Production

Tartis—Biomedical Engineering, Targeted Drug Delivery

Civil Engineering

Professor Huang, Richardson (Chair of the Department)
Associate Professors Azarbayejani, Wilson
Assistant Professor Cook
Adjunct Faculty Ghosh, Hendrickx, Kuhn

Degree Offered: B.S. in Civil 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.

Undergraduate Program

Bachelor of Science in Civil Engineering

Minimum credit hours required—132
In addition to the General Education Core Curriculum (page 88), 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 231 (4), 283 (3), 335 (3)
- ME 220 (3), 420(3)
- Basic Science Elective— 3 credits from the following: BIOL 111, ERTH 101, ERTH 120, ERTH 130, ERTH 140, ERTH 150. 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), ERTH 440 (3), ERTH 440L (1), ERTH 441 (1), ERTH 442 (1), ERTH 443 (1), ES 347 (3), ES 350 (3)
- **Structural** (12): CE 410 (3), CE 412 (3), CE 414 (3), CE 418 (3), CE 420 (3), MATE 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 121 & 121L (general)
    3 ENGL 111 (college English)
    2 ES 110 (drafting)
    4 MATH 131 (calculus)
    3 Basic Science*
   17 Total credit hours
* Basic Science Elective from one of the following:
BIOL 111, ERTH 101, ERTH 120, ERTH 140, ERTH 150

Semester 2
    3 ENGL 112 (college English)
    3 ES 111 (computer programming)
    4 MATH 132 (calculus)
    5 PHYS 121 & 121L (general)
   15 Total credit hours

Semester 3
    4 CHEM 122 & 122L (general)
    3 ES 201 (statics)
    4 MATH 231 (calculus)
    5 PHYS 122 & 122L (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 283 (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
   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 ERTH 440 (hydrological theory and field methods)
    1 ERTH 441 (aquifer mechanics)
    1 ERTH 442 (vadose zone processes)
    1 ERTH 443 (atmospheric dynamics and rainfall processes)
    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 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 MATE 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 122

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, 302 or consent of instructor

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 method and slope–deflection; and an introduction to computer applications by means of a general purpose structural analysis program.

CE 401 – Finite Element Analysis for Civil Engineers, 3 cr, 3 cl hrs
Prerequisite: CE 302 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.

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.

CE 406, Design of Steel Structures, 3 cr, 3 cl hrs

Prerequisite: CE 302 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.

CE 407, Design of Concrete Structures, 3 cr, 3 cl hrs

Prerequisite: CE 302 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.

CE 410, Reinforced Masonry and Timber Design, 3 cr, 3 cl hrs

Prerequisite: CE 302 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).

CE 412, Advanced Design of Steel Structures, 3 cr, 3 cl hrs

Prerequisite: CE 406 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.

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).

CE 414, Advanced Design of Concrete Structures, 3 cr, 3 cl hrs

Prerequisite: CE 407 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.

CE 418, Structural Dynamics, 3 cr, 3 cl hrs

Prerequisites: Math 335 and CE 302 or consent of instructor

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 , 3 cr, 3 cl hrs

Prerequisite: Senior standing

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

New and developing areas of knowledge in civil engineering offered to augment the formal course offerings.

CE 518, Structural Dynamics, 3 cr, 3 cl hrs

Prerequisite: MATH 335 and CE 302 or consent of instructor

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.

Faculty Research Interests

Cook—Full-scale infrastructure destructive testing, bridge risk assessment (observed failures).

Ghosh—Macro behavior of composites, structural health monitoring and restoration

Hendrickx—Vadose zone hydrology, water and salt balance of natural and irrigated systems, evapotranspiration, remote sensing, soil physics, electromagnetic induction

Kuhn—Geotechnical engineering

Richardson—Biological wastewater treatment, environmental risk assessment, groundwater contamination, site remediation

Wilson—Structural vibration control, fuzzy control, earthquake engineering

Computer Science and Engineering

Professors Liebrock, Soliman
Associate Professors Mazumdar, Shin (Chair of the Department), Zheng
Assistant Professors Rezgui, Ramyaa
Instructors Chadde, Kuo, Stuteville
Adjunct Faculty Anselmo, Mukkamala, Clausen
Emeritus Faculty Stavely, Sung

Degrees Offered: B.S., M.S., and Ph.D. in Computer Science; and M.S. in Computer Science with Specialization in Information Technology

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* is accredited by the Computing Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore MD 21202-4012, telephone (410) 347-7700. 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 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 will 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.

Program Outcomes

The undergraduate academic program in Computer Science will enable our graduates to acquire by the time of their graduation:

the ability to design, implement, and test small software programs, as well as large programming projects;

knowledge of the theoretical concepts of computing;

knowledge of the fundamental principles of programming languages, systems, and machine architectures;

exposure to one or more computer science application areas;

technical communication skills in written and oral form;

the capacity to work as part of a team; and

awareness of the legal, ethical, and societal impact of developments in the field of computer science.

Undergraduate Program
Bachelor of Science in Computer Science

Minimum credit hours required—123
In addition to the General Education Core Curriculum (page 88), 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), 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;
- Each of the above courses must be completed with a grade of *C* or better.
- General Electives to complete 130 credit hours.

Sample Curriculum 1 for the **Bachelor of Science in Computer Science** *program*

Semester 1 (Fall)
4 MATH 131 (calculus)
2 CSE 101 (intro to comp science & info tech)
4 CSE 113 & 113L (introduction to programming)
3 ENGL 111 (college English)
13 Total credit hours *

Semester 2 (Spring)
4 MATH 132 (calculus)
3 CSE 122 (algorithms and data structures)
4 CHEM 121 & 121L (general chemistry I)
3 ENGL 112 (college English)
14 Total credit hours *

Semester 2.5 (Summer)
4 CHEM 122 & 122L (general chemistry II)
4 Total credit hours

Semester 3 (Fall)
3 CSE 221 (computer systems)
3 CSE 241 (foundations of computer science)
3 Humanities
5 PHYS 121 & 121L (general physics I)
3 ENGL 341 (technical writing)
17 Total credit hours

Semester 4 (Spring)
3 CSE 213 (intro to object oriented programming)
3 CSE 222 (systems programming)
3 CSE 331 (computer architecture)
5 PHYS 122 & 122L (general physics 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 of algorithms)
4 MATH 382 & 382L (probability and statistics)
3 Technical Electives
15 Total credit hours

Semester 6 (Spring)
3 CSE 326 (software engineering)
3 CSE 342 (formal languages and automata)
3 CSE 324 (principles of programming languages)
3 Technical Electives
3 Humanities
15 Total credit hours

Semester 7 (Fall)
- 3 CSE 353 (data and computer communications)
- 4 CSE 353 (data and computer communications)
- 3 CSE 382 (legal, ethical, social issues)
- 3 Humanities/Social Science
- 3 Technical Electives
- 3 Social Science
- 15 Total credit hours

Semester 8 (Spring)
- 4 CSE 423 & 423L (compiler writing)
- 6 Humanities/Social Science
- 3 Technical Electives
- 13 Total credit hours *

* In order to earn or retain the NM Lottery Scholarship, students must earn 15 credits each semester. Please see

Sample Curriculum 2 for the **Bachelor of Science in Computer Science** *program*

Semester 1(Spring)
- 4 MATH 131 (calculus)
- 4 CSE 113 & 113L (introduction to programming)
- 3 ENGL 111 (college English)
- 4 CHEM 121 & 121L (general chemistry I)
- 15 Total credit hours

Semester 1.5 (Summer)
- 4 CHEM 122 & 122L (general chemistry II)
- 4 Total credit hours

Semester 2 (Fall)
- 4 MATH 132 (calculus)
- 2 CSE 101 (introduction to comp science & info tech)
- 3 CSE 122 (algorithms and data structures)
- 5 PHYS 121 & 121L (general physics I)
- 3 ENGL 112 (college English)
- 17 Total credit hours

Semester 3 (Spring)
- 3 CSE 213 (intro to object oriented programming)
- 3 CSE 222 (systems programming)
- 3 CSE 324 (principles of programming languages)
- 5 PHYS 122 & 122L (general physics II)
- 3 Social Science
- 17 Total credit hours

Semester 4 (Fall)
- 3 CSE 221 (computer systems)
- 3 CSE 241 (foundations of computer science)
- 3 MATH 352 (basic concepts of mathematics)
- 3 ENG 341 (technical writing)
- 3 Humanities
- 15 Total credit hours

Semester 5 (Spring)
- 3 CSE 326 (software engineering)
- 3 CSE 331 (computer architecture)
- 3 CSE 342 (formal languages and automata)
- 4 MATH 382 & 382L (probability and statistics)
- 3 Social Science
- 16 Total credit hours

Semester 6 (Fall)
- 4 CSE 325 & 325L (operating systems)
- 4 CSE 344 & 344L (design and analysis of algorithms)
- 3 CSE 353 (data and computer communications)
- 3 Humanities
- 14 Total credit hours *

Semester 7 (Spring)
- 4 CSE 423 & 423L (compiler writing)
- 3 Humanities/Social Science
- 6 Technical Electives
- 13 Total credit hours *

Semester 8 (Fall)
- 3 CSE 382 (legal, ethical, social issues)
- 3 Technical Electives
- 3 Technical Electives
- 3 Humanities/Social Science
- 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: 19

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(3), and CSE 353(3).
- Each of the above courses must be completed with a grade of *C* or better.

Graduate Program
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:

1) Course work approved by the student's advisory committee fulfilling the general requirements of 27 credit hours for the master's degree must include CSE 524, 525, 544, and 546, unless already completed with a C or better. At least 18 credit hours must be in computer science courses numbered 500 or above, not including CSE 590 (Independent Study) or 591 (Thesis). Three of these hours must be CSE 585 (Graduate Seminar).

2) CSE 590: 3 credit hours.

With Thesis:

1) Course work approved by the student's advisory committee fulfilling the general requirements of 24 credit hours for the master's degree must include CSE 524, 525, 544, and 546, unless already completed with a C or better. At least 18 credit hours must be in computer science courses numbered 500 or above, not including 590 (Independent Study) or 591 (Thesis). Three of these hours must be CSE 585 (Graduate Seminar).

2) CSE 591 (Thesis): 6 credit hours.

Master of Science Degree in Computer Science with Specialization in Information Technology

Students earning a Master of Science degree in Computer Science can choose the Specialization in Information Technology. The requirements for the Specialization in Information Technology are the same as those for a Master of Science in Computer Science, except that:

Course work approved by the student's advisory committee fulfilling the general requirements of 24 credit hours (with thesis) or 27 credit hours (without thesis) for the master's degree must include CSE 524, 528, 544, and 553, unless already completed with C or better. At least 18 credit hours must be in computer science courses numbered 500 or above, not including 590 (Independent Study) or 591 (Thesis). Three of these hours must be CSE 585 (Graduate Seminar). A minimum of 9 credit hours must be in a sequence of upper-division information technology courses approved by the student's advisory committee.

There is no foreign language requirement for the Master of Science degree in Computer Science or the Master of Science degree in Computer Science with Specialization in Information Technology. The independent study or thesis topic may be selected, subject to approval from the student's advisory committee and the computer science chair (or information technology program coordinators), from any area of computer science or information technology.

Five Year Program: CS B.S./M.S. Program

Highly motivated students with strong academic records may earn a Bachelor of Science in Computer Science and a Master of Science in Computer Science within a five-year period. The BS in CS degree requires a total of 123 credit hours, while the MS in CS degree associated with this program requires a total of 30 credits hours. Three credits of 300-level or above may be shared between the graduate and undergraduate degree. Combined, a total of 150 credit hours are required to earn both degrees. Students may apply for the CS BS/MS program at the end of their 4th semester, and students admitted to the program may apply for graduate standing during their senior year. The BS in CS and MS in CS degrees will be awarded simultaneously upon completion of the MS in CS degree requirements.

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 parallel computation, information assurance, high speed networks, neural networks, software engineering, verification, genetic algorithms, databases and knowledge-base systems, and computational intelligence. 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 systems (operating systems and computer architectures), programming (programming languages, compilers, data structures, and formal semantics), and theory (automata theory, algorithms, and computational complexity). 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.

The student must pass a preliminary examination in each of the core areas. A detailed list of topics to be covered is available from the department. The student must also pass a candidacy examination in his or her specific area of specialization. See page 58 for further details.

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.

Computer Science Courses:

In the following, each prerequisite requires a grade of *C* or better.

Some courses are marked 'cannot be used towards graduation' to emphasis that they cannot be used to fulfill the requirements for the major; they *can* be used as general electives to complete 130 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.
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
Usually offered in the Fall semester.
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

Usually offered in both Fall and Spring semesters.

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

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 bask 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: CSE 101, Math 132 each with a grade of C or higher

Usually offered in the Fall semester

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 213 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 developments, 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

Co-requisite: CSE 213

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.

Software I/O buffering. Discussion of concurrent processes, including mutual exclusion, synchronization, and deadlock. Processor scheduling, memory management, and resource control. Hoare's monitors. File systems. Each student is expected to design and implement a small operating system as a substantial portion of the course grade.

CSE 326, Software Engineering, 3 cr, 3 cl hrs

Prerequisites: CSE 122, 213 each with a grade of C or higher

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, 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.

Computer design fundamentals and hardware components: instruction set design, memory hierarchies, ALU's, control units, bus architectures, input and output, system design. Performance modeling and measurement.

CSE 342, Formal Languages and Automata, 3 cr, 3 cl hrs

Prerequisite: CSE 241; MATH 352 each with a grade of C or higher

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.

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. Introduction to the theory of 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 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; design theory for relational databases. Database integrity. Physical data organization. Introduction to problems of concurrency control, recovery, security, and distributed databases. 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 Information Technology, 3 cr, 3 cl hrs

Prerequisite: CSE 326 with a grade of C or higher
Usually offered in the Fall semester

Philosophy of ethics. Social and ethical issues associated with computing and information technologies. Ethics and the responsibilities of computing professionals. Legal ramifications will be explored whenever possible. (Same as IT 382.)

CSE 391, Directed Study, cr and topics arranged

CSE 423, Compiler Writing, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: CSE 324, 326, 342, 344 each with a grade of C or higher
Corequisite: CSE 331
Usually offered in the Spring semester.

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. (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 each with a C or higher, or consent of instructor

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 with a grade of C or higher

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 254 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 each with a grade of C or higher

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

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 with a grade of C or higher and consent of instructor

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 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, Advanced Programming Languages, 3 cr, 3 cl hrs

Prerequisites: CSE 324, 344 each wit ha grade of C or higher, or consent of instructor

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, Advanced Operating Systems, 3 cr, 3 cl hrs

Prerequisites: CSE 325 and 331 with a grade of C or higher or consent of instructor

Advanced topics in operating systems such as real-time, distributed systems, fault-tolerance, parallel I/O, performance, safety-critical systems, and verification.

CSE 528, Formal Methods in Software Development, 3 cr, 3 cl hrs

Prerequisites: CSE 326, 342, and 344 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

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

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 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

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

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 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 o advanced research in access control. In addition, the protection mechanisms of general-purpose operating systems, software systems, and web applications are discussed.

CSE 565, Neural Nets, 3 cr, 3 cl hrs

Prerequisites: CSE 344; MATH 254 and 382 with a grade of C or higher, or consent of instructor

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, Soft Computing, 3 cr, 3 cl hrs

Prerequisites: MATH 254, 382; CSE 344 or equivalent with a grade of C or higher, 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. (Same as MENG 567: Smart Engineering Systems)

CSE 568, Intelligent Systems, 3 cr, 3 cl hrs

Prerequisites: MATH 254, 382; CSE 344 or equivalent with a grade of C or higher, 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. (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 protest the location, identity, and query history of mobile users. Recent developments.

CSE 572, Advanced Data Management, 3 cr, 3 cl hrs

Prerequisite: consent of instructor

Semi-structures, 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 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—Strategic Management, Decision Theory, Risk Analysis

Clausen — Software Construction, Internet via Satellite, Multimedia/Internet Technologies, Embedded Systems

Liebrock—Computer Forensics, Information Assurance, Parallel Processing, Well Posedness Analysis, Visualization

Mazumdar—Mobile and distributed databases: Integrity, Privacy, Security; Information Systems, Software Integrity

Mukkamala—Information Assurance, Digital Forensics, Knowledge Mining, Applied Soft Computing Techniques, Bioinformatics, Information and Network Security Practices

Rezgui —Cloud Computing, Service-based computing, Energy-aware cellular networks

Shin— System security, Usable Security, Applied Cryptography, Software Engineering

Soliman—Computer Networks — fiber/wireless modern technologies and protocols, Sensor Networks — modern technologies and protocols, Computer/Sensor Networks Security, Programming Languages, Neural Networks — applications in image compression, cloud computing management, and sensor networks

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

Electrical Engineering

Professors Teare, Wedeward (Dean of Engineering)
Associate Professors Arechiga, El-Osery (Chair of the Department), Erives, Jorgensen
Assistant Professor Senay
Emeritus Professor Bond
Adjunct Faculty Andrews, Elias, Helmboldt, Kassim, Mansfield, Meason, Patamia, Prager, Restaino, Wick, Wilber, 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

Upon graduation with the degree of Bachelor of Science in Electrical Engineering, students will have obtained:
- an ability to apply knowledge of mathematics, science, and engineering;
- an ability to design and conduct experiments, as well as to analyze and interpret data;
- an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
- an ability to function on multidisciplinary teams;
- an ability to identify, formulate, and solve engineering problems;
- an understanding of professional and ethical responsibility;
- an ability to communicate effectively;
- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
- a recognition of the need for, and an ability to engage in life-long learning;
- a knowledge of contemporary issues;
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

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. The laboratories are closely coupled with the lecture parts of courses and utilize modern, state-of-the-art equipment. 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. Three 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—127

In addition to the General Education Core Curriculum (page 88), the following courses are required:

- Electrical Engineering core: EE 211 (3) or ES 332 (3), EE 212 (4), EE 231 (4), EE 308 (4), EE 321 (4), EE 333 (3), EE 341 (3), EE 382 (3), EE 434 (3), EE 446 (3), EE 451 (4), EE 481 & 481L (3), EE 482 & 482L (3)

- Introduction to problem-solving and computer skills: EE 251 (3) or CSE 113 (4) or ES 111 (3)

- Introduction to Engineering: EE 101 (2) or two credit hours (100-level or above) of engineering courses not used to satisfy other requirements of the degree

- Mathematics core: MATH 231 (4), 254 (3), 335 (3), upper-level (300-level and above) mathematics elective (3)

- Electrical Engineering electives: a minimum of six credit hours from Electrical Engineering upper-level (300-level or above) courses, excluding the Electrical Engineering core classes listed above

- Engineering electives: Six hours of engineering courses numbered 200 and above. Courses from Electrical Engineering may not be used to satisfy this requirement

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 382 and 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 131 (calculus I)
    5 PHYS 121 & 121L (general physics I)
    2 EE 101 (introduction to electrical engineering)
    3 ENGL 111 (college writing)*
  14 Total credit hours **

Semester 2
    4 MATH 132 (calculus II)
    5 PHYS 122 & 122L (general physics II)
    4 CHEM 121 & 121L (general chemistry I)*
    3 EE 251 (programming)
  16 Total credit hours

Semester 3
    4 MATH 231 (calculus III)
    4 CHEM 122 & 122L (general chemistry II)*
    3 EE 211 (circuits I)
    4 EE 231 (digital electronics)
    3 ENGL 112 (college writing)*
  18 Total credit hours

Semester 4
    3 MATH 254 (linear algebra)
    3 MATH 335 (differential equations)
    4 EE 212 (circuits II)
    4 EE 308 (microcontrollers)
    3 Social Science*
  17 Total credit hours

Semester 5

    4 EE 321 analog electronics)
    3 EE 333 (electricity and magnetism)
    3 EE 341 (signals and linear systems)
    3 ENGL 341 (technical writing)*
    3 Humanities *
  16 Total credit hours

Semester 6

    3 EE 382 (introduction to design)
    3 EE 434 (electromagnetic wave transmission/radiation)
    3 EE 446 (stochastic processes and communications)
    3 Engineering Elective
    3 Social Science*
  15 Total credit hours

Semester 7

    3 EE 481 & 481L (senior design project I)
    4 EE 451 (digital signal processing)
    3 Electrical Engineering Elective
    3 Mathematics Elective (upper-level)
    3 Humanities or Social Science*
  16 Total credit hours

Semester 8

    3 EE 482 & 482L (senior design project II)
    3 Electrical Engineering Elective
    3 Engineering Elective
    3 Humanities or Social Science*
    3 Humanities*
  15 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.

** 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 211 or ES 332 (3), EE 212 (4), EE 231(4)
- Seven (7) additional credit hours of upper-level(300-level or above) Electrical Engineering courses.

Graduate Program

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 (MS thesis students).

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 55), and must include any two of the following courses:

- EE 521, Measurement and Instrumentation
- EE 531, Advanced Digital Design
- EE 544, Modern Control Systems
- EE 554, Embedded Control Systems
- EE 570, Advanced Topics in Electrical Engineering

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.

A five-year B.S./M.S. Electrical Engineering degree can be achieved by fulfilling the requirements of both the B.S. degree and M.S. degree with independent study in Electrical Engineering. Three credits of 300-level or above may be applied to both degrees. Students in the Electrical Engineering five-year program will normally apply for graduate standing at the end of their seventh semester. Graduate status will be granted upon fulfillment of the requirements for the B.S. degree.

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

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. Upon completion of the program, students shall exhibit:

a) an ability to apply methods of advanced analysis appropriate for professionals to use when solving problems;

b) an ability to apply in-depth knowledge in the area of cyber electronic systems that supports the use of innovative techniques to solve problems;

c) 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.

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)

     - EE 560, Electronic Warfare
     - 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 and 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.

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.

EE 101, Introduction to Electrical Engineering 2 cr, 1 cl hr, 3 lab hrs

Corequisite: MATH 103

Normally offered fall and spring semesters

A broad overview of electrical engineering, including an introduction to analog and digital circuitry. Practical exercises using the EE department's computer-based applications software and lab equipment.

EE 211, Circuits and Signals I, 3 cr, 3 cl hrs

Prerequisites: MATH 132

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 231, Digital Electronics, 4 cr, 3 cl hrs, 3 lab hrs

Corequisites: EE 251 or CSE 113 or ES 111

Normally offered fall semester

Foundation of combinational digital system analysis and design; including Boolean algebra, logic gates, and truth tables. Sequential digital design via finite state machines. Lab provides exposure to computer-aided design software and programmable logic hardware.

EE 251, Mathematical Engineering, 3 cr, 3 cl hrs

Corequisite: MATH 131

Normally offered fall semester

Standard programming languages in engineering are applied to data acquisition, data analysis, and mathematical modeling and computations. Fundamental concepts in Matlab and C are used to develop programming skills and techniques by addressing problems related to electrical engineering.

EE 308, Microcontrollers, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: EE 251 or CSE 113 or ES 111

Normally offered spring semester

Introduction to microcontrollers. Elementary assembly- and C-language programming, bus structures, parallel and serial interfaces, support devices. Use of logic analyzers and disassemblers in circuit testing. Use of microcontrollers in measurement and control applications.

EE 321, Analog Electronics, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisite: EE 212

Normally offered fall semester

Basic principles and use of operational amplifiers, diodes, field-effect transistors, and bipolar junction transistors in electronic circuits.

EE 324, Semiconductor Theory and Devices, 3 cr, 3 cl hrs

Prerequisite: PHYS 122

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 333, Electricity and Magnetism, 3 cr, 3 cl hrs

Prerequisite: PHYS 122 and MATH 231

Normally offered fall semester

Introduction to Maxwell's equations in free space. Calculation of electric and magnetic fields produced by simple current and charge sources. The effects of materials on Maxwell's equations. Energy storage as a function of field quantities and the relation of this to capacitance and 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.

EE 341, Signals and Linear Systems, 3 cr, 3 cl hrs

Prerequisites: EE 212 and MATH 335

Normally offered fall semester

Principles of linear time-invariant systems. Dynamic systems, Laplace transforms, z-transforms, sampling theory, system functions, poles and zeros, frequency domain, Fourier Transforms, feedback systems, convolution.

EE 352, Microcomputer Interfacing, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: EE 308

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 382, Introduction to Design, 3 cr

Prerequisites: EE 231, 308, 321, and have declared electrical engineering as a major

Normally offered spring semester

A course in design methodology as applied to a particular problem in electrical engineering. For a given project, students will integrate their formal course work with the use of computer-aided tools to design, construct, evaluate, and document a prototype system.

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 422, Advanced Electronics, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: EE 321 and EE 341

Advanced electronics theory with applications. Topics may include linear and switching power supplies, current feedback op-amps, electronic noise and interference ,timers and oscilators, feedback systems and phase-locked loops, and active filters.

EE 424, Mixed Signal Electronics, 3 cr, 3 cl hrs

Prerequisite: EE 231 and EE 321

Applications of analog and digital electronics focused on the integration of FPGA, microcontroller and sensor systems. The emphasis will be on sensor fusion in embedded systems using decision matrix and feedback control. Sensor systems will include mechanical, electrical and optical systems commonly encountered in structural health monitoring, electronic warfare and countermeasure systems.

EE 434, Electromagnetic Wave Transmission and Radiation, 3 cr, 3 cl hrs

Prerequisite: EE 333

Normally offered spring semester

Transient and sinusoidal steady state solutions of uniform transmission line problems modeled in terms of circuit parameters. The propagation characteristics of metallic and dielectric waveguides. Radiation from linear wire antennas along with large and small aperture radiators. Radiation patterns of antenna arrays. Analysis of simple communication links.

EE 435L, RF and Microwave Laboratory, 1 cr, 3 lab hrs

Corequisite: EE 434

Experiments in radio frequency and microwave techniques and measurements.

EE 443, Intermediate Control Theory, 3 cr, 3 cl hrs

Prerequisite: EE 341

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 446, Stochastic Processes and Communications, 3 cr, 3 cl hrs

Prerequisite: EE 341

Principles of communication theory. Modulation techniques, random signals and noise, analysis of communication systems in presence of noise, digital communication, matched filters, channel capacity, multiple access.

EE 451, Digital Signal Processing, 4 cr, 3 cl hrs, 3 lab hrs

Prerequisites: EE 308 and EE 341
Normally offered fall semester

Principles of digital signal processing. Infinite and finite impulse response filters, discrete and fast Fourier transforms, multirate processing, spectral estimation, quantization effects, system design. Implementation of real-time DSP algorithms on state-of-the-art hardware. Principles discussed in class will be demonstrated with real applications. Labs include design and implementation of infinite and finite impulse response filters, and applications such as communication systems, sound processing, and image processing.

EE 481, 481L, Senior Design Project I, 3 cr

Prerequisites: EE 382, 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. Each team may undertake a different project and will build a team, determine design requirements, perform detailed planning, identify project needs and establish goals leading toward the successful completion of the project. Periodic design reviews and reports, applications of engineering skills, project management and formal presentations are major components of the program. Successful completion of the project requires the application of electronics, applied physics, numerical computation, signal processing and other electrical engineering techniques to real-world engineering problems.

EE 482, 482L, Senior Design Project II, 3 cr

Prerequisites: EE 481, and have declared electrical engineering as a major
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, 481L to maintain project continuity. The student teams bring their design projects to successful conclusion. Status reports, a final presentation to faculty and reviewers and the submission of a senior thesis are included in the program.

EE 491, Special Topics, hrs and crs to be arranged

EE 500, Directed Research, cr to be arranged

Prerequisite: Graduate standing

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: EE 308, 322, 341 or equivalent or consent of instructor

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: EE 231 or equivalent or consent of instructor

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

Prerequisites: EE 324, 434 or equivalent or consent of instructor

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

Prerequisites: Graduate standing; EE 434; or consent of instructor

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

Prerequisites: EE 443; MATH 454; or equivalent or consent of instructor

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: EE 446 or equivalent or consent of instructor

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: EE 545 or consent of instructor

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: EE 443 or equivalent or consent of instructor

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.

EE 551, Discrete-Time Signal Processing, Filtering, and Estimation, 3 cr, 3 cl hrs

Prerequisites: EE 451; MATH 254, 382; or consent of instructor

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

Prerequisites: EE 451; MATH 254, 382; or consent of instructor

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

Prerequisites: EE 308, 443 or equivalent or consent of instructor

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

Explores the various aspects of Electronic Warfare (EW) from the standpoint of both the user and the attacker. The course begins wit ha 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: EE 434 or equivalent or consent of instructor

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

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: EE 446 or equivalent courses or consent of instructor

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: EE 333 or equivalent or consent of instructor

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

Andrews—Optoelectronics, Experimental Adaptive Optics, Imaging Systems

Arechiga—Speech Processing, Thunderstorms

Bond—Design for Test/Manufacturability, Teaching Effectiveness

Elias—Ionospheric Research, Optical Interferometry, Astronomical Photon Orbital Angular Momentum

El-Osery—Wireless Communications, Control Systems, Soft Computing

Erives—Hyperspectral Imaging, Sound Processing, Embedded Control Systems

Helmboldt—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

Mansfield—Communications, Radio Frequency (RF) Systems

Meason—Nuclear, Electromagnetic and Space Radiation Effects, Directed Energy

Patamia—Analytical and Numerical Modeling, Space Elevators

Prager—Semiconductors

Restaino—Adaptive Optics, Novel Optical Systems

Senay—Communications, Signal Processing, Control Systems

Teare—Adaptive Optics, Smart Sensors, Ballistics, Energetic Materials

Wedeward—Control Systems, Robotic Systems, Electric Power Systems

Wick—Experimental Adaptive and Active Optics

Wilber—Electronic Countermeasures, Energetic Materials

Xiao—Photonic/Fiber Sensors

Engineering Management

Professor Sueyoshi
Associate Professor Anselmo, Reinow (Chair of the Department)
Assistant Professor Yuan
Adjunct Faculty Mazumdar, Peterson

Degree offered: Master of Engineering Management

The New Mexico Tech Master of Engineering Management (MEM) graduate program is designed to provide working engineers and applied scientists with a terminal degree in Engineering Management. The curriculum is designed to be innovative and deliverable both on campus and in other areas of New Mexico live via interactive webcasts and everywhere else via Internet streaming. Qualified students at any location may enroll and receive the program through the Internet and/or mailed copies of lectures and course materials. New Mexico Tech developed the Engineering Management program since most engineers eventually have the opportunity to become managers, and many undergraduate engineering and applied science programs do very little to prepare their graduates for that career event.

Graduate Program

Master of Engineering Management (MEM)

Admission to the Program

Entrance into the MEM program in the New Mexico Tech Management Department requires competence in engineering, science and mathematics comparable to a calculus-based bachelor of science degree in an engineering or applied science discipline. Preference for limited program slots will be given to individuals with at least 2 years work experience in either engineering or applied science. A committee of New Mexico Tech Management and Engineering faculty will evaluate program applicants, and the Management Department chair will review and finalize committee recommendations. Each student is responsible for forming a graduate committee during the first semester of full-time study or before the end of the second semester of part-time coursework.

For complete information on applying to the MEM Program, see page 46.

Graduate Advisory Committee

Participants will form a three-member committee that will be composed of at least one New Mexico Tech faculty member and two other qualified individuals. Examples of qualified individuals include faculty members at New Mexico Tech, faculty members at other higher-education institutions, workplace supervisors, and/or professional peers. In the case where there is only one committee member from the New Mexico Tech faculty, that individual will serve as committee chair. If there are more than one New Mexico Tech faculty members on the student's project committee, the student will select a chair.

The primary roles of the committee will be to assist the student in selection of an elective sequence and to advise and approve the required final project.

Program Requirements

A total of 30 credit hours, including the following courses, is required for the MEM degree:
- Core (21): EMGT 501 (3), 502 (3), 503 (3), 505 (3), 506(3), 507 (3); EMGT 504 (3) or MATH 585 (3)
- Electives (6): Example sequences are EMGT 511 (3) and 512 (3) or EMGT 521 (3) and 522 (3). Other sequences are possible and should be selected in consultation with the student's academic advisor.
- EMGT 590 (3)

The purpose of the core is to provide foundations in quantitative and qualitative methods that will assist the practicing (or aspiring-to-practice) engineer in a changing technological and economic environment. The core is designed for engineers and is grounded in the notion that program participants possess the analytical skills associated with a calculus -based undergraduate bachelor of science in engineering.

The minimum of six (6) hours of electives will assist program participants to gain expertise in an area of interest and relevance to their careers. These two courses should be taken as a sequence, and participants may select their sequence after consulting with their faculty advisor(s). The elective sequence may be any approved graduate elective sequence from graduate coursework offered at New Mexico Tech. Students considering elective sequences from other graduate institutions may do in consultation with their New Mexico Tech graduate committee.

The terminal MEM requirement is a final project, culminating in a formal document and presentation to the faculty that is analogous to the Independent Study option currently available to graduate students at New Mexico Tech. Participants will benefit from designing, supervising, and executing a project that will ideally be a workplace application. This experience will aid them throughout their careers as they are faced with the need to resolve critical strategic questions and implement recommended solutions.

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, Organizational Entrepreneurship (Capstone), 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 511, 511D, Financial Modeling, 3 cr, 3 cl hrs

Prerequisites: EMGT 502 and three other courses from EMGT 501-507 or consent of instructor

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

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 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

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

Peterson—Management, Economics, Accounting

Reinow - Strategic Management, Leadership

Sueyoshi—Management Science, Data Envelopment Analysis, Risk and Policy Analysis

Yuan - Finance and Economics

Environmental Engineering

Professors Huang, Richardson (Chair of Department)
Associate Professor Carrico
Adjunct Faculty Brady, Hendrickx

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.

Undergraduate Program
Bachelor of Science in Environmental Engineering

Minimum Hours Required—132

In addition to the General Education Core Curriculum (page 88), the following courses are required:

*   MATH 231 (4), 283 (3), 335 (3)
*   BIOL 111 (3), 111L (1), 343 (3)
*   ERTH 440 (3), ERTH 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; ERTH 441, 442, 443; ChE 351, 352, 443; CHEM 333, 422; EE 211; ES 305, 332; MATE 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 111 (college English)
 4 BIOL 111 & 111L (general)
 4 CHEM 121 & 121L (general)
 4 MATH 131 (calculus)
 2 ES 110 (intro to engineering)
 18 Total credits

Semester 2
 3 ENGL 112 (college English)
 3 ES 111 (computer programming for engineers)
 4 MATH 132 (calculus)
 4 CHEM 122 & 122L (general)
 3 Social Science
 17 Total credit hours

Semester 3
 4 MATH 231 (calculus)
 5 PHYS 121 & 121L (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 122 & 122L (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 283 (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 ERTH 440 & 441L (hydrologic theory/field methods)
 3 ME 420 Soil Mechanics
 16 Total credits

Semester 8
 3 ENVE 406 (unit operations)
 2 ENVE 490 (senior design thesis II)
 3 Approved Technical Elective
 3 Social Science
 3 Humanities/Social Science
 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.

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 ERTH 440

Graduate Programs

Master of Science in Environmental Engineering

The Environmental Engineering graduate program at New Mexico Tech provides a unique educational and research experience in the engineering and science of the natural 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 Environmental Engineering program requires competence in mathematics, chemistry, biology, physics, and engineering science comparable to the Bachelor of Science in 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 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.

Thesis Option

A total of 30 credit hours are required for a M.S. in Environmental Engineering, which must include a minimum of 18 credit hours of Environmental Engineering coursework, and 6 credit hours of ENVE 591 (thesis). All students must take a minimum of 12 credit hours of 500-level 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 (ENVE 590).   All students must take a minimum of 12 credit hours of 500-level Environmental Engineering courses, and an additional 6 credits of 400- or 500-level 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 Environmental Engineering degree program with the exception of 6 credit hours of thesis (ENVE 591).

Five Year Bachelor's/Master's Degree Program

A five-year B.S. /M.S. Environmental Engineering degree can be achieved by fulfilling the separate requirements of both the undergraduate degree and graduate degree. A combined minimum of 159 credit hours is required for the dual degree with at least 12 credit hours of 500-level ENVE courses and 6 credit hours of Thesis (ENVE 591). Students in the five-year program are also required to take ENVE 581 (summer). A B.S. degree in Environmental Engineering will be granted after the five-year student has completed the 132 credit-hour undergraduate requirement. 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 below.

Summer
   3 ENVE 581

Semester 7
   4 ENVE 411
   4 ENVE 413
   4 ERTH 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 ENVE 591

Semester 9
   3 ENVE 501
   3 ENVE 503
   3 ENVE 512
   3 ENVE 591
  12 Total credit hours

Semester 10
   3 ENVE 520
   3 Elective
   3 Elective
   3 ENVE 591 (optional)
  12 Total credit hours

Summer
   3 ENVE 591 (optional)

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 122 & 122L; BIOL 111 & 111L; MATH 132

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

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
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

Corequisites: ENVE 303 or 304 or consent of instructor

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

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, 3 lab hrs

Prerequisites: ES 216 and 350; or consent of instructor

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 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

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
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 time-line schedule posted by the department. The investigative component integrates knowledge and skills gained in previous and concurrent courses.

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, literature 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.

ENVE 491, Special Topics in Environmental Engineering, 3 cr, 3 cl hrs
Prerequisite: Senior standing or consent of instructor

ENVE 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.

ENVE 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.

ENVE 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.

ENVE 511, Water Quality Management and Control, 3 cr, 3 cl hrs
Prerequisite: MATH 335 or consent of instructor
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.

ENVE 512, Industrial Water and Wastewater Treatment, 3 cr, 3 cl hrs
Prerequisites: ENVE 303, 304, 501; or consent of instructor
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.

ENVE 513, Air Resources Engineering, 4 cr, 3 cl, 3 lab hrs
Prerequisites: ES 216 and 350; or consent of instructor
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.

ENVE 520, Hazardous Waste Site Remediation, 3 cr, 3 cl hrs
Prerequisites: ENVE 411, 501; or consent of instructor
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.

ENVE 521, Green Engineering, 3 cr, 3 cl hrs
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 421, with additional expectations for graduate credit.

ENVE 522, Geotechnical Waste Containment Design, 3 cr, 3 cl hrs

Prerequisite: ME 420 or consent of instructor

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.

ENVE 523, Open Channel Hydraulics, 3 cr, 3 cl hrs

Prerequisite: ES 216 or consent of instructor

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.

ENVE 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.

ENVE 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.

ENVE 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.

ENVE 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

ENVE 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 (Co-Chair of the Department), Fuierer, Kalugin, Majumdar, McCoy (Co-Chair of the Department)
Associate Professor Henneke
Assistant Professor C. Hargather
Professors with Joint Appointments in Chemical Engineering Choudhury, Chowdhury, Leclerc, Tartis
Adjunct Faculty Chambers, Curro, Donley, Hirschfeld, Jacobson, Kropka, Lowe, Prasad, Ravi, 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. and Ph.D. in Materials Engineering

Web site: http://infohost.nmt.edu/~mtls/

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 related fields;
2) Advance in their chosen profession; and
3) Engage in appropriate professional societies and in continuing education activities

Undergraduate Program *(ABET Accredited)*

Advanced technologies often initiate with innovations in new materials, such as in the electronic or aerospace industries. These material innovations rest on a fundamental understanding of how the internal structure of a material influences properties at different length scales, ranging from sub-atomic, to nano, to micro, and ultimately macro-scale. 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 attempts to provide these 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 which continue 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, nanomaterials, 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 Core Curriculum (page 88), the following courses are required:

- MATH 231 (4), 335 (3)
- ES 110 (2), 111 (3), 201 (3), 302 (3), 332 (3) or EE 211 (3)
- MATE 101L (1), 202 & 202L (4), 235 & 235L (4), 301 (3), 310 (3), 311 (3), 314 (3), 350 (3), 351 (3), 410 (3), 445 (3), 481 (3), 482 (3)
- METE 327 (3)
- Advanced basic science (3): CHEM 311, 331, 333 or MATE 452 are recommended; advisor approval is required.
- Technical electives (12): Approved upper level MATE and METE 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 MATE 101L (Intro. Materials Lab)
3 ENGL 111 (College English 1)
4 MATH 131 (Calculus 1)
4 CHEM 121 & 121L (General Chemistry 1)
3 Social Science
2 ES 110 (Intro. to Engineering)
17 Total credit hours

Semester 2
3 ENGL 112 (College English 2)
4 MATH 132 (Calculus 2)
4 CHEM 122 & 122L (General Chemistry 2)
3 ES 111 (Computer Programming)
3 Humanities
17 Total credit hours

Semester 3
4 MATE 202 & 202L (General Materials 1)
4 MATH 231 (Calculus 3)
5 PHYS 121 & 121L (General Physics 1)
3 Humanities
16 Total credit hours

Semester 4
3 MATH 335 (Applied Analysis)
5 PHYS 122 & 122L (General Physics 2)
4 MATE 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 MATE 301 (Ceramics)
3 MATE 350 (Materials Thermodynamics)
3 MATE 310 (Processing and Microstructure)
15 Total credit hours

Semester 6
3 ENGL 341 (Technical Writing)
3 ES 332 or EE 211 (Electrical Engineering)
3 METE 327 (Physical Metallurgy)
3 MATE 351 (Polymers)
3 MATE 314 (Transport Processes)
3 MATE 311 (Thermal and Mechanical Properties)
18 Total credit hours

Semester 7
3 Technical Elective*
3 Technical Elective*
3 MATE 445 (Composites)
3 MATE 481 (Senior Design 1)
3 MATE 410 (Microstructural Characterization)
15 Total credit hours

Semester 8
3 Technical Elective*
3 Technical Elective*
3 Advanced Basic Science Elective*
3 MATE 482 (Senior Design 2)
3 Humanities/Social Science
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 Core Curriculum (page 88), the following courses are required:

- MATH 231 (4), 335 (3)
- ES 110 (2), 111 (3), 201 (3), 302 (3), 332 (3) or EE 211 (3)
- MATE 101L (1), 202 & 202L (4), 235 & 235L (4), 310 (3), 311 (3), 314 (3), 350 (3), 410 (3), 435 (3), 481 (3), 482 (3)
- METE 327 (3)
- Two of the following: MATE 301 (3), MATE 351 (3), MATE 445(3)
- Advanced basic science (3): MATE 452 is recommended.
- Technical electives (12): Approved upper level MATE and METE 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 MATE 101L (Intro. Materials Lab)
3 ENGL 111 (College English 1)
4 MATH 131 (Calculus 1)
4 CHEM 121 & 121L (Chemistry 1)
3 Social Science
17 Total credit hours

Semester 2
3 ENGL 112 (College English 2)
4 MATH 132 (Calculus 2)
4 CHEM 122 & 122L (Chemistry 2)
3 ES 111 (Computer Programming)
3 Humanities
17 Total credit hours

Semester 3
4 MATE 202 & 202L (Materials 1)
4 MATH 231 (Calculus 3)
5 PHYS 121 & 121L (Physics 1)
3 Humanities
16 Total credit hours

Semester 4
3 MATH 335 (Applied Analysis)
5 PHYS 122 & 122L (Physics 2)
4 MATE 235 & 235L (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 MATE 350 (Materials Thermodynamics)
3 MATE 310 (Processing and Microstructure)
3 MATE 301 or MATE 445 **
15 Total credit hours

Semester 6
3 MATE 311 (Thermal and Mechanical Properties)
3 MATE 314 (Transport Processes)
3 MATE 351 (Polymers)**
3 METE 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 MATE 481 (Senior Design 1)
3 MATE 410 (Microstructural Characterization)
3 Humanities/Social Science
15 Total credit hours

Semester 8
3 Technical Elective*
3 Technical Elective*
3 Advanced Basic Science Elective*
3 MATE 482 (Senior Design 2)
3 MATE 435 (Mechanical Behavior)
15 Total credit hours

* Electives must be approved by the student's advisor.

** Two of the following: MATE 301 (Ceramics) (3), MATE 351 (Polymers) (3), or MATE 445 (Composites)(3)

Bachelor of Science Degree in Materials Engineering with Biomaterials Engineering Option

Minimum credit hours required—130

In addition to the General Education Core Curriculum (page 88), the following courses are required:

- MATH 231 (4), 335 (3)
- ES 110 (2), 111 (3), 201 (3), 302 (3), 332 (3) or EE 211 (3)
- MATE 101L (1), 202 & 202L (4), 235 & 235L (4), 301 (3), 314 (3), 350 (3), 351 (3), 481 (3), 482 (3)
- METE 327 (3)
- Two of the following: MATE 310 (3), 311 (3), 410(3)
- BIOL 111, 111L (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); MATE 445 (3), 470 (3); MATH 283 (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 MATE 101L (Intro. Materials Lab)
        3 ENGL 111 (College English 1)
        4 MATH 131 (Calculus 1)
        4 CHEM 121 & 121L (Chemistry 1)
        3 Social Science
        2 ES 110 (Intro. to Engineering)
    17 Total credit hours

Semester 2
        3 ENGL 112 (College English 2)
        4 MATH 132 (Calculus 2)
        4 CHEM 122 & 122L (Chemistry 2)
        3 ES 111 (Computer Programming)
        3 Social Science
    17 Total credit hours

Semester 3
        4 MATE 202 & 202L (Materials 1)
        4 MATH 231 (Calculus 3)
        5 PHYS 121 & 121L (Physics 1)
        4 BIOL 111 & 111L (Biology 1)
    17 Total credit hours

Semester 4
        3 MATH 335 (Applied Analysis)
        5 PHYS 122 & 122L (Physics 2)
        4 MATE 235 & 235L (Materials 2)
        3 ES 201 (Statics)
        3 Humanities
    18 Total credit hours

Semester 5
        3 METE 327 (Metals)
        3 BIOL 331 (Cell Biology)
        3 ES 302 (Mechanics of Materials)
        3 MATE 350 (Materials Thermodynamics)
        3 Program-Specific Elective*
    15 Total credit hours

Semester 6
        3 MATE 311 (Thermal and Mechanical Properties)
        3 MATE 314 (Transport Processes)
        3 METE 326 (Process Metallurgy)
        3 METE 327 (Physical Metallurgy)
        3 ES 332 or EE 211 (Electrical Engineering)
        3 ENGL 341 (Technical Writing)
        3 Humanities
    18 Total credit hours

Semester 7
        3 Technical Elective*
        3 Social Science/Humanities
        3 Social Science/Humanities
        3 MATE 481 (Senior Design 1)
        3 MATE 410 (Microstructural Characterization)
    15 Total credit hours

Semester 8
        4 BIOL 333, 333L (Molecular Biology)
        3 Technical Elective*
        3 MATE 482 (Senior Design 2)
        3 Social Science/Humanities
    13 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:

•MATE 202 and MATE 235 (6+).
• 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)
- •MATE 202 & 202L (4) or 235 & 235L (4)
- •MATE 351 (3)
- •Approved Technical Electives (6)

Graduate Programs

Graduate students in the M.S. program, Ph.D. program, or five-year B.S./M.S. program must take MATE 592 each semester offered. The student may appeal to their advisory committee for possible exception.

Master of Science in Materials Engineering

Thesis Option

The Thesis 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:

a)   At least 24 credit hours of course work that must include: (i) a minimum of 12 credit hours of 500 level courses, and (ii) at least 6 hours of upper level (300+) courses outside the Materials Department, unless the student is from a non-Materials background. No more than 3 hours of MATE 581 Directed Study.

b)   6 credit hours of MATE 591 (Thesis) that will be defended in a public oral defense. Students may take MATE 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 (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.

Independent Study Option

A student may petition the department with the approval of the faculty to pursue a Master of Science degree with an Independent Study Option. The selection of committee members and the research topic must follow the same requirements as those for the Master's Thesis Option.

The Course Requirements include:

a)   At least 27 credit hours of course work that must include: (i) a minimum of 15 credit hours of 500 level courses and (ii) at least 6 hours of upper level (300+) courses outside the Materials Department, unless the student is from a non-materials background.

b)   3 credit hours of MATE 590 (Independent Study) that will be defended in a public oral defense. Students may take MATE 500 (Directed Research) in multiple semesters but the credits will not count towards their degree requirements.

Courses must be approved by the advisory committee. Students must inform faculty advisors in advance regarding courses that they plan to take in the following semester. The MATE 592 requirements as stated in the Master's Thesis Option will also be applicable here.

Students are required to write an 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 Independent Study 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.

Combined Five Year Bachelor of Science/Master of Science Degree Program

The combined degrees of a MS in Materials Engineering (either Thesis or Independent Study Option) along with a BS in Materials Engineering or affiliated field may be achieved in five years. For students in MATE or METE BS programs, a minimum of 158 credit hours are required to complete the combined (BS+MS) degree. For students in affiliated BS programs, there are commensurate requirements. Students must fulfill all the requirements for their BS program and, depending upon their selection of a Thesis or Independent Study Option, complete the following additional requirements:

- **Thesis Option:** (i) A minimum of 12 credit hours of 500 level courses; (ii) 9 additional credit hours of upper or 500 level courses that may include no more than 3 credit hours of MATE 491 (directed study), (iii) 6 credit hours of MATE 591 (Thesis) that will be defended in a public oral defense.
- **Independent Study Option:** (i) A minimum of 15 credit hours of 500 level courses, (ii) 9 additional hours of upper or 500 level courses that may include no more than 3 credit hours of MATE 491 (Directed Study), (iii) 3 credit hours of MATE 590 (Independent Study) that will be defended in a public oral defense.

Students graduating with a BS in Materials Engineering must include a minimum of 6 credit hours of approved upper-division or graduate course work from other departments in the above list, as part of the general breadth requirements for the MS degree. The breadth requirement may be waived for non-materials students, but they are highly encouraged to take all courses towards their MS degree in Materials Engineering. The student must select courses in close consultation with the MS advising committee and research work should be directed towards a publication. Students for the 5-year program must apply for graduate standing, normally in their 6th semester. Admission is contingent upon their having a 3.0 GPA and the acceptance of their proposed course of study. Students with upper division standing may apply, but admittance into the program will be conditional. Graduate admission will be contingent upon adherence to the approved programs of study and a 3.0 minimum overall cumulative GPA. Graduate status will be granted upon fulfillment of the requirements for the BS degree.

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 MATE 581 Directed Study may be used for fulfilling the course requirements. Students may take MATE 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 MATE 595 Dissertation during which the student completes the research project approved by the advisory committee. The student cannot start taking MATE 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:

MATE 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 domains, (explosive) welding, and composite design. Course provides a glossary of terms and concepts used in the field of materials science and engineering.

MATE 202, Materials Engineering I, 3 cr, 3 cl hrs
Corequisite: CHEM 122
> Application of the student's background in physical sciences, mathematics, and computer science to the solution of elementary problems in the materials sciences. Introduction to metallurgical techniques and the science of materials. Elementary design problems involving the optimum use of materials.

MATE 202L Materials Engineering I Laboratory, 1 cr, 3 lab hrs
Corequisite: MATE 202
> Laboratory experiments addressing elementary design problems involving optimal use of materials. Designed to reinforce principles discussed in Mate 202.

MATE 235 Materials Engineering II, 3 cr, 3 cl hrs
Prerequisites: CHEM 122 and 122L
Corequisite: Phys 122 & 122L
> 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 Mate 235L concurrently.

MATE 235L Materials Engineering II Laboratory, 1 cr, 3 lab hrs

Prerequisites: CHEM 122 and 122L

Corequisites: MATE 235

Laboratory experiments introducing the fabrication of technical materials and the measurement of their properties. Designed to reinforce principles discussed in Mate 235.

MATE 301, Introduction to Ceramic Engineering, 3 cr, 3 cl hrs

Prerequisites: MATE 235; or consent of instructor

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.

MATE 310 Processing and Microstructure Methods and Analysis 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: MATE 202, MATE 235; or consent of instructor

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.

MATE 311 Thermal and Mechanical Methods and Analysis 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: MATE 202, MATE 235, ES 302; or consent of instructor

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.

MATE 314, Transport Processes, 3 cr, 3 cl hrs

Prerequisites: MATH 131, MATH 132; PHYS 121

Introduction to the concepts of fluid dynamics and mass and heat transfer.

MATE 350, Materials Thermodynamics, 3 cr, 3 cl hrs

Prerequisite: MATH 231, CHEM 121, PHYS 121. (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)

MATE 351, Introduction to Polymeric Materials, 3 cr, 3 cl hrs

Prerequisites: MATE 202 or MATE 235, MATH 231 or MATH 335

Basic concepts of polymer science; polymerization reactions and mechanisms, as well as kinetics involved; polymer solutions, molecular-weight determinations, analysis and testing of polymers; structural properties of polymers; properties of commercial polymers; processing of polymers.

MATE 402, Physical Ceramics, 3 cr, 3 cl hrs

Prerequisite: MATE 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.

MATE 410 Microstructural Characterization Methods and Analysis 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: PHYS122, MATE 202, MATE 235 or consent of instructor

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.

MATE 420 Biomedical Materials, 3 cr, 3 cl hrs

Prerequisite: MATE 202 or MATE 235 or consent of instructor

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. Students taking the graduate-level course will write an additional report proposing a new solution to an unsolved surgical problem. Shares lecture with MATE 520, with additional expectations for graduate credit.

MATE 430, 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 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). (Same as ChE 463)

MATE 431, 431D, Fundamentals in Manufacturing Processes of Materials I, 3 cr, 3 cl hrs

Prerequisites: MATE 202; ES 302; and senior standing or consent of instructor

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.

MATE 435, Mechanical Behavior of Materials, 3 cr, 3 cl hrs

Prerequisite: MATE 202 or consent of instructor

Elasticity and plasticity; flow criteria. Strengthening mechanisms. Deformation processes. Mechanical testing of materials: tensile, hardness, fatigue, fracture, formability.

MATE 441, 441L, X-Ray Diffraction, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: PHYS 122, MATE 202 or MATE 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.

MATE 442, Solid State Diffusion, 3 cr, 3 cl hrs

Prerequisite: MATE 314 or ES 314

Development of the diffusion equations in solids and their solutions by analytical and numerical methods. Diffusion theory and mechanisms. Diffusion phenomena in semiconductors, metals, alloys, ionic crystals, and oxides. Thermodynamic, point-defect and defect reactions, and impurity effects. High-diffusivity paths; Electromigration (EM) in metallic films and EM measurement. Review of experimental techniques.

MATE 443, Magnetic Materials, 3 cr, 3 cl hrs

Prerequisite: MATE 235 or consent of instructor

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.

MATE 445, 445D, Introduction to Composite Materials, 3 cr, 3 cl hrs

Prerequisites: ES 302 or consent of instructor

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.

MATE 446, 446D, Computer Simulation in Materials Science, 3 cr, 3 cl hrs

Prerequisite: MATH 231

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.

MATE 447, Optical Materials, 3 cr, 3 cl hrs

Prerequisite: MATE 235 or consent of instructor

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.

MATE 452, 452D, Solid State Physics for Engineers, 3 cr, 3 cl hrs

Prerequisite: Senior standing or consent of instructor

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 opto-electronic devices.

MATE 452L, Electronic Materials Laboratory, 1 cr, 3 lab hrs

Prerequisites: MATE 235, 235L, or consent of instructor

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.

MATE 460, Failure Analysis, 3 cr, 3 cl hrs

Prerequisite: ES 302

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.

MATE 466, 466D, Interfacial Phenomena, 3 cr, 3 cl hrs

Prerequisite: MATE 350 or equivalent or consent of instructor

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; case studies in ethical decision making. Shares lectures with MATE 566, but is graded separately and additional work is required at the graduate level.

MATE 470, Corrosion Phenomena, 3 cr, 3 cl hrs

Prerequisite: CHEM 122, MATE 202 or MATE 235

Theory of aqueous corrosion (thermodynamics and kinetics); forms of corrosion; corrosion testing and evaluation; designing to minimize corrosion; methods of corrosion prevention; corrosion of specific systems; case studies.

MATE 472, 472D, Advanced Transport Phenomena, 3 cr, 3 cl hrs

Prerequisite: ES 216 and 350 or MATE 314 or consent of instructor

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.

MATE 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. (Same course as ChE 474)

MATE 479, Transmission Electron Microscopy, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: MATE 441, MATE 410, or consent of instructor

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.

MATE 480, Advanced Dislocation Theory, 3 cr, 3 cl hrs

Prerequisite: METE 327 or consent of instructor

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. Shares lectures with MATE 580, but is graded separately and additional work is required at the graduate level.

MATE 481, 481L, Engineering Design I, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: Senior Standing, MATE 301, MATE 351, METE 327, MATE 310, MATE 311 (BIOL 111/111L may substitute for MATE 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 MATE 481 and MATE 481L concurrently.

MATE 482, 482L, Engineering Design II, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: MATE 481, MATE 481L

Continuation of the design projects initiated in MATE 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 MATE 482 and MATE 482L concurrently.

MATE 483, 483L, Scanning Electron Microscopy, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: PHYS 122 or consent of instructor

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 MATE 483 and MATE 483L concurrently.

MATE 491, Directed Study/Senior Thesis, 3 cr

Prerequisite: Senior standing or consent of instructor

MATE 500, Directed Research, cr to be arranged

Prerequisite: Graduate standing

This course may not be used to fulfill graduate degree requirements.

MATE 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.

MATE 502, Physical Ceramics, 3 cr, 3 cl hrs
Prerequisite: MATE 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 MATE 402, but is graded separately, and additional work is required at the graduate level.

MATE 503, 503D, Crystal Chemistry and Crystal Physics, 3 cr, 3 cl hrs
Prerequisite: Graduate standing or consent of instructor
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.

MATE 504, Non-linear Dielectric Ceramics, 3 cr, 3 cl hrs
Prerequisite: MATE 235 and graduate standing; or consent of instructor
Review of polarization mechanisms and relaxation phenomena in non-linear dielectrics. New capacitor formulations (high permittivity) and "relaxor" ferroelectrics. Ferroelectric phase transitions and phenomenology. Piezoelectricity, pyroelectricity, and applications.

MATE 505, 505D, Electronic Materials, 3 cr, 3 cl hrs
Prerequisite: MATE 235 and graduate standing; or consent of instructor
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.

MATE 509, 509D, Statistical Mechanics of Simple Materials, 3 cr, 3 cl hrs
Prerequisite: MATE 350 or ChE 349 or Graduate Standing or consent of instructor
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.

MATE 510, Mechanical Properties of Ordered Intermetallic Alloys, 3 cr, 3 cl hrs
Prerequisite: Graduate standing or consent of instructor
Development of understanding of the mechanical behavior of ordered alloys and of the process of alloy development. Crystal structures, ordering phenomena, lattice defects in ordered alloys, tensile and compressive behavior, anomalous yielding, enhanced work hardening, fracture, creep and fatigue, environmental effects, alloy development strategies.

MATE 512, 512D, Electronic Thin Films: Science and Technology, 3 cr, 3 cl hrs
Prerequisite: Graduate standing or consent of instructor
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.

MATE 514, 514D, Liquid State Theory, 3 cr, 3 cl hrs
Prerequisite: MATE 509, Graduate Standing or consent of instructor
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.

MATE 515, Glasses and Other Complex Fluids, 3 cr, 3 cl hrs

Prerequisite: MATE 351 or consent of instructor

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.

MATE 516, Biomimetic Materials, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor

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.

MATE 520 Biomedical Materials, 3 cr, 3 cl hrs

Prerequisite: MATE 202 or MATE 235 or consent of instructor

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. Students taking the graduate-level course will write an additional report proposing a new solution to an unsolved surgical problem. Shares lecture with MATE 420, with additional expectations for graduate credit.

MATE 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 MATE 430, but is graded separately, and additional work is required at the graduate level.

MATE 531, 531D, Fundamentals in Manufacturing Processes of Materials I, 3 cr, 3 cl hrs

Prerequisite: MATE 202 or equivalent; ES 302 or equivalent

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. Shares lectures with MATE 431, but is graded separately, and additional work to include learning manufacturing software, as well as a detailed research paper, is required at the graduate level.

MATE 534, 534D, Phase Equilibria in Materials Systems, 3 cr, 3 cl hrs

Prerequisites: MATE 350 and METE 327, or consent of instructor

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.

MATE 540, 540D, Electrochemical Techniques & Process, 3 cr, 3 cl hrs

Prerequisites: Upper division or graduate student standing

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.

MATE 541, Advanced Physical Metallurgy, 3 cr, 3 cl hrs

Prerequisites: METE 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.

MATE 543, 543D, Advanced Mechanical Metallurgy, 3 cr, 3 cl hrs

Prerequisites: MATE 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.

MATE 544, Strengthening Mechanisms, 3 cr, 3 cl hrs

Prerequisite: MATE 435 or consent of instructor

Application of dislocation theory to precipitation, dispersion and solution hardening; yielding; strain aging; Hall-Petch phenomena and strengthening by grain refinement; strengthening by dislocation substructures; work hardening; strength of martensite; fiber- reinforced composites; production of strong microstructures.

MATE 545, Micromechanics of Fracture, 3 cr, 3 cl hrs

Prerequisite: MATE 435 or equivalent or consent of instructor

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).

MATE 548, Advanced Composite Materials, 3 cr, 3 cl hrs

Prerequisite: MATE 445 or consent of instructor

Reinforcements, their fabrication and properties. Matrix materials and their characteristics. Interfaces in various types of composites. Micromechanics of composites; macromechanics of composites. Failure processes in composites. Designing with composites. Specific important composite systems, their fabrication, properties, and applications.

MATE 549, Nano-Materials, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor

Physical basics of nanosystems, physics and chemistry of nanostructure synthesis and fabrication, semiconductor nanostructures, magnetic nanostructures and spintronics, molecular nanostructures, electron transport in nanosystems, optical effects in nanosystems, nanomachines, nanoscale biological assemblies, nanocomposite materials.

MATE 554, Scattering Techniques, 3 cr, 3 cl hrs

Prerequisite: MATE 351 or consent of instructor

Application of scattering techniques to the characterization of polymeric materials, ranging from polymer solutions to melts or composites. Molecular motion of polymers in solutions and melts, Flory-Huggin theory, phase separation. Fundamentals and applications of scattering techniques to polymeric materials. Dynamic light scattering, laser light scattering neutron scattering, X- ray scattering.

MATE 560, 560D, Failure Analysis, 3 cr, 3 cl hrs

Prerequisite: ES 302 or consent of instructor

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. Shares lecture with MATE 460, but is graded separately, and additional graduate-level work is required.

MATE 563, Radiation Effects in Materials, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor

Fundamentals of radiation damage (energetic particles and energy dissipation, atomic displacements and cascades, evolution of damage); material-dependent radiation-damage phenomena (at atomic, microstructural, and macrostructural levels); applications (swift-ion irradiation effects, ion-beam modification of materials, nanostructure design via irradiation, nuclear fuels and waste forms, radiation detectors and dosimeters, solar and galactic cosmic particles).

MATE 564, 564D, Nano-Optics, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor

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 nanoscale 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.

MATE 565, 565D, Catalyst Characterization Techniques, 3 cr, 3 cl hrs

Prerequisite: ChE 349/MATE 350 and/or CHEM 331/332 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. A research project is required.

MATE 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.

MATE 567, Dynamic Deformation of Solids, 3 cr, 3 cl hrs

Prerequisite: Graduate standing

Elastic waves. Plastic waves. Shock waves (Rankine-Hugoniot equations and more advanced treatments incorporating materials strength). Wave interactions and attenuation (including spalling). Spherical and cylindrical waves. Impact; Gurney equation. Principles of detonation.

MATE 568, Material Behavior at High Strain Rates, 3 cr, 3 cl hrs

Prerequisite: MATE 567

Mechanical properties of materials as a function of strain rate. Dislocation dynamics at high velocities. Structural changes introduced by shock waves: phase transformations, point defects, line defects, interfacial defects. Dislocation models for shock front. Materials aspects of adiabatic shear localization, spalling, dynamic deformation. Shock modification of ceramics.

MATE 569, 569D, 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 underlying thermodynamics and physical factors which govern fuel cell performance and efficiency. Cell components and integrative cell design.

MATE 570, 570D, Corrosion Phenomena, 3 cr, 3 cl hrs

Prerequisite: Graduate Standing or consent of instructor

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. Shares lecture with MATE 470, but is graded separately and additional graduate-level work is required.

MATE 575, 575D, Introduction to Nano Materials, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor

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, nanomachines, nanoscale biological assemblies, nanocomposite materials.

MATE 576, Drug Delivery Techniques, 3 cr, 3 cl hrs

Prerequisite: Senior or graduate standing 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. Same as BIOT 576. Shares lecture with ChE 476, with additional expectations for graduate credit.

MATE 579, Advanced Electron Microscopy, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisite: MATE 479 or MATE 483; graduate standing

Advanced topics in transmission electron microscopy. In-situ studies of deformation and fracture processes, environmental effects, and radiation damage. High-resolution electron microscopy, weak-beam techniques, scanning transmission electron microscopy, electron microdiffraction. Analytical electron microscopy; electron energy loss spectroscopy and energy- dispersive analysis of X-rays; instrumentation, techniques, quantitation, applications.

MATE 580, Advanced Dislocation Theory, 3 cr, 3 cl hrs

Prerequisite: MATE 435 or consent of instructor

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.

Shares lectures with MATE 480, but is graded separately, and additional work is required at the graduate level.

MATE 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.

MATE 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.

MATE 591, Thesis (master's program), cr to be arranged

MATE 592, 592D, Materials Engineering Graduate Seminar, 1 cr, 1 cl hrs

Must be taken S/U

Prerequisite: Graduate standing or consent of instructor

Seminar presentations by students, faculty and outside speakers. Discussion of topics of technical interest in materials science and engineering and related fields.

MATE 595, Dissertation (doctoral degree program), cr to be arranged

Prerequisite: Successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.

MATE 599, 599D, Special Topics, cr to be arranged

Lectures in new or advanced areas of materials.

Metallurgical Engineering Courses:

METE 326, Introduction to Process Metallurgy, 3 cr, 3 cl hrs

Prerequisite: CHEM 121
Corequisite: MATH 132

Introduction to stoichiometric computations. Calculations of energy and material balance. Elementary process analysis and reactor design. Single-phase and multi-phase systems. (Same as ChE 326)

METE 327 Introduction to Physical Metallurgy, 3 cr, 3 cl hrs

Prerequisite: MATE 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.

METE 434, Introduction to Dislocation Theory, 3 cr, 3 cl hrs

Prerequisite: METE 327 or consent of instructor

An introduction to elasticity and the theory of plastic flow in materials. Geometrical and crystallographic features of dislocations, elastic equations of dislocations in crystals. Partial dislocations and stacking faults. Dislocation interactions and multiplication.

METE 491, Directed Study/Senior Thesis, 3 cr

Prerequisite: Senior standing or consent of instructor

Faculty Research Interests

Burleigh—Corrosion Mechanisms, Alloy Design, Coatings for Corrosion Prevention and Electrochemical Processes

Fuierer—Electronic/Functional Ceramics, Ionic Conductors for Fuel Cells and Sensors, Photovoltaics, Grain-Oriented Ceramics, and Aerosol Deposition of Ceramic Thick Films

C. Hargather—Computational Metal Alloy Design, Density Functional Theory, Calculation of Phase Diagrams, diffusion coefficients, thermodynamics, high entropy alloys

Henneke—Nanomaterial Synthesis and Characterization, Nano-Structured Optical Waveguides, and Interfacial Phenomena

Kalugin — Optoelectronics and Nonlinear Optics, Nanostructures and Nanotechnology, TeraHz Lasers and Photodetectors, Solid State Physics of Nanostructures, and Semiconductor Materials and Devices

Majumdar— Structure-Property Relations in Materials, Processing of Metals and Composites, SMAs, Fatigue, Creep, Fracture

McCoy— Glass Transition, Epoxies, Rheology, Thin Films, Mechanical and Thermal properties of Polymers

G. Bond—Electron Microscopy, Hydrogen Effects, Metal Hydrides, Radiation Damage, Biomimetic Materials and Processing, Carbon Dioxide Sequestration, and Controlled Crystallization

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—Plasmonic nanomaterials, Nanoparticle-Bioparticle Interactions, Single Molecule Microscopy, Proton Transport Membranes, Plasmon Enhanced Photocatalysis

Leclerc—Catalysis, Reactor Design, Alternative Fuels, Biofineries, Hydrogen Production

Tartis—Biomedical Engineering, Targeted Drug Delivery

Mechanical Engineering

Professors Bakhtiyarov, Ford, Zagrai (Chair of the Department)
Associate Professors Ghosh, Grow, Hargather, Kimberley, Lim
Assistant Professors Ilie, Lee, Mousavi, O'Malley, Ryu, Wei
Adjunct Faculty Anderson, Cooper, DeChant, Fakhimi, Field, Fortner, Jaramillo, Kennedy, Langley, A. K. Miller, Rivera, Romero, Ruff, Ryan, Stofleth, Westpfahl
Emeritus Faculty A. Miller, Ostergren

Degrees Offered: B.S. 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 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.

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 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 the Baja SAE® vehicles to aerospace aircraft design.

Minimum credit hours required—135
In addition to the General Education Core Curriculum (page 88 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)
- MATE 202 & 202L (4)
- MATH 231 (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.

  * or MENG 216(3)

Credit for MATH 103, pre-calculus, and MATH 104, 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).

Sample Curriculum for the Bachelor of Science in Mechanical Engineering

Semester 1
   3 ENGL 111 (college English)
   4 MATH 131 (calculus)
   4 CHEM 121 & 121L (general)
   3 MENG110 & 110L (intro.)
   3 Social Science
  17 Total credit hours

Semester 2
   3 ENGL 112 (college English)
   4 MATH 132 (calculus)
   5 PHYS 121 & 121L (general)
   3 CHEM 122 & 122L (general)
  16 Total credit hours

Semester 3
   3 Humanities
   4 MATH 231 (calculus)
   3 MENG 210 & 210L (soph design)
   3 ES 201 (statics)
   4 MATE 202 & 202L (intro to materials)
  17 Total credit hours

Semester 4
   3 MATH 335 (ordinary differential equations)
   5 PHYS 122 & 122L (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
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

It is strongly recommended that all Mechanical Engineering students follow the sample curriculum.

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
AE Elective, 3 cr, 3 cl hrs
One course from:
- AE 313, Orbital Mechanics, 3 cr, 3 cl hrs
- AE 414, Aerospace Structures, 3 cr, 3 cl hrs

Two courses from:
- AE 313, Orbital Mechanics, 3 cr, 3 cl hrs
- AE 318, Experimental Methods in Aerodynamics, 2 cr,   2 cl hrs
- AE 318L, Experimental Methods in Aerodynamics Lab,   1 cr, 3 lab hrs
- AE 414, Aerospace Structures, 3 cr, 3 cl hrs
- AE 415, Aerodynamics II, 3 cr, 3 cl hrs
- AE 416, Aircraft Flight Dynamics and Controls, 3 cr, 3 cl hrs
- AE 417, Aerospace Propulsion, 3 cr, 3 cl hrs
- AE 418, Structural Dynamics in Aerospace   Engineering, 3 cr, 3 cl hrs

Minor in Biomedical Engineering

Minimum credit hours required – 19
The following courses are required:
BIOL 111, 111L, 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:
- MATE 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
- MATE 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 311/MENG 545, Introduction to Explosives Engineering, 3 cr, 3 cl hrs
EXPL 412/MENG 549, Wave Propagation, 3 cr, 3 cl hrs
EXPL Elective, 3 cr, 3 cl hrs (subject to the approval of the Explosives Engineering Minor Advisor)
One course from:
- EXPL 314, Theory and Application of Pyrotechnic, 3 cr, 3 cl hrs
- EXPL 413/MENG 513, Impact Dynamics, 3 cr, 3 cl hrs

Two courses from:
- EXPL 314, Theory and Application of Pyrotechnic, 3 cr, 3 cl hrs
- EXPL 316, Energetic Material Chemistry, 3 cr, 3 cl hrs
- EXPL 317, Energetic Material Safety, 3 cr, 3 cl hrs
- EXPL 320, Explosives Technology and Applications, 3 cr, 3 cl hrs
- EXPL 413/MENG 513, Impact Dynamics, 3 cr, 3 cl hrs
- EXPL 414/ChE 475, Explosives Surety, 3 cr, 3 cl hrs
- EXPL 415/MENG553, Computer Modeling of Detonations, 3 cr, 3 cl hrs
- EXPL 418, Shock Physics and Structural Response to Blast, 3 cr, 3 cl hrs
- EXPL 419, Experimental and Diagnostic Techniques, 3 cr, 3 cl hrs

Graduate Program

Department Requirements for the Master of Science in Mechanical Engineering

The Mechanical Engineering Department administers the Master of Science in Mechanical Engineering degree for those students wanting to pursue an advanced degree in mechanical engineering. The degree may be earned with a thesis or independent study option. Students selecting the independent study option must complete one additional three credit elective course. There are currently four areas of specialization for this degree:
- Specialization in Explosives Engineering
- Specialization in Fluid and Thermal Sciences
- Specialization in Mechatronics Systems & Robotics
- Specialization in Solid Mechanics

Students must take MENG 585 each semester offered if the student is in residence. Distance-education students and part-time on-campus students are required to take two semesters of 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 in Mechanical Engineering.
- Core Specialization Courses—at least 12 credit hours from the selected specialization listed below:
  - *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
    Students completing the undergraduate minor in explosives engineering cannot re-use the classes (including co-listed classes) used in the minor program toward the MS in explosives engineering program.
  - *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.

- 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.
- 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) or MENG 590, Independent Study (3 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, or complete an independent study with accompanying report.

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 a n 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):
- 27 credit hours of core courses (9 credit hours from each core segment)
- 9 credit hours of elective courses, as approved by the graduate advisory committee
- 3 credits of Graduate Seminar (MENG 585)
- 9 credits maximum of Directed Study (MENG 581 or related 581, must be graded)
- 24 credits 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 credits beyond the Master's degree:
- 18 credit hours of core courses (9 credit hours from Energetics and 9 credit hours from Intelligent Systems core segments)*
- 3 credits of graduate seminar (MENG 585)
- 3 credits maximum of Directed Study (MENG 581 or related 581, must be graded)
- 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 (including credits from the Basic Science and Engineering core segment) as determined by the Graduate Advisory Committee.

Energetics core segment: MENG 545 Introduction to Explosives Engineering, MENG 546 Detonation Theory, MENG 549 Wave Propagation, MENG 550 Advanced Explosives Engineering, MENG 552 Explosives Technology and Applications, MENG 513 Impact Dynamics, ME 548 Rock Fracturing and Fragmentation by Explosives, 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, EMNG 572 Sensor Technology, MENG 574 Electrical Measurements of Non-Electrical Quantities, EE 551 Discrete-Time Signal Processing, Filtering, and Estimation, CSE 568 Intelligent Systems.

Fundamental Science and Engineering 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, MATE 530 Design and Analysis of Experiments, PHYS 509 Methods of Theoretical Physics.

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 shortly after the end of each 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 purse a M.S. in Mechanical Engineering subject to those degree requirements.

Candidacy Examination:
• Written dissertation proposal
• 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) Q&A
• Defense must take pace 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 122 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
> 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 254 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 231, 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 311, Introduction to Explosives Engineering, 3 cr, 3 cl hrs

Prerequisites: ES 216, ES 302, and ES 347 or consent of instructor

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.

EXPL 314 Theory and Application of Pyrotechnic, 3 cr, 3 cl hrs

Prerequisite: EXPL 311

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 316 Energetic Material Chemistry, 3 cr, 3 cl hrs

Prerequisite: EXPL 311

An introduction to the chemical aspect of energetic materials. Based on basic/advanced chemical and thermo-chemical concepts and dynamics, understand the characteristic and typical properties of energetic materials.

EXPL 317 Energetic Material Safety, 3 cr, 3 cl hrs

Prerequisite: EXPL 311

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 320 Explosives Technology and Applications, 3 cr, 3 cl hrs

Prerequisite: EXPL 311

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 412, Wave Propagation, 3 cr, 3 cl hrs

Prerequisites: EXPL 311 and MATH 335; or consent of instructor

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-Gruneisen 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 413 Impact Dynamics, 3 cr, 3 cl hrs

Prerequisites: EXPL 412

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).

EXPL 414 Explosives Surety, 3 cr, 3 cl hrs

Prerequisite: Upper class standing or consent of instructor

An introduction to explosives and other energetic materials. The basic chemical compositions, properties and environmental effects of commercial, military, and improvised 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 ChE 475.)

EXPL 415 Computer Modeling of Detonations, 3 cr, 3 cl hrs

Prerequisite: EXPL 412; or EXPL 311 and MENG 421: or consent of instructor.

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 418 Shock Physics and Structural Response to Blast, 3 cr, 3 cl hrs

Prerequisite: EXPL 412 or consent of instructor

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 419 Experimental and Diagnostic Techniques, 3 cr, 3 cl hrs

Prerequisite: EXPL 412

An introduction to the explosive testing date 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 419L Explosives Testing and Diagnostic Techniques Laboratory, 1cr., 3 cl. hrs

Prerequisite: MENG 545 or EXPL 311 and EXPL 412 or consent of instructor.
Co-requisite: EXPL 419

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 103 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 121

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 231

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 and Matlab 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 111 and 112 or the equivalent passed with a grade of C or better.

Corequisites: MENG 381.

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, MENG 341

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 341; 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

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; MATE 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

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

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

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
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 equivalent or consent of instructor
　　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 513, Impact Dynamics, 3 cr, 3 cl hrs
　　Prerequisite: Graduate standing or consent of instructor
　　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, 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 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

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

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: ES 216, ES 302 and ES 347; or consent of instructor

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.

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, Pyrotechnics Theory and Application, 3 cr, 3 cl hrs

Prerequisites: MENG 545 or consent of instructor

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

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 (passed with a B or better) and MATH 335 or MENG 305/ES 305; or consent of instructor

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

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 254 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: MENG 545 or consent of instructor

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 and MENG 421 or consent of instructor.

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 ME 553)

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

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 549 and MENG 556 (or AE 420) or consent of instructor

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: ES 216/MENG 216, ES 347, or graduate standing

Explanation of the physical phenomena encountered in compressible flow by providing practical applications and examples. Provide the knowledge and understanding of the basic fundamentals of compressible flow and gas dynamics.

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 558L, Explosives Science and Application Lab, 1-3 cr hrs, 1-3 lab hrs

Prerequisite: MENG 545 or consent of the instructor

Introduction of the multi-disciplinary fields of engineering hands-on knowledge of explosives including chemistry, mechanics, and applications of explosives. Based on multi-disciplinary areas of engineering of explosives, students can learn more in-depth and hands-on based explosives application and science, providing different levels of achievement, starting with the basic science and moving toward more advanced engineering principles.

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 567, 567D, Smart Engineering Systems, 3 cr, 3 cl hrs

Prerequisites: MATH 254, 382; CSE 344; or equivalent; 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: MATH 254, 382; CSE 344; or equivalent; 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

The theory, design, manufacture and use of instrumentation 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

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

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

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

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: MENG 431 or equivalent

Corequisite: MENG 575

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

MENG 582, 582D, Nondestructive Evaluation and Structural Health Monitoring, 3 cr, 3 cl hrs

Prerequisites: MENG 304, MENG 305, MATH 335 or consent of instructor.

This multi-disciplinary course introduces key physical concepts in elasticity, material science, acoustics, optics, and electromagnetics applied to system condition monitoring, material characterization, structural damage detection and failure prevention. A broad spectrum of nondestructive evaluation (NDE) methods and emerging structural health monitoring (SHM) technologies is discussed including the ultrasonic inspection, vibration monitoring, acoustic emission, radiography, eddy currents, electrical and magnetic testing. Examples of practical NDE/SHM applications in scientific research and industrial practice are presented.

MENG 583, 583D, Engineering Mechanics of Composite Structures, 3 cr, 3 cl hrs

Prerequisites: MENG 305, Pre/Corequisite MENG 523 or consent of the instructor

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.

MENG 585, 585D, Graduate Seminar, 1 cr

MENG 589, 589D, Advanced Topics in Mechanical Engineering, 2-3 cr, 2-3 cl hrs

Prerequisites: Consent of the instructor

MENG 590, Independent Study, cr to be arranged

MENG 591, Thesis (master's degree), cr to be arranged

MENG 595, Dissertation, cr to be arranged

Prerequisites: Successful completion of PhD candidacy exam and Academic Advisor recommendation for candidacy.

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

Cooper - Explosives Technology, Explosives Engineering

DeChant – Theoretical Fluid Mechanics, Gas Dynamics, Applied Mathematics

Fakhimi - Geomechanics, Numerical Modeling

Ford – Written and Oral Communication, Teamwork, Communication Pedagogy, Leadership

Field – Structural Dynamics, Random Vibration, Applied Probability, Computational Modeling, Model Validation, and Robust Control

Fortner—Energetic Materials: Initiation, Applications, and Systems

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, Thermal Convection Problems

Jaramillo – Space Systems; Flight Dynamics, Simulation & Testing; Missile Flight Safety

Ilie - Aerodynamics, Aeroelasticity, Combustion, Computational Fluid Dynamics, Multiphase flows

Kennedy - Basic Science and Applications of Explosives, Microdetonics and Initiation of Detonation in Explosives

Kimberley – Solid Mechanics, Impact Studies, Dynamic Behavior of Materials

Langley – Mechanical Systems Design

Lee - Uncertainty Quantification, Distributed Network Control Systems, Multi-Objective Optimization, Robotics

Lim-Energetic Materials, Explosives Technology, Linear and Conical Shaped Charges

Miller, A.K. —System Dynamics, System Modeling and Simulation, Actuators and Actuator Controls

Mousavi – Micro/Nano-Electro-Mechanical Systems (MEMS/NEMS), BioMEMS, Interferometry, Fabrication, Characterization, BioMimicking, Simulations

Ostergren—Mechanics of Materials, Structural Analysis, Machine Design, Propulsion and Power Systems

Rivera – Energetic Materials, Explosives Technology

Romero—Energetic Materials, Shock Phenomena, High Energy Physics

Ruff – Mechanics of Materials, Instrumentation

Ryan – Telescope Observations, Characterization of Small Bodies in the Solar System, Laboratory and Numerical Simulations of Impact Phenomena, Tracking and Characterization of Artificial Resident Space Objects

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, Fakhimi, N. Mojtabai (Chair of the Department)
Associate Professor Razavi
Adjunct Faculty Bakhtar, Elliot, Kuhn, McLemore, Preece, Wimberly
Emeritus Professor Oravecz, Aimone-Martin

Degrees Offered: B.S. in Mineral Engineering; B.S. in Mineral Engineering with Emphasis in Explosives Engineering; M.S. 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.

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. The department also maintains its own experimental underground mining facility to allow students valuable hands-on experience in solving mineral engineering problems. 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—130

In addition to the General Education Core Curriculum (page 88), the following courses are required:

- MATH 231 (4), 335 (3)
- ES 201 (3), 216 (3), 302 (3), ES 303 or 347 (3)
- ERTH 101 & 101L (4), 200 (4)
- ME 101 (1), 220 (3), 320 (2), 340 (3), 360 (3), 380 (6), 410 (3), 413 (3), 419 (2), 420 (3), 422 (3), 435 (3), 437 (3), 440 (3), 462 (3), 470 (1), 471 (2)
- Technical Elective (3)
- Electives to complete 130 credit hours
- All ME majors must take the Fundamentals in Engineering (FE) exam as a requirement for graduation.

Sample Curriculum for the Bachelor of Science in Mineral Engineering

Semester 1
1 ME 101 (intro to mineral engineering)
4 ERTH 101 & 101L (principals)
4 MATH 131 (calculus I)
4 CHEM 121 & 121L (general)
3 ENGL 111 (college English)
16 Total credit hours

Semester 2
3 ENGL 112 (college English)
4 MATH 132 (calculus II)
4 CHEM 122 & 122L (general)
3 Social Science/Humanities
3 Social Science/Humanities
17 Total credit hours

Semester 3
5 PHYS 121 & 121L (general physics)
4 MATH 231 (calculus III)
3 ES 201 (statics)
3 ME 220 & 220L (surveying)
3 Social Science/Humanities
18 Total credit hours

Semester 4
5 PHYS 122 & 122L (general physics)
3 ES 216 (fluid mechanics)
3 ES 302 (strength of materials)
4 ERTH 200 (mineralogy)
2 ME 320 (economic analysis)
17 Total credit hours

Semester 5
3 ME 360 (exploration and field mapping)
3 ME 340 (geostatistics and mineral evaluation)
3 ENGL 341 (technical writing)
3 ME 420 & lab (soil mechanics)
3 Humanities/Social Science
15 Total credit hours

Semester 6
6 ME 380 & 380L (mine systems)
3 ME 413 (foundation engineering)
3 ME 422 & 422L (rock mechanics)
3 Social Science/Humanities
15 Total credit hours

Semester 7
1 ME 470 (senior design I)
3 ME 435 (rock slope stability)
3 MATH 335 (applied analysis)
3 ES 347 (thermodynamics) or ES 303 (dynamics)
3 ME 462 (mineral deposits)
3 ME 440 (mine ventilation)
16 Total credit hours

Semester 8
2 ME 410 & 410L (environmental issues)
2 ME 471 (senior design II)
2 ME 419 (mineral and natural resources law)
3 ME 437 (tunneling & underground excavations)
3 Technical Elective
3 Humanities/Social Science
15 Total credit hours

Bachelor of Science in Mineral Engineering with Explosives Engineering Option

Minimum credit hours required—138

In addition to the General Education Core Curriculum (page 88), the following courses are required:

- MATH 231 (4), 335 (3)
- ES 201 (3), 216 (3), 302 (3), ES 332, ES 303 or 347 (3)
- ERTH 101 & 101L (4), 200 (4)
- ME 101 (1), 220 (3), 320 (2), 340 (3), 360 (3), 380 (6), 410 (3), 419 (2), 420 (3), 422 (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 220 (3), ME 320 (2), ME 340 (3), ME 360 (3), ME 380 (6), ME 410 (3), ME 413 (3), ME 420 (3), ME 422 (3), ME 435 (3), ME 437 (3), ME 440 (3), ME 462 (3)

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

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.

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 220, Surveying and Map Preparation, 3 cr, 2 cl hrs, 3 lab hrs

Prerequisites: MATH 103, 104

Surveying instruments and measurement techniques. Data acquisition by means of advanced surveying methods for map production. Layout design and measurements. Correlations of surface and underground surveys.

ME 320, Economic Analysis, 2 cr, 2 cl hrs

Corequisite: MATH 131

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, 2 cl hr, 2 lab hrs

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: ERTH 200; ME 220
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, Mine Systems, 6 cr, 4 cl hrs, 6 lab hrs

Prerequisite: ME 340, ME 320, or ES 316

Surface and underground mining methods and design; drilling and blasting design; materials handling and equipment selection. Concepts of mine plant design. Emphasis on computer applications.

ME 410, Environmental Issues, 3 cr, 3 cl hrs

Prerequisites: ME 380
Corerequisite: 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 419, Legal Aspects of Mineral Engineering, 2 cr, 2 cl hr

A comprehensive study of laws pertaining to the exploration, planning, and development for resource extraction including minerals and water. Mineral and water rights issues will be presented and debated. A case study paper will be presented.

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 hrs

Prerequisite: ERTH 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 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 stereonets 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 422

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 stereonets and stereographic projection. Stress and rock mass strength, elastic and elasto-plasic 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; 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: ERTH 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 ERTH 462)

ME 470, Senior Design I, 1 cr, 1 cl hr

Prerequisites: ME 380

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: 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: 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

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 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

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

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

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 Misses 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 531, Advanced Foundation Design and Analysis, 3 cr, 3 cl hrs

Prerequisite: Graduate standing or consent of instructor

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

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

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: ME 420 or 506; ME 422 or 508; basic computer skills

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

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

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. 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

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

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-Gruneisen 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, 3cl hrs

Prerequisites: MENG 549 or ME 549; or consent of instructor.

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

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

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. 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

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

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: 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

Faculty Research Interests

Chávez—Applied Mineral Exploration, Ore Deposits, Natural Resource Utilization
Elliot—Surveying
Fakhimi—Geomechanics, Numerical Modeling
Kuhn—Engineering Geology
McLemore—Economic Geology
N. Mojtabai—Site Investigation, Rock Fragmentation, Mine Design, Geomechanics
Preece—Explosive Engineering and Computer Modeling
Razavi – Soil Mechanics, Image Processing, X-Ray computer Tomography
Oravecz—Rock Mechanics, Surveying
C. Wimberly—Natural Resources Law

Petroleum Engineering

Professors Engler, Lee
Associate Professors Chen, Leclerc (Chair of the Department), Nguyen, Rahnema
Assistant Professors Kelly, Lin, Rafieepour
Adjunct Faculty: Balch, Buckley, Grigg, Harris, Martin, Liu, Seright, Ruan

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.

Undergraduate Program
Bachelor of Science in Petroleum and Natural Gas Engineering

Minimum credit hours required—134

In addition to the General Education Core Curriculum (page 88), 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 231 (4), 335 (3)
- ERTH 101 & 101L (4), 460 (3)
- ERTH 202 (4) or ERTH 203 (3). ERTH 203 recommended.
- Technical 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 88) 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 131 (calculus)
  4 CHEM 121 & 121L (general)
  3 ENGL 111 (college English)
  4 ERTH 101 & 101L (earth processes)
16 Total credit hours

Semester 2

  4 MATH 132 (calculus)
  3 PETR 111 (Comp applications)
  5 PHYS 121 & 121L (general)
  3 ENGL 112 (college English)
  3 Social Science/Humanities
16 Total credit hours

Semester 3

  4 MATH 231 (calculus)
  4 CHEM 122 & 122L (general)
  5 PHYS 122 & 122L (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 ERTH 203 (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 ERTH 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 Technical Elective
  3 Humanities/Social Science
  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 104

Development of algorithms in ExcelTM 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 122; MATH 132
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 drillrig 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 122; 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 ERTH 370)

PETR 411, Advanced Drilling, 3 cr, 3 cl hrs

Prerequisite: PETR 311 or consent of instructor

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

Prerequisite: 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

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 Testing, 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; ERTH 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

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

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; 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.

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

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

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

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

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

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

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
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
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

Balch—Fuzzy Expert Systems, Data Mining
Bretz—Transport Phenomena, Phase Behavior, Natural Gas Processing
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
Kelly—Reservoir Evaluation and Management
Lee—Natural Gas Storage, Applied Numerical Methods, Phase Behavior, Membrane Technology
Lin—production well performance, horizontal well analysis
Lorenz—Petroleum Geology
Martin—Reservoir Management, EOR
Nguyen—Drilling Fluids, Multiphase Flow and Artificial Lift
Plisga—Production Operations
Rafieepour -- Wellbore and Reservoir Geomechanics, Drilling in Partially Depleted Reservoirs, Horizontal Well Completion, Hydraulic Fracturing, Unconventional Reservoirs
Rahnema—Simulation/Modeling, IOR, Reservoir Phase Behavior
Ruan—Design of Web-Based Systems
Seright—Profile Control; Polymer, Water, and Chemical Flooding
Warpinski—Hydraulic Fracturing, In-Situ Stresses, Natural Fractures, Geomechanics, Rock Mechanics

Administration, Faculty, and Professional Staff

Board of Regents

Jerry A. Armijo
David Gonzales
Donald Monette
Deborah Peacock
Emily Silva—Student Regent Designate

Administration

President...**Stephen G. Wells**
Vice President for Academic Affairs.........................**Douglas P. Wells**
Vice President for Administration
    and Finance..**Cleve McDaniel**
Vice President for Student and
    University Relations..**Melissa Jaramillo**
Vice President for Research and
    Economic Development...**Van Romero**
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    and Mineral Resources......................................**Nelia Dunbar**
Director, New Mexico Petroleum
    Recovery Research Center.......................................**Robert Balch**
Director, Energetic Materials Research
    and Testing Center (EMRTC)..........................**Michael Stanley**
Dean of Arts & Sciences. . ...**William D. Stone**
Dean of Engineering..**Kevin Wedeward**
Dean of Graduate Studies...**Lorie Liebrock**
Dean of Students...**Melissa Jaramillo**

Academic Department Chairs

Biology...**Snezna Rogelj**
Chemistry...**Michael Heagy**
Civil and Environmental Engineering...................**Clint Richardson**
CLASS…………………….....................................**Steve Simpson**
Computer Science. Engineering..............................**Dongwan Shin**
Earth and Environmental Science............................**Glenn Spinelli**
Electrical Engineering...**Aly El-Osery**
Management...**Frank Reinow**
Materials Engineering.....................**David Burleigh, John McCoy**
Mathematics...**Anwar Hossain**
Mechanical Engineering...**Andrei Zagrai**
Mineral Engineering...**Navid Mojtabai**
Petroleum and Chemical Engineering.......................**Corey Leclerc**
Physics...**Richard Sonnenfeld**
Psychology and Education..**Mark Samuels**

Department Directors

Academic Affairs...**Douglas P. Wells**
Academic Center for Technology...............................**Iver Davidson**
Admission..**Anthony Ortiz**
Advancement..**Colleen Guengerich**
Affirmative Action and Compliance.......................**Randy Saavedra**
Auxiliary Services..**Valerie Del Curto**
Bookstore...**Scott Botko**
Budget and Analysis..**Leyla Sedillo**
Bureau of Geology...**Nelia Dunbar**
Business Office..**Arleen Valles**
Campus Dining...**Anthony Roybal**
Campus Police...**Scott Scarborough**
Career Services..**Michael Voegerl**
Child Care Center..**Darlene Sanchez**
Communications Office..**David Lepre Jr.**
Community Education...**Lillian Armijo**
Cooperative Education..**Michael Voegerl**
Counseling Services...**Angela Gautier**
EMRTC...**Michael Stanley**
Facilities Management...**Yvonne Manzano**
Financial Aid...**Kenneth Aerts**
Geophysical Research Center....................................**Van D. Romero**
Golf Course...**Sabino Grijalva**
Graduate Studies...**Lorie Liebrock**
Gymnasium...**Melissa Begay**
Health Services...
Human Resources..**JoAnne Salome**
ICASA...**Mike Smith**
Information Technology & Communication.............**Joe Franklin**
Instrument Room...**Ed ward Gangemi**
International and Exchange Services.........................**Michael Voegerl**
IRIS/PASSCAL Instrument Center..................**Bruce C. Beaudoin**
Langmuir Laboratory..**Ken Eack**
Macey Center...**Nowka Leviner**
Multicultural Programs..**Michael Voegerl**
Office for Student Learning......................................**David Cox**
Performing Arts...**Ronna Kalish**
Post Office...
President's Office..**Stephen G. Wells**
Property Office...**Steven Hicks**
PRRC...**Robert Balch**
Purchasing Services...**Kimela Miller**
Registrar..**Sara Grijalva**
Research and Economic Development....................**Van D. Romero**
Residential Life..**Mitchell Tappen**
Science Fair and Olympiad......................................**Troylynn Zimmerly**
Skeen Library...**David Cox**
Student Affairs...**Michael Voegerl**

Faculty and Professional Staff

Key: **NMBGMR,** *New Mexico Bureau of Geology and Mineral Resources;* **PRRC,** *New Mexico Petroleum Recovery Research Center;* **ICASA**, *Institute for Complex Additive Systems Analysis;* **MRO**, *Magdalena Ridge Observatory;* **ACT**, *Academic Center for Technology;* **EMRTC**; *Energetic Materials Research and Testing Center*

Emma Aafloy, Associate Director for Budget, Administration & Finance
B.S., New Mexico Institute of Mining and Technology

Robert Abernathy, Computational Analyst, EMRTC; Adjunct Faculty, Mechanical Engineering
B.S., Ph.D., New Mexico State University

Kenneth Aerts, Director of Financial Aid
B.B.A., New Mexico State University

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Higher Education Diploma, Candidate of Sciences, Kazakh State University, USSR; Ph.D., University of Kentucky

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B.A., New Mexico Highlands University; M.B.A., Ph.D., University of Texas at Austin

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B.S., Rostov State University, Russia

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B.S., M.S., Massachusetts Institute of Technology; Ph.D., Harvard University

Mohammad Azarbayejani, Associate Professor of Civil Engineering
Ph.D., University of New Mexico

Sayavur I. Bakhtiyarov, Professor of Mechanical Engineering
B.S., M.S., Azerbaijan State Oil Academy; Ph.D, Russian Academy of Sciences

Robert Balch, Director (PRRC), Adjunct Faculty, Petroleum Engineering and Computer Science
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