New Mexico Tech
2005–2006 Catalog

For information on undergraduate admission, contact:

Director of Admission
New Mexico Tech
801 Leroy Place
Socorro, New Mexico 87801
(505) 835-5424
1-800-428-TECH
admission@admin.nmt.edu
www.nmt.edu/prospective/

International students who wish to apply for undergraduate admission should contact:

International and Exchange Programs Office
(505) 835-5022
international_undergrad
@admin.nmt.edu

For information on graduate admission, contact:

Dean of Graduate Studies
New Mexico Tech
801 Leroy Place
Socorro, New Mexico 87801
(505) 835-5513
1-800-428-TECH
graduate@nmt.edu
www.nmt.edu/~grad

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

Published June 2005
New Mexico Institute of Mining and Technology
New Mexico Tech Academic Calendar

2005 Summer Session
Apartments open: June 1
Registration and Validation: June 13
Classes begin: June 14
Academic holiday: July 4
Last day to change to audit or S/U: July 19
Last day to withdraw: July 19
End of session: August 4

2005 Fall Semester
Apartments open: August 15
Residence halls open: August 19
Registration and Validation: August 22
Classes begin: August 23
Academic holiday: September 5
Registration closes: September 9
Midsemester: October 12
Academic holiday: October 21
Last day to change to audit or S/U: November 1
Last day to withdraw: November 1
Thanksgiving vacation: November 24–25
Last day of classes: December 9
Finals begin: December 10
End of finals & semester: December 16
Apartments and residence halls close: December 16

2006 Spring Semester
Apartments open: January 3
Residence halls open: January 15
Registration and Validation: January 16
Classes begin: January 17
Registration closes: February 3
Midsemester: March 8
Spring vacation: March 13–17
Last day to change to audit or S/U: April 4
Last day to withdraw: April 4
Academic holiday: April 14
Last day of classes: May 5
Finals begin: May 6
End of finals & semester: May 12
Apartments and residence halls close: May 12
Commencement: May 13

2006 Field Camp
Geology Field Camp: May 20–July 2

2006 Summer Session
Registration and Validation: June 12
Classes begin: June 13
Registration closes: June 16
Academic holiday: July 4
End of session: August 4

2006 Fall Semester
Registration and Validation: August 21
Classes begin: August 22
Academic holiday: September 4
Registration closes: September 8
October 20
Academic holiday: October 21
Thanksgiving vacation: November 23–24
Last day of classes: December 8
Finals begin: December 9
End of finals & semester: December 15

2007 Spring Semester
Registration and Validation: January 15
Classes begin: January 16
Registration closes: February 2
Spring vacation: March 12–16
Academic holiday: April 6
Last day of classes: May 4
Finals begin: May 5
End of finals & semester: May 11
Commencement: May 12

2007 Field Camp
Geology Field Camp: May 19–July 1

2007 Summer Session
Registration and Validation: June 11
Classes begin: June 12
Academic holiday: July 4
End of session: August 3
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Institute for Complex Additive Systems Analysis  
Institute for Engineering Research and Applications  
International Law Enforcement Academy  
IRIS/PASSCAL Instrument Center  
Langmuir Laboratory for Atmospheric Research  
Magdalena Ridge Observatory  
Mount Erebus Volcanic Observatory  
National Cave and Karst Research Institute  
National Radio Astronomy Observatory  
New Mexico Bureau of Geology and Mineral Resources  
New Mexico Bureau of Mine Inspection  
New Mexico Petroleum Recovery Research Center  
New Mexico Tech Research and Economic Development  
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New Mexico Tech Seismological Observatory  
Playas Training Center  

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Degrees Offered at Tech

Associate Degrees
- Associate of General Studies
- Associate of Science in Business

Bachelor of Science
- Basic Sciences
- Biology
- Chemical Engineering
- Chemistry
- Civil Engineering
- Computer Science
- Earth Science
- Electrical Engineering
- Engineering Mechanics
- 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

Minors
- Biology
- Chemistry
- Earth Science
- Education
- Electrical Engineering
- Hispanic Studies
- History
- Literature
- Management
- Materials Engineering
- Mathematics
- Mineral Engineering
- Optical Science and Engineering
- Petroleum Engineering
- Philosophy
- Physics
- Polymer Science
- Psychology
- Technical Communication

Master of Engineering Management

Master of Science Teaching

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

Doctor of Philosophy
- Chemistry
- Computer Science
- Earth and Environmental Science
- Geochemistry
- Geology
- Geophysics
- Hydrology
- Materials Engineering
- Mathematics
- Applied and Industrial Mathematics
- Petroleum Engineering
- Physics
- Astrophysics
- Atmospheric Physics
- Mathematical Physics

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, religion, color, age, sex, national origin, ancestry, physical or mental handicap or disability, medical condition, or veteran status, as required by the New Mexico Human Rights Act, Title VII of the Civil Rights Act of 1964, as amended, Executive Order 11246, Section 504 of the Rehabilitation Act of 1973, the Americans with Disabilities Act, or by other laws and regulations. Inquiries regarding compliance may be directed to Edmund L. Trujillo, Director, Affirmative Action and Compliance Office, Fitch 215, New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, New Mexico 87801; telephone (505) 835-5165.

Other Formats
The New Mexico Tech 2005–2006 catalog is available on-line at: www.nmt.edu/catalog
The catalog is also available in other formats upon request. Contact: The Office of Admission
New Mexico Tech
801 Leroy Place
Socorro, NM 87801
(505) 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.

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 students: see page 31 for information about academic 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 College (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 in the Office of the Registrar.

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.

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

These practices are observed in the numbering system:
1) 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.
2) Odd-numbered courses are usually offered in the fall semester; even-numbered courses are usually offered in the spring semester.

Credit Hours

Credit hours are measured in class hours (cl hrs), lab hours (lab hrs), and recitation/discussion hours (recitation hrs).

“1 cl hr” and “1 recitation hr” correspond roughly to one hour spent in class each week and is equivalent to one (1) credit hour. “3 lab hrs” equals about three hours per week in the laboratory and is also equivalent to one (1) credit hour.

In addition to class and lab time, you 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. To graduate with a bachelor’s degree, you will need a minimum of 130 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.

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 College classes (designated by the letter “C” in the course number) may not be used to fulfill the General Degree Requirements for a Bachelor of Science degree (page 48). However, some majors allow student to use these classes to fulfill elective credit.

General Degree 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. See page 53 and 54 for both undergraduate and graduate general degree requirements.

Good Academic Standing (Undergraduate)

Graduate students: For information on satisfactory progress, see page 32.

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:

<table>
<thead>
<tr>
<th>Total semester hours attempted (cumulative)</th>
<th>Minimum semester GPA needed to maintain good standing</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-29</td>
<td>1.60</td>
</tr>
<tr>
<td>30-59</td>
<td>1.80</td>
</tr>
<tr>
<td>60 or more</td>
<td>2.00</td>
</tr>
</tbody>
</table>

For determination of academic standing, “semester hours attempted” means courses in which a student earns grades of A, A-, 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 42).

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.

For determination of academic standing, “semester hours attempted” means courses in which a student earns grades of A, A-, 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 42).

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For determination of academic standing, “semester hours attempted” means courses in which a student earns grades of A, A-, 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 42).

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For determination of academic standing, “semester hours attempted” means courses in which a student earns grades of A, A-, 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 42).
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 4 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.

Prerequisites and Corequisites

Some courses have prerequisites, courses you must successfully complete before enrolling in that course. Exceptions may 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.

Satisfactory Academic Progress for Financial Aid

To be in good standing for financial aid purposes, a student must earn at least 75 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 page 27 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 Tech Business Office before you can complete registration.

Course Abbreviations

<table>
<thead>
<tr>
<th>Course Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCT</td>
<td>Accounting</td>
</tr>
<tr>
<td>ART</td>
<td>Art History</td>
</tr>
<tr>
<td>BA</td>
<td>Business Administration</td>
</tr>
<tr>
<td>BCS</td>
<td>Business Computer Systems</td>
</tr>
<tr>
<td>BIOL</td>
<td>Biology</td>
</tr>
<tr>
<td>CE</td>
<td>Civil Engineering</td>
</tr>
<tr>
<td>CH E</td>
<td>Chemical Engineering</td>
</tr>
<tr>
<td>CHEM</td>
<td>Chemistry</td>
</tr>
<tr>
<td>CS</td>
<td>Computer Science</td>
</tr>
<tr>
<td>ECON</td>
<td>Economics</td>
</tr>
<tr>
<td>EDUC</td>
<td>Education</td>
</tr>
<tr>
<td>EE</td>
<td>Electrical Engineering</td>
</tr>
<tr>
<td>EMGT</td>
<td>Engineering Management</td>
</tr>
<tr>
<td>ENGL</td>
<td>English</td>
</tr>
<tr>
<td>ENVE</td>
<td>Environmental Engineering</td>
</tr>
<tr>
<td>ENVYS</td>
<td>Environmental Science</td>
</tr>
<tr>
<td>ES</td>
<td>Engineering Science</td>
</tr>
<tr>
<td>FA</td>
<td>Fine Arts</td>
</tr>
<tr>
<td>FIN</td>
<td>Finance</td>
</tr>
<tr>
<td>FREN</td>
<td>French</td>
</tr>
<tr>
<td>GEOC</td>
<td>Geochemistry</td>
</tr>
<tr>
<td>GEOL</td>
<td>Geology</td>
</tr>
<tr>
<td>GEOP</td>
<td>Geophysics</td>
</tr>
<tr>
<td>GERM</td>
<td>German</td>
</tr>
<tr>
<td>HIST</td>
<td>History</td>
</tr>
<tr>
<td>HYD</td>
<td>Hydrology</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>MATE</td>
<td>Materials Engineering</td>
</tr>
<tr>
<td>MENG</td>
<td>Mechanical Engineering</td>
</tr>
<tr>
<td>MATH</td>
<td>Mathematics</td>
</tr>
<tr>
<td>ME</td>
<td>Mineral Engineering</td>
</tr>
<tr>
<td>METE</td>
<td>Metallurgical Engineering</td>
</tr>
<tr>
<td>MGT</td>
<td>Management</td>
</tr>
<tr>
<td>MKT</td>
<td>Marketing</td>
</tr>
<tr>
<td>MUS</td>
<td>Music</td>
</tr>
<tr>
<td>OPT</td>
<td>Optics</td>
</tr>
<tr>
<td>PETR</td>
<td>Petroleum Engineering</td>
</tr>
<tr>
<td>PHIL</td>
<td>Philosophy</td>
</tr>
<tr>
<td>PHYS</td>
<td>Physics</td>
</tr>
<tr>
<td>PR</td>
<td>Physical Recreation</td>
</tr>
<tr>
<td>PS</td>
<td>Political Science</td>
</tr>
<tr>
<td>PSY</td>
<td>Psychology</td>
</tr>
<tr>
<td>SPAN</td>
<td>Spanish</td>
</tr>
<tr>
<td>ST</td>
<td>Science Teaching</td>
</tr>
<tr>
<td>SVC</td>
<td>Community Service</td>
</tr>
<tr>
<td>TC</td>
<td>Technical Communication</td>
</tr>
</tbody>
</table>
Other Abbreviations, Acronyms, and Terms Used at Tech

AOC  Array Operations Center
ARC  Advising Resource Center
CC  Community College/Continuing Education
CEMED Center for Energetic Materials and Devices
DE Distance Education
E&ES Department of Earth and Environmental Science
EED Environmental Evaluation Group
ECO Etscorn Campus Observatory
EMRTC Energetic Materials Research and Testing Center
EODI Educational Outreach and Distance Instruction
FacMgmt Facilities Management
FE exam Fundamentals of Engineering exam
GOLD Group Opportunities for Learning and Development
GPA Grade Point Average
ICASA Institute for Complex Additive Systems Analysis
IERA Institute for Engineering Research and 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
MRO Magdalena Ridge Observatory
MROI Magdalena Ridge Observatory Interferometer
MSEC Mineral Science and Engineering Complex
NCKI National Cave and Karst Research Institute
NMBCMR New Mexico Bureau of Geology and Mineral Resources
NRAO National Radio Astronomy Observatory
OCLC Library Database
OIEP Office of International and Exchange Programs
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 Resident Computing Network
SA Student Association
SAC Student Activities Center
SACIC Science Application International Corporation
SUB Student Union Building
SUR Student and University Relations Office
TA Teaching Assistant
TAC Tech Authorization Code (for long-distance telephone 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.

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 Tech student gains a liberal education, as well as thorough technological training.

At New Mexico Tech there is no artificial distinction between pure and applied research and no sharp dividing line between teaching and research. The 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 Tech’s programs.

Undergraduate students can choose from among 21 bachelor of science programs or pursue a degree in general studies, a relatively unstructured program dictated by personal needs and interests. 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 1,800 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 Student Union Building (SUB), 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, 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, electrical, materials, environmental, petroleum, and mineral engineering.

In addition to the educational arm of the Institute, 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, 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 is an institute of higher learning that serves the people of New Mexico by integrating education, research, public service, and economic development through emphasis on science, engineering, and natural resources. Its mission is threefold:

1) helping students learn creative approaches to complex issues,
2) creating and communicating knowledge, and
3) solving technical and scientific problems.

Institutional Values

The people who comprise the community that is New Mexico Tech are guided by certain values as they perform their daily tasks. More than mere rules or operating procedures, our institutional values are qualitative and idealistic. They are our most fundamental touchstones that measure the worth of what we do. They are:

• Creative Excellence

Creativity is possible in virtually all endeavors. It calls for curiosity, adaptability, and resourcefulness. It requires imagination and often diligence. But whether the task is being performed by a carpenter, a secretary, a graduate student, or a regent, creativity is an expected part of this value.

Excellence speaks for itself. New Mexico Tech is known for the high quality of its education and research, but we aspire to a new level of excellence in which the whole is greater than the sum of its parts. At this new level, we expect that creative excellence will be rewarded at New Mexico Tech.

• Integrity

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.

• Collegiality

New Mexico Tech is a place where people care about each other. That means establishing open communications with others, sharing values with them, and collaborating with them for the good of the institution and society as a whole. Collegiality also means mentoring: acting as a guide and advisor to a colleague, a student, a fellow staff member. It means caring about the community—the campus community, the community of Socorro, and the larger community of the State of New Mexico. This sense of communal caring stems largely from our shared responsibility to each other and the expression of our commitment to the communities we serve, whether local or global. And, collegiality means valuing diversity, realizing that persons of race or gender or ethnicity or nationality different from our own have importance both because they are human and because their experiences are different from ours and are therefore valuable.

• Service

As a community of learners, New Mexico Tech also acknowledges a responsibility to serving society, especially since learning helps meet not only individual needs, but also those of the larger community. Service is a source of motivation and inspiration to those who practice it, reflecting both a capacity for relating to others, as well as deep-seated concern for the quality of human life. The social benefits of service are further fulfilled through the expansion of knowledge by teaching, scientific investigation, technology transfer, and economic development.

• Leadership

New Mexico Tech has been, is, and will continue to be at the forefront of science and engineering research and education. Creating an open environment which also develops and fosters tomorrow’s leaders in those and other fields is of paramount importance. Leadership involves moving everyone toward a shared perception of our university’s vision, mission, and outcomes, toward a common understanding of where New Mexico Tech is now and where it should be heading, and toward an increased commitment to those ends. By engaging, enabling, and empowering others throughout the university, members at all levels and in a variety of areas can take on leadership roles. Strong, effective leadership is best exemplified not through methods of control, but through positive influence.

Accreditation

New Mexico Tech is accredited by the Higher Learning Commission (HLC) of the North Central Association of Colleges and Secondary Schools as a degree-granting university through the doctoral level. The website of the HLC is www.ncahlc.org, and the phone number is (312) 263-0456.

Tech’s 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 nonimmigrant students, by the United States Department for Exchange Visitor Program P-1-1282, and by the Veteran’s Approval Division of the Office of Military Affairs for attendance by students entitled to veteran’s benefits.

The chemistry curriculum is approved by the Committee on Professional Training of the American Chemical Society.

The bachelor’s programs in chemical engineering, electrical engineering, engineering mechanics, environmental engineering, materials engineering, mineral engineering and petroleum engineering are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET).

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

The Graduate School is a member of the Western Association of Graduate Schools and the Council for Graduate Schools in the United States.
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 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 friendly 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)

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 multi-million dollar training and decision support system to 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. Students with an interest in computer science, electrical engineering, management, information technology, or may find themselves working on an entry-level project. 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.

Institute for Engineering Research and Applications (IERA)

IERA is a contract research, development and technical assistance organization working in a variety of areas that are energy-, space-, and environment-related. IERA includes an administrative office and three technical divisions, all located in Albuquerque: the Environmental Finance Center, the Engineering and Information Sciences Division, and a Strategic Programs Office.

The Environmental Finance Center (EFC) was established in 1992 by the Environmental Protection Agency to provide assistance to state, local, and tribal governments and the private sector with the financial and managerial side of environmental compliance and infrastructure. The EFC provides technical assistance to tribal water systems to improve compliance with the Safe Drinking Water Act and to build and enhance the capabilities of tribal water system operators and managers. The EFC is also involved in Source Water Protection, alternative wastewater treatment methods, Clean Air Investment Fund, utility rate setting, tribal water system operator certification, and many other activities associated with environmental and security issues surrounding drinking water and waste water systems.

The Engineering and Information Sciences (E&IS) Division of IERA is involved in three major areas: engineering technologies, information technologies, and direct energy conversion, power, and propulsion technologies.

The Strategic Programs Office fosters growth of new areas and incubates a wide variety of research and applications. Currently, there are two efforts in international programs. First is the development and implementation of chemical/biological sensors and the establishment of the International Sensor Technology program within New Mexico Tech. Second is participation in a program to mentor and train engineers from foreign countries with regard to radioactive waste disposal issues (sponsored by the International Atomic Energy Agency and USAID). Additionally, investigators are working on energy conservation/energy efficiency studies for various agencies.

International Law Enforcement Academy (ILEA)

The mission of the International Law Enforcement Academy—Roswell is to provide advanced criminal justice management instruction to mid- to senior law enforcement officials from around the world and expose them to American society and institutions. ILEA’s goals are to enhance the ability of experienced law enforcement officials to combat crime in their respective countries and encourage bilateral and regional cooperation in combating transnational crime.

ILEA-R is a program of the U.S. Department of State, Bureau for International Narcotics and Law Enforcement Affairs.

ILEA-R is administered through a cooperative agreement with the New Mexico Tech. Tech has partnered with Science Applications International Corporation, Sam Houston State University and Eastern New Mexico University - Roswell to operate the Academy.
IRIS/PASSCAL Instrument Center and EarthScope USArray Array Operations Facility
(http://www.passcal.nmt.edu)

The Incorporated Research Institutions for Seismology (IRIS, www.iris.edu) consortium’s Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL) Instrument Center is located in New Mexico Tech’s Research Park. The Center is primarily funded by the National Science Foundation (NSF) and is operated by Tech professional staff in coordination with the Geophysics Program and the Geophysical Research Center. The Center staff engage in hardware/software development and training associated with earthquake, volcano, and other seismological research, handle logistical support for seismic experiments, and maintain the world’s largest academic pool of research seismological instrumentation. PASSCAL instruments are routinely employed throughout the world for research by NSF-funded and other investigators from Tech’s Geophysics Program, as well as many other U.S. and international research institutions. A key component of the Center’s operations is to provide unique opportunities for NM Tech students to learn about and contribute to the international seismological research community.

The Instrument Center also hosts the Array Operations Facility for the USArray component EarthScope (www.earthscope.org), a more than decade-long research project of unprecedented scope studying the deep geology and geophysics of the North American continent and the deep Earth.

Langmuir Laboratory for Atmospheric Research
(www.cee.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 related to cloud physics at Tech 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)
(mro.nmt.edu)

Magdalena Ridge Observatory, MRO, currently in construction and development stages, will be a world-class, state-of-the-art astronomical research facility. At an elevation of almost 10,700 feet, 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 will electronically link ten large optical and infrared telescopes to provide the resolving power of a single 400-meter telescope. The MRO will also have a stand-alone, 2.4-meter telescope that will make use of adaptive optics techniques to improve resolution.

New Mexico Tech is the lead institution in the consortium operating MRO, which also includes the University of Cambridge (U.K.), New Mexico State University, New Mexico Highlands University, and the University of Puerto Rico, and Los Alamos National Laboratory.

Federal funding for the research facility has been secured through the U.S. Naval Research Laboratory, the lead government agency for the project; while the U.S. Air Force Research Laboratory has supplied optics expertise and hardware for MRO.

Mount Erebus Volcanic Observatory
(www2.nature.nps.gov/nckri/index.htm)

Under support from the National Science Foundation Office of Polar Programs, the New Mexico Tech Geophysics and Geochemistry programs operate a year-round network of seismographs and associated seasonally deployed geochemical instrumentation on Mount Erebus, Antarctica. Mt. Erebus, the world’s southernmost active volcano, features a unique lava lake in its summit crater. Data from the seismic network are radio-telemetered to Crazy Science Lab at McMurdo Station on Ross Island, Antarctica, and are subsequently transferred via Internet to Tech for website posting to the general community, analysis, and archiving.

National Cave and Karst Research Institute
(www.nationalcaveandkarst.org)

The National Cave and Karst Research Institute facilitates speleological research, enhances public education, and promotes environmentally sound cave and karst management.

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
(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 the mineral industry and 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 Mineralogical Museum represents one of the 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.

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 Inspection

The New Mexico Bureau of Mine Inspection is a department of New Mexico Tech and the agency dedicated to promoting a safe and healthy environment for all contractors, miners, and visitors who enter and work in the mines and quarries of New Mexico.

The staff assists the State Mine Inspector in providing safety and health programs, training of miners, state certification of coal mine officials, and outreach to increase public awareness of the benefits of mining and hazards of abandoned mines. Service is available to all companies representing the aggregate and stone industry, coal mining, industrial minerals mining, metal mining, potash industry, and independent mining contractors located throughout the state as specified by federal and state laws. The staff also consults with mining companies to aid in their compliance with federal regulations, New Mexico statutes, and New Mexico constitutional mandates.

The Bureau of Mine Inspection promotes education by engaging in the instructional program of New Mexico Tech, employing student workers, and sponsoring public forums dedicated to promoting safe practice in the New Mexico mining industry.

### New Mexico Petroleum Recovery Research Center (PRRC)

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 CO2 flooding with emphasis on mechanisms that control injectivity; fundamental research on rock/fluid interactions and their influence on oil recovery; with emphasis on studies of wettability alteration and asphaltenes; reservoir characterization using artificial intelligence; carbon dioxide (CO2) sequestration studies; and the exploration of membrane and sensor technologies for potential use in cleanup of produced water from oil and gas recovery, for high-temperature CO2 capture, and even 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 support to three faculty joint appointments, 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 20,000 square feet), specially designed storage areas, a core-cutting and welding facility, machine and woodworking shops, an information center, and a large seminar room.
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

The Tech 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 National Science Foundation, and other agencies.

Playas Training Center

Playas Training Center, located in the “boothel” of New Mexico, is a "real-world" training center for programs in prevention and response to suicide bombings, terrorist activities, and other related programs. Operated by New Mexico Tech’s EMRTC division, 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

(www.nmt.edu/~nmtlib)

The Joseph R. Skeen Library participates in and encourages the education, research, public service, and economic development mission of New Mexico Tech and serves library users from the Tech community, Socorro, and beyond. The library is responsive to change in research and education programs and is current in implementing developments in information services. The library respects the rights and privacy, supports intellectual freedom, and upholds intellectual property rights of all.

Housed in an attractive, three-story building, Skeen Library contains 600,000 books, government documents, and periodicals. It also contains study rooms and carrels, a reading room, a computer lab with 19 computers, as well as a snack room. While the library is open 91 hours a week, as it moves to more and more electronic resources, these resources become available, both on and off campus, 24 hours a day. The library provides videos, maps, and microform collections that support the academic mission of New Mexico Tech.

The library also provides inter-library loan services that expand our borrowing privileges to more than 40,000 libraries worldwide. Students and faculty may also obtain permits to borrow materials at other university libraries in New Mexico.

A growing collection of archival materials relating to Tech, the New Mexico School of Mines, and late U.S. Representative Joseph R. Skeen, is also housed in the library.

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

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 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 Sun, 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 and Computer Science Department, 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 the facilities are encouraged to contact the director of the center at 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

New Mexico Tech’s Distance Education program offers graduate-level courses in energetic materials, engineering management, environmental engineering, mechanical engineering, petroleum engineering, science teaching and other disciplines. All distance education courses are offered to supplement campus degree program offerings. Distance courses are designated with a D following the course number in the New Mexico Tech Schedule of Classes.

The courses can be taken nearly anytime, anywhere, using live links between studios as well as live and recorded lectures delivered via the Internet. They are intended as a way to help graduate students complete degree programs while on varied work and travel schedules or when they live too far from New Mexico Tech to make attending an on-campus course feasible. No online degrees are offered at New Mexico Tech.

For information on Distance Education courses, contact us at (505) 835-5511, toll-free at 1-866-644-4887, eodi@nmt.edu. Current course listings can be found on the Educational Outreach and Distance Instruction web site, www.nmt.edu/~eodi.

New Mexico Tech Community College

The New Mexico Tech Community College provides continuing education courses in physical recreation, fine arts, workforce training, first aid, and other personal development classes for New Mexico Tech students, faculty, and staff and the surrounding community. Courses offered through the Community College complement the traditional Tech curriculum. No degrees are offered through the Community College.

Community College classes, designated with a C following the course number in the New Mexico Tech Schedule of Classes, are graded Satisfactory/Unsatisfactory.

Not all degree programs allow students to use Community College classes as electives toward the degree. Be sure to check with your major department to find out whether these classes may be used toward fulfilling their degree requirements.

Credit Community College classes are counted as part of an undergraduate student’s full-time course load and financial aid. Graduate students may enroll in a limited number of Community College classes to supplement their full-time course load on approval from the Graduate Office.

Full-time NMT faculty and staff may use their tuition waiver for Community College credit classes and receive a special price on most non-credit classes.

Socorro community members may enroll in Community College classes as special students.

The Community College Coordinator may be reached at 505-835-6581, at commcoll@nmt.edu, or at the office in Weir 105. Further information on the Community College may be found at www.nmt.edu/~eodi.
Advising Resource Center (ARC)

The Advising Resource Center serves both faculty advisors and students. We work towards the development of quality advising relationships between faculty and students, as well as provide a wide spectrum of academic support services to help students explore their life goals, interests, and abilities.

Academic advisors are assigned to undergraduate students from among the faculty in their major department. Undecided majors receive counseling and are provided with suitable interim advisors from the faculty.

Freshman First-Year Experience Program

The Freshman First-Year Experience program (FYE) is designed to help first year students smoothly transition from high school to New Mexico Tech. The program is an advocate for student success and fulfillment both inside and outside the classroom. The major component of the FYE program is the Freshman Seminar, EDUC 101. Freshman Seminar is a one credit hour course which covers the “how to’s” of becoming successful Tech student. Topics covered in the course include: college study skills, learning style, test-taking skills, time and stress management, goal setting, personal responsibility and money management.

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.

Group Opportunities for Learning and Development (GOLD)

GOLD is an academic assistance program based upon the idea that successful students can help other students. The GOLD tutoring services offer help in biology, computer science, chemistry, physics, math, and other courses. It is administered through the ARC, and services are free.

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 underprepared for the rigorous and demanding curricula at New Mexico Tech.

Student Affairs

Student Affairs’ goal is to help Tech students succeed in college. Offices include Career Services, Counseling and Student Health Center, Minority Programs, and International and Exchange Programs. Staff are available to provide students with information and advice on subjects including learning about a chosen profession, applying to study abroad, developing a time management plan, helping to find a scholarship, and dealing with a personal problem. Located in Wells Hall, offices are open 8 a.m. to 5 p.m. daily.

Career Services Office

This office coordinates on-campus interviews for permanent, summer, and cooperative education jobs, provides career counseling, advises students about the job search, keeps student placement records, maintains a library of employer and career opportunity materials, and provides workshops on various aspects of the job search process. The office coordinates the Cooperative Education Program, posts on-campus student job opportunities, assists students in finding on-campus employment, and sponsors fall and spring career fairs. Although Tech assumes no responsibility for obtaining employment for its students, every effort is made to assist those who take advantage of the service.

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 Psychologist Examiners. All services are strictly confidential and are free to students enrolled for six or more credits hours. The office is located in Wells 106 and is open from 8 a.m. to 5 p.m. weekdays. Crisis intervention is available during regular business hours. Counseling is short-term (five to ten sessions per semester) and focuses on coping with the stresses of academic life and personal development.

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 Wells 106 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.

Minority Programs Office

This office helps recruit and retain U.S. ethnic minority students by helping these students become part of the Tech community. A variety of activities and services are available:

- advising
- tutoring in math, chemistry, and physics
- providing information about scholarships, internships, and employment.

Minority Programs also serves as advocate for minority student organizations and club conferences.
Office of International and Exchange Programs (OIEP)

The International and Exchange Programs Office provides advice and counsel 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 include orientation, seminars, international receptions, an annual international exhibit, and coffee hours.

In addition, the office maintains information about study away opportunities in other countries, coordinates Tech’s student exchange program with a number of foreign universities (page 20), and manages the National Student Exchange program.

Student and Campus Life

Residential Life

New Mexico Tech housing consists of nine student residence halls and 24 family housing units located on and off campus, as well as one apartment complex off campus. 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; about 47 percent of full-time Tech students do. Freshmen are not required to live on campus.

Four of the halls (Driscoll, Presidents’, West, and South) sit on Tech’s tree-lined Campus Drive, surrounded by the gym, student union building, athletic field, student activity center, swimming pool, and tennis courts. The Altamirano Apartments and Baca Hall are just a block farther away. Desert Willow Apartments and the Guest House are southwest of these halls.

Driscoll Hall is a two-story, closed* hall for women. Each floor is divided into two wings, each of which shares a common bath. Hallways lead from the large lobbies on each floor to the rooms. Ceilings are high and open, with lots of sunshine.

Presidents’ Hall was built in the 1930s by the Federal Works Progress Administration (WPA). This three-story, closed* hall is accented by hardwood floors (except in the basements, which are carpeted). All basement rooms have window wells. Each floor shares a common bath.

West Hall, for men, is adjacent to the dining room and Student Union Building. This two-story, closed* hall has four wings, each of which shares a common bath. Hallways run on the interior of the building with room windows surrounding the exterior.

South Hall, Tech’s largest hall, is motel-style, with an open exterior layout. The three-story co-ed hall offers residents excellent views and easy access to fresh air. The rooms are suite-style, with two rooms sharing a bath.

Baca Hall is Tech’s co-ed tobacco- and alcohol-free hall, with quiet hours 24 hours a day. The motel-style, open exterior also offers excellent views and easy access to fresh air.

Altamirano Apartments offer both four-bedroom, two-bath, and two-bedroom, one-bath apartments. Each apartment is furnished and has a fully functional kitchen and ample closet space. The complex also offers laundry facilities, study rooms, and open courtyards.

Desert Willow Apartments are located in a private cul-de-sac. The two-bedroom, 1 1/2 bath townhouse apartments offer a secure, community-like atmosphere for single students and families. Each building is made up of six apartments, and each two buildings share a laundry room. In addition to the playground out the back door, Tech’s Children’s Center is just down the street.

Mountain Springs Apartments offer off-campus living with on-campus amenities for single students and families. Mountain Springs is located within walking distance, at the corner of Bullock and El Camino Real, with two different two-bedroom layouts and a one-bedroom layout. All apartments include local phone service, cable TV, and high-speed internet connections.

The Guest House overlooks the 15th green of the Tech Golf Course and is reserved for graduate students and non-traditional undergraduate students. To live in this fully furnished, four-bedroom house, the resident must be over 25 or be enrolled in a graduate program.

All Tech students, whether they live on or off campus, are accorded the rights of privacy and individuality expected by any U.S. citizen. Insofar as possible, commensurate with laws and the rights of others, students living in the residence halls have the same freedoms and responsibilities as any citizen.

* A closed hall has rooms which open onto interior hallways.
If you live on campus, you are expected to abide by Residential Life rules and procedures, which are found in the New Mexico Tech Student Handbook, the Room and Board Agreement, the Residential Life Handbook, and the New Mexico Tech catalog.

**Food Services**

**Dining Room and Meal Plans**

The New Mexico Tech food service is operated by Chartwells. The student board plan is served in the Dining Room, located in the Student Union Building. All-you-can-eat breakfast, lunch, and dinner are offered Monday through Friday. Brunch and dinner are served on Saturday and Sunday. Students may purchase a block of meals to be used during the course of a semester. For smaller purchases, flex dollars are included with meal plans. The block may be used to cover any meals served in the Dining Room. Meals and flex dollars may not be carried over to the next semester. Students living in Driscoll, Presidents, West, South and Baca halls must purchase a block of at least 150 meals plus 75 flex dollars per semester, which allows a student to dine on campus about 10 times per week. Block plans of 175 plus 50 flex dollars, 200 plus 25 flex dollars, and 250 plus 25 flex dollars are also available. For those living off campus, 25-, 50-, and 80-meal block plans are available.

Daily lunch and dinner features include a selection of hot entrees (including vegetarian entrees), a full salad bar, deli bar, dessert and beverage stations. Dinners include carved meats, pizza, display cooking, and steak or shrimp every other week. Students may also use their meal plan in the Canteen, where an assortment of sandwiches, hamburgers, pizzas, and hot entrees are offered. A brunch is offered on weekends in the Dining Room.

**Canteen**

The Canteen, also located in the Student Union Building, is a full service snack bar operated by Chartwells. Daily entrees are rounded out with offerings from an in-house bake shop, specialty coffees, salads, grab-and-go sandwiches, and pizza and grilled items. Students may also use their meal plan in the Canteen, where an assortment of sandwiches, hamburgers, pizzas, and hot entrees are offered. A brunch is offered on weekends in the Canteen.

**Coffee Shop**

A student-operated Coffee Shop is located in the Student Activity Center. The Coffee Shop offers students the opportunity to visit with friends, play jigsaw puzzles, do homework or work on one of the computers while indulging in a late-night snack. Coffee Shop hours are 7:00 to 10:00 p.m. seven days a week.

**Children’s Center**

The New Mexico Tech Children’s Center offers 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 2 1/2 through 6 that uses the Creative Curriculum and developmentally appropriate practices of the National Association for the Education of Young Children (NAEYC). 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 (505) 835-5240 or children@nmt.edu, or visit the Center at 1015 Neel for more information.

**Student Health Center**

Located in the Student Activities Center (SAC), 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 of the patient’s choice.

**Extracurricular Activities**

**SCOPE and Master Calendar**

The Office for Advancement and Information Systems Division (ISD) provide services to help you find out what is happening on campus. Events for the next few days are listed in the left-hand column of the Tech homepage, www.nmt.edu. SCOPE is emailed twice a week, on Mondays and Thursdays. When you open an account at the Tech Computer Center, you are automatically signed up for SCOPE. There is also a Tech calendar on the web, covering events for the next few years.

The Office for Advancement also provides news releases telling about the latest research and activities on campus. Be sure to check the Tech homepage for the most recent information.

**Student Government**

Students at New Mexico Tech assume important responsibilities for the regulation of their affairs. The Student Association is comprised of all enrolled undergraduate students who have paid the Student Activity Fee. Its governing body is the Student Senate, whose members are elected twice a year for one-year terms. With the approval of the Tech administration, the Student Senate regulates extracurricular activities, organizations, and events. 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.

A Graduate Student Association exists for graduate students.

**Physical Recreation**

The Physical Recreation Department enhances campus life by promoting wellness activities and offering instruction, wellness counseling, competitions, and club sports to the Tech community.

A number of Physical Recreation courses are offered for credit, such as yoga, basketball, volleyball, aerobics, golf, scuba, belly dancing, and many more. In addition, Physical Recreation maintains a fully-equipped health club/weight room and offers training in the use of equipment. The Tech community may use this facility at no charge.

Physical Recreation also oversees a number of club sports, including caving, climbing, golf, fencing, Frisbee, soccer (men’s and women’s), paintball, rugby, volleyball, and whitewater rafting. Rugby, soccer, and golf belong to regional leagues and compete against off-campus teams.

Equipment for backpacking, rock climbing, 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. Shows are generally free to students. In any given season, shows may include Celtic, classical, and Cajun music; theatrical performances, circus arts (juggling, acrobatics, magic), dance, world beat bands, jazz and blues, and many other forms of entertainment. Swing bands, Christmas shows, gospel music, ethnic folk dance groups, and bluegrass have all been known to put in appearances.

SPLAT (Student-Produced Leisure Activities at Tech) also brings entertainment to campus. SPLAT sponsors events such as Comedy Night, Movie Night, poetry slams, dances with live salsa or swing bands, barbecues with DJ’d dances, open mic nights, and shuttles to events of interest, like the Albuquerque Balloon Fiesta. SPLAT and PAS work together to find entertainment that will interest Tech students.

The Student Association funds various Tech clubs and organizes two big celebrations each year. In the fall, 49ers is a celebration of Tech’s mining heritage. Spring Fling gives students a fun break in the spring. Both feature games, contests, music, dances, barbecue dinners, and other events.

Socorro and New Mexico

Socorro is a friendly community of over 9000 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. Socorro’s population has one of the highest percentages of Ph.D.s per capita in the state of New Mexico.

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, and Taos (New Mexico), or Aspen and Durango (Colorado). Socorro’s year-round mild climate is ideal for bicycling, running, golfing, horseback riding, river rafting, and many other pursuits.

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. The entire state, with its long, colorful history and its mingling of Indian, Hispanic, and Anglo cultures, is an enchanting place to live and to explore.

Socorro has a pleasant, sunny climate year-round. Average rainfall is less than 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

Orchestra
Jazz Band
Chorus
Drama Club
Spring Musical

Club Sports

Rugby
Soccer, Men’s and Women’s
Golf
Caving
Climbing
Shooting
Fencing
Frisbee
Paintball
Volleyball
Whitewater Rafting

Games

Adventurers’ Guild
Chess Club
Billiards Club

Just for Fun

Anime Addicts
Society for Creative Anachronism
Miner’s Ink (creative writing journal)
Paydirt (student newspaper)
KTEK (student radio station)
Tech Amateur Radio Association
Aquatic Recreation

Professional Associations

Association for Computing Machinery (ACM)
American Indian Science and Engineering Society (AISES)
American Society of Mechanical Engineers (ASME)
Institute of Electrical and Electronics Engineers (IEEE)
International Society of Explosives Engineers (ISEE)
MAES, Society of Mexican American Engineers and Scientists
Materials Society
Society of Women Engineers
Society of Hispanic Professional Engineers (SHPE)
Tau Beta Pi, Engineering Honor Society
Society of Economic Geologists, student chapter (SEG)
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 Degree Requirements, the requirements common to all bachelor of science degrees, are listed on page 53. 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. The Bachelor of Science degrees 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 116 for more information about preprofessional programs.

Teacher Certification

Students enrolled at New Mexico Tech may work toward New Mexico alternative certification as secondary school teachers. The Bachelor of Science in Basic Sciences is appropriate for these students, and education courses required for teacher certification can be used for electives in this program. The Socorro Public School System cooperates by providing opportunities for observation and student teaching. Prospective teachers should consult the chair of the Department of Education as well as their regular academic advisor in planning their programs. See page 86.

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

New Mexico Tech offers three programs that allow students capable of above-average academic achievement to earn both a bachelor’s and master’s degree in five years. Through the Department of Earth and Environmental Science, students can earn a bachelor’s degree in Earth science with an environmental geology option and a master’s degree in geology (page 72) or a bachelor’s in a science or engineering field and a master’s degree in hydrology (page 80). The Department of Mathematics offers a similar opportunity for students majoring in mathematics (page 102), as does the Department of Electrical Engineering for students majoring in electrical engineering (page 129).

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 9–13).

Study-Away Opportunities

Arrangements for all types of study-away activity are made through the Office of International and Exchange Programs. To be eligible to apply for participation, students must, at a minimum:
- have been a full-time student at Tech for at least one year,
- have a cumulative G.P.A. of at least 2.5,
- have a clean disciplinary record, and
- be in good financial standing

National Student Exchange

New Mexico Tech is a member of the National Student Exchange, a consortium of some 175 schools within the United States and its territories, plus a few in Canada. Through NSE participation, students may spend up to a year at another NSE university while paying normal tuition and fees at New Mexico Tech.

International Student Exchange

New Mexico Tech has exchange agreements in place with the following institutions:
- Monterrey Tech – Campus Queretaro (Mexico)
- Monterrey Tech – Campus Cuernavaca (Mexico)
- Universidad Autonoma de Chihuahua (Mexico)
- Universidad de Sonora (Mexico)
- Stavanger University (Norway; restricted to graduate students in petroleum engineering)

As with the National Student Exchange, Tech students may arrange to spend up to a year abroad at one of these schools while paying their regular Tech tuition and fees.

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. Application forms are also available on the Web at www.nmt.edu/prospective.html.

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. 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 24.

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 explain any deficiencies.

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 used for course placement and advising purposes.

Procedure

To be considered for admission, an entering freshman 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.

In addition, students who do not meet Tech’s minimum ACT or SAT requirement but who have taken college-preparatory classes in math and science must:

6) submit letters of recommendation from at least two of their high school math and science teachers sent directly to the Office of Admission.

Appeal

Students who are denied admission may appeal the decision (see page 24).

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 24.

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.

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 used for course placement and advising purposes.

Procedure

Home-schooled students must follow the same procedure as entering freshmen (above) but instead of official high school transcripts, they must supply documentation of courses completed.

Transfer Students

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

Admission Requirements

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

1) The student transferring from another college or university must have completed the same high school course work requirements as entering freshmen (either from high school or from equivalent courses taken since high school).

2) The applicant must present college transcripts showing a cumulative GPA of 2.0 or better.
Transfer among New Mexico Higher Education Institutions

To facilitate transfer of students and course credits among New Mexico’s colleges and universities, the state’s public institutions of higher education are required to accept transfer courses taken within approved modules of lower-division coursework and apply them toward degree requirements. Several transfer guides have been developed through collaboration of New Mexico’s public postsecondary institutions, consistent with requirements of state law (21-18, NMSA 1978). Students enrolling for first-year or second-year study at a New Mexico institution and wishing to prepare for possible transfer into a degree program at another institution are advised to take these courses during their freshman and sophomore years.

Student Responsibility

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

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 earn their baccalaureate degree 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 New Mexico university and apply toward bachelor’s degree program requirements. 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.

<table>
<thead>
<tr>
<th>Area I: Communications</th>
<th>select 9 cr hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) College-level English Composition</td>
<td>3–4 cr hrs</td>
</tr>
<tr>
<td>b) College-level Writing</td>
<td>3 cr hrs</td>
</tr>
<tr>
<td>(a second course building on the above)</td>
<td>3 cr hrs</td>
</tr>
<tr>
<td>c) Oral Communication *</td>
<td>3 cr hrs</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Area II: Mathematics</th>
<th>select 3 cr hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) College Algebra *</td>
<td>3 cr hrs</td>
</tr>
<tr>
<td>b) Calculus</td>
<td>3 cr hrs</td>
</tr>
<tr>
<td>c) Other College-level Math+</td>
<td>3 cr hrs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Area III: Laboratory Science</th>
<th>select 8 cr hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) General Biology with Lab</td>
<td>4–8 cr hrs</td>
</tr>
<tr>
<td>b) General Chemistry with Lab</td>
<td>4–8 cr hrs</td>
</tr>
<tr>
<td>c) General Physics with Lab#</td>
<td>4–8 cr hrs</td>
</tr>
<tr>
<td>d) Geology/Earth Science with Lab</td>
<td>4–8 cr hrs</td>
</tr>
<tr>
<td>e) Astronomy with Lab</td>
<td>4–8 cr hrs</td>
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</tbody>
</table>

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<thead>
<tr>
<th>Area IV: Social/Behavioral Sciences</th>
<th>select 6–9 cr hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Economics (macro or micro)</td>
<td>3 cr hrs</td>
</tr>
<tr>
<td>b) Introductory Political Science</td>
<td>3 cr hrs</td>
</tr>
<tr>
<td>c) Introductory Psychology</td>
<td>3 cr hrs</td>
</tr>
<tr>
<td>d) Introductory Sociology</td>
<td>3 cr hrs</td>
</tr>
<tr>
<td>e) Introductory Anthropology</td>
<td>3 cr hrs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Area V: Humanities and Fine Arts</th>
<th>select 6–9 cr hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Introductory History Survey</td>
<td>3 cr hrs</td>
</tr>
<tr>
<td>b) Introductory Philosophy</td>
<td>3 cr hrs</td>
</tr>
<tr>
<td>c) Introductory Course in History, Theory or Aesthetics of the Arts or Literature</td>
<td>3 cr hrs</td>
</tr>
</tbody>
</table>

Total to be selected 35 cr hrs

* Will not meet general degree requirements (page 48)
+ Should be Calculus II
# Must be calculus-based physics

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:

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

Modules for additional areas of study are being developed. Copies of these transfer modules may be obtained at www.nmche.org

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) 827-7383, www.nmche.org
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) provide an official high school transcript;
3) provide official college transcripts from all colleges attended, reflecting all courses completed and in progress;
4) 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.

**Appeal**

Students who are denied admission may appeal the decision (see page 24).

**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 page 22 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://nmche.org/colleges/matrix.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). 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 the OIEP (Office of International & Exchange Programs). You must:
- Complete an International Undergraduate Application, either (1) online or (2) by downloading the International Student Information Packet from wwww.nmt.edu/prospective/admin/intl_under/. You may also request a Packet from the OIEP.
- Make sure official academic records (transcripts, mark sheets, exam results), along with certified English translations, are sent by the school you attended directly to the OIEP.
- If you want transfer credit from a foreign institution, supply a syllabus or catalog description, in English, of courses taken.
- Send a $15 application fee.
- If English is not your native language, submit an official TOEFL score.
- Complete the Certificate of Financial Responsibility (available at wwww.nmt.edu/prospective/admin/intl_under/ and in the Packet) 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 (page 24).

**Application Deadlines**

- June 1 for fall semester
- November 1 for spring semester
- April 1 for summer session

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**

All students at Tech are required to show proof of medical insurance coverage before initial registration. 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 Admission Office, 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 (page 21).
Concurrent Enrollment of High School Students

A student currently enrolled in high school may be admitted to New Mexico Tech as a concurrently enrolled student upon submission of a high school transcript and the written permission of the high school principal. High school students will be expected to pass pertinent course placement tests. **Concurrently enrolled high school students are not eligible for financial aid.**

### Readmission

A student who has not been continuously enrolled (excluding summer session) must submit an application for readmission to the Office of the Registrar. Deadlines for all readmission materials are:

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

The application will be reviewed by the Academic Standards and Admission Committee. Written notice of the decision will be given to the petitioner.

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

1. the catalog in effect when the student was readmitted or
2. any subsequent catalog, provided the student is continuously enrolled after readmission.

### Conditions of Readmission

1. A student in good standing will be readmitted by the Registrar.
   - If you have attended another 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 that institution.
2. A student who left on probation or suspension must submit the following documents before the Academic Standards and Admission Committee will consider the application:
   - A one-page appeal letter that persuasively makes a case for readmission;
   - A supporting letter from the student’s advisor;
   - A three-semester plan for coursework with a minimum of 12 credit hours in the first semester of the plan;
   - 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.

When readmitted from suspension status, the student will be on probation and subject to all the rules and regulations of a student on probation. Failure to meet the minimum GPA for academic good standing (page 5) will result in second suspension from New Mexico Tech. After such suspension, no student will be considered for readmission for at least 12 months. Credits earned at another institution during the period of suspension at New Mexico Tech will not be accepted for transfer.

### 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 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.

#### 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 on page 25. Advanced Placement credit is not awarded for grades of 1 or 2.

#### College Level Examination Program

No credit is given for the College Level Examination Program (CLEP). However, challenge exams are available in various courses (page 47).

### 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.

<table>
<thead>
<tr>
<th>ACT Math Score</th>
<th>SAT Math Score</th>
<th>Initial Math Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 or lower</td>
<td>490 or below</td>
<td>MATH 101</td>
</tr>
<tr>
<td>21 to 23</td>
<td>500 to 550</td>
<td>MATH 103</td>
</tr>
<tr>
<td>24 to 25</td>
<td>560 to 580</td>
<td>MATH 103 and 104</td>
</tr>
<tr>
<td>(concurrently)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26 to 29</td>
<td>590 to 660</td>
<td>MATH 104</td>
</tr>
<tr>
<td>30 or higher</td>
<td>670 or higher</td>
<td>MATH 131</td>
</tr>
</tbody>
</table>

You may also enroll in MATH 131 (Calculus and Analytic Geometry I) if:

1. You are transferring college credit in college algebra and trigonometry.
2. You have earned a 3 or higher on the Advanced Placement (AP) Calculus AB exam or a 3 or higher 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. **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 Credit

<table>
<thead>
<tr>
<th>Subject</th>
<th>Grades</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>3, 4, and 5</td>
<td>Receive credit for BIOL 111 for a total of three (3) credits. Students must take BIOL 111L for laboratory credit.</td>
</tr>
<tr>
<td>Calculus AB</td>
<td>3</td>
<td>Receive two (2) elective credits in mathematics. Students proceed directly into MATH 131, Calculus and Analytic Geometry I.</td>
</tr>
<tr>
<td></td>
<td>4 and 5</td>
<td>Receive credit for MATH 131 for a total of four (4) credits. Students proceed directly into MATH 132, Calculus and Analytic Geometry II.</td>
</tr>
<tr>
<td>Calculus BC</td>
<td></td>
<td>Use Calculus AB subscore. Credit awarded as above.</td>
</tr>
<tr>
<td>Chemistry</td>
<td>3 and 4</td>
<td>Receive credit for CHEM 121(3) for a total of three (3) credits. The student should consult the department chair concerning laboratory credits.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>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.</td>
</tr>
<tr>
<td>Computer Science A</td>
<td>3, 4, and 5</td>
<td>Receive credit for CS 111 for a total of four (4) credits.</td>
</tr>
<tr>
<td>Computer Science AB</td>
<td>3, 4, and 5</td>
<td>Receive credit for CS 111 and 122 for a total of seven (7) credits.</td>
</tr>
<tr>
<td>Economics</td>
<td>4 and 5</td>
<td>Receive credit for ECON 251 for a total of three (3) credits.</td>
</tr>
<tr>
<td>Macroeconomics</td>
<td>4 and 5</td>
<td>Receive credit for ECON 252 for a total of three (3) credits.</td>
</tr>
<tr>
<td>Microeconomics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>English</td>
<td>4 and 5</td>
<td>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.</td>
</tr>
<tr>
<td>Foreign Languages</td>
<td>3, 4, and 5</td>
<td>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.</td>
</tr>
<tr>
<td>Government</td>
<td>3, 4, and 5</td>
<td>Receive credit for PS 171 for a total of three (3) credits.</td>
</tr>
<tr>
<td>History</td>
<td>3, 4, and 5</td>
<td>Receive credit for HIST 141 and 142 for a total of six (6) credits.</td>
</tr>
<tr>
<td>U.S. History</td>
<td>3, 4, and 5</td>
<td>Receive credit for HIST 151 and 152 for a total of six (6) credits.</td>
</tr>
<tr>
<td>European or World History</td>
<td>3, 4, and 5</td>
<td></td>
</tr>
<tr>
<td>Music Listening and Literature</td>
<td>3, 4, and 5</td>
<td>Receive credit for MUS 101 (3) and 102 (3) for a total of six (6) credits.</td>
</tr>
<tr>
<td>Music Theory</td>
<td>3, 4, and 5</td>
<td>Receive credit for MUS 201 for a total of three (3) credits.</td>
</tr>
<tr>
<td>Physics C Mechanics</td>
<td>3, 4, and 5</td>
<td>Receive credit for PHYS 121 for a total of four (4) credits. The student should consult the instructor concerning laboratory credit.</td>
</tr>
<tr>
<td>Physics C E &amp; M</td>
<td>3, 4, and 5</td>
<td>Receive credit for PHYS 122 for a total of four (4) credits. The student should consult the instructor concerning laboratory credit.</td>
</tr>
<tr>
<td>Physics B</td>
<td>5</td>
<td>Receive credit for PHYS 121 for a total of four (4) credits. The student should consult the instructor concerning laboratory credits.</td>
</tr>
<tr>
<td>Psychology</td>
<td>5</td>
<td>Receive credit for PSY 121 for a total of three (3) credits.</td>
</tr>
</tbody>
</table>
Financial Aid for Undergraduate Students

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, financial aid, and student employment.

1. Institutional scholarships are based solely on your grades (high school GPA, standardized test scores, and college grades if you are a transfer student). You do not need to demonstrate financial need for an institutional scholarship—only your own academic merit.

2. In addition to scholarships, we offer financial aid, which includes:
   - Federal grants (e.g., Pell Grant, SEOG Grant)
   - Federal loans (e.g., Perkins Loan, Stafford Loan, PLUS Loan)
   - Federal work study
   - New Mexico grants (State Student Incentive Grant)
   - New Mexico Scholars Program (based on academic merit and financial need)
   - New Mexico work-study

Details on this year’s institutional scholarships and financial aid programs, including dollar amounts, are available at www.nmt.edu and in a brochure available from the Admission Office.

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.)

Deadlines for consideration of scholarships for the fall semester for first-time students are February 1 for the Gold and Silver scholarships and March 1 for the other scholarships. For consideration for a scholarship for the spring semester, the deadline is November 1.

Deadlines for scholarships for transfer students are June 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.

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 (e.g., 3.25 for Gold or Silver, 3.0 for Presidential, etc.) and have earned a minimum of 24 credit hours in the regular academic year. The requirements for your institutional scholarship are in the Scholarship Conditions and Requirements that you received with your scholarship offer. If your GPA falls below the requirements, the Financial Aid Office will award you whichever scholarship you do meet the requirements for. If your GPA again rises to meet the criteria of the higher level scholarship, your scholarship may return to the higher one. It is your responsibility to bring this change of eligibility to the attention of the Financial Aid Office. Please note that you may not qualify for a scholarship higher than the one you were awarded when you entered New Mexico Tech.

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 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.

Financial Aid

To apply for financial aid you must complete the Free Application for Federal Student Aid (FAFSA) and the New Mexico Tech Supplemental Application. There are a couple of ways to submit your FAFSA for processing. You may send the completed paper copy of the application form in the envelope provided with the application, OR you may apply over the internet at www.fafsa.ed.gov. New Mexico Tech’s Title IV code for the FAFSA is 002654.

For maximum consideration, please submit your FAFSA for processing before June 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 are 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 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 sign the award letter and return it to the Financial Aid Office.

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. be enrolled at least half time for all aid programs except Federal Pell Grant
5. not be in default on a federal student loan or owe a repayment on a federal grant.
Continuing Your Financial Aid at Tech

Each year, you must fill out the FAFSA and the New Mexico Tech Supplemental Application. These forms should be filed as soon as possible after January 1. For maximum consideration you should fill out the FAFSA before our priority deadline of June 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 quantitative and qualitative way. This is done by measuring both credit hours earned and cumulative grade point average. 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 (page 5).

The Satisfactory Academic Progress Policy applies to undergraduate students that participate in the following programs: Federal Pell Grant, Supplemental Grant, New Mexico State Student Incentive Grant, Federal Work Study, New Mexico Work Study, New Mexico Non-need Work Study, Perkins Loan, Federal Stafford Loan, and PLUS loan. Satisfactory Academic Progress for graduate students is defined by the Office of Graduate Studies.

To be in good standing for Financial Aid purposes, a student must earn at least 75% of the hours they have attempted with a cumulative G.P.A. of:

- 1.6 if you have attempted 0-29 credit hours
- 1.8 if you have attempted 30-59 credit hours
- 2.0 if you have attempted 60 or more hours.

If you fall below this standard you will be placed on financial aid probation 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 probation semester. If you do not meet the policy requirements by the end of the probation semester, you will be placed on financial aid suspension UNLESS during the most recent semester you earn 100% of the hours you attempt during that semester with a 2.25 semester G.P.A. In this case, you will be placed on conditional probation. During conditional probation, you will still be eligible to receive aid. To continue on conditional probation, you must earn 100% of the hours you attempt during a semester with a semester G.P.A. of at least 2.25. If you fail to meet the conditional probation requirements, you will be placed on financial aid suspension. To get off of conditional probation, you must meet the requirements of the Satisfactory Academic Progress Policy. 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.

There is also a maximum timeframe that a student has to complete an undergraduate degree. The maximum is 195 attempted credit hours. Once a student has reached 195 attempted credit hours, he/she will no longer be eligible for Federal or State Financial Aid. For students pursuing a second bachelors degree, the maximum timeframe is 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 30 hours to earn a second degree, the student will have financial aid eligibility for a maximum of 45 attempted credit hours.

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 G.P.A. 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 timeframe.

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 an A will have the hours count as attempted and earned when the course is repeated.


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


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.

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
- New Mexico State Student Incentive Grant
- Perkins Loan
- Federal Stafford 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.

Pre-Loan Counseling Policy

According to federal law, if you intend to borrow, you must complete a Pre-Loan Interview. Go to [www.mapping-your-future.org](http://www.mapping-your-future.org) and click the Online Student Loan Counseling icon. Complete the entrance loan counseling for the type(s) of student loans you intend to borrow or have been offered.
Exit Interview Policy

If you receive an education loan and you graduate, withdraw, drop below six credit hours, or do not re-enroll, you must complete an Exit Interview. Go to www.mapping-your-future.org and click the Online Student Loan Counseling icon. 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 27). 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 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 Career Services for more information.)

The Graduate Program

(www.nmt.edu/~grad/)

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. Our Master of Science Teaching program provides a growing number of New Mexico secondary school teachers with science and mathematics tools to challenge students back 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. The student is 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 an astronomical 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 and mineral science and engineering fields.

The Energetic Materials Research and Testing Center provides opportunities for graduate work in materials and mineral engineering, engineering mechanics, chemistry, physics, geophysics, and applied mathematics.

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.

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 guideline) and research in Tech’s programs are encouraged to apply for admission to graduate study. Applicants are strongly encouraged to employ application forms available on the internet at www.nmt.edu/~grad/. Printed forms can be requested by e-mail from graduate@nmt.edu or by mail from:

Graduate Office
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
- September 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 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 Graduate Office by April 1 (for summer and fall semesters) or by October 1 (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
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 $16 for those using domestic and online application packets mailed to applicants
4. Official Graduate Record Examination (GRE) scores. Applicants to Master of Science and Doctor of Philosophy programs at New Mexico Tech must submit GRE general test scores. If your GRE scores are no longer available because you took the examination too long ago, you must retake the GRE examination.

Information related to departmental requirements for the subject GRE may be obtained online, from the Graduate Office, 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 the Graduate Applications page and is included with preprinted materials sent to domestic applicants.

**Master of Engineering Management (MEM)**

Tech’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;
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 $16.00 for those using domestic and online international applications, or $30 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 Tech 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 Tech MEM program will aid in achievement of those goals.

**Master of Science Teaching**

Applicants to the Master of Science Teaching program must provide the following in addition to the completed Master of Science Teaching application materials:

1. Sealed, official transcripts of all college work;
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 $16 for those using domestic and online international applications, or $30 for international application packets mailed to applicants.

**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) examination in addition to the GRE. A computer-administered TOEFL score of 207 or paper-administered score of 540 is used as a guide for admission. Information about these examinations is available from the Educational Testing Service, Princeton, New Jersey 08540.

The cost of one calendar year of study for a graduate student paying out-of-state tuition is approximately $23,000. This includes tuition, fees, room and board, and reasonable personal expenses. In-state tuition rates, which would reduce the total by about $6,500, are available to international students only if they have been granted assistantships or qualified fellowships. Financial statements must be included with the application. Applications from international students, complete with supporting documents, and application fee should arrive in the Graduate Office by April 1 (for summer and fall semester) or by October 1 (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 September 15 for the spring semester. Individual departments may have earlier dates for consideration of assistantships. Tuition and fees are payable upon registration.

**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. 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 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 Graduate Office (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 the 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 who meets the qualifications 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.

Financial Aid 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 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. 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 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 if assigned recitation, laboratory, or tutorial duties. The maximum 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 is generally 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. Forms to document this understanding are available through the Graduate Office and must be on file with the Graduate Office 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 professional and industrial organizations and certain federal agencies. Amounts range from those covering tuition and fees to full support through monthly stipends. Fellows must devote full time to studies and research.

Need-Based Financial Aid for Graduate Students

Graduate students who are U.S. citizens or resident aliens are eligible to apply for the following programs: Federal and New Mexico Work-Study, Stafford Student Loans, and Perkins Loans. Regular graduate students must be registered for at least six hours per semester to be eligible for federal or state need-based aid.

International students may qualify for Tech’s Competitive Scholarship for International Students.

Employment

Part-time, on-campus employment is sometimes available to regular, full-time graduate students for up to 20 hours per week.

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.

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/ 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). The thirteenth credit is intended for registration in classes that are not related to the degree in progress. All other credits must be numbered 300 or above and must be applicable to the graduate program as determined by the advisory committee. Only full-time graduate students registered for a minimum of 12 credit hours are eligible for financial support.

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. A full-time graduate student may request transfer to part-time status provided the student is in good standing. Similarly, a part-time graduate student may request transfer to full-time status provided the student has a cumulative grade-point average of at least 3.0 for those courses in which a standard letter grade is received.

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. There are currently no graduate degrees that may be obtained solely by distance delivery. Distance graduate students are typically place bound or employed full-time. To be admitted as a distance graduate student, an applicant must meet the same standards for admission as a regular full-time graduate student. Distance students register for as many credits as are necessary, but typically not for more than 13 credits. While there is no requirement for continuous registration, each distance student must complete and have on file in the Graduate Office the Course Program that outlines the courses to be taken for the degree and the timing for completion of each.

Provisional

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. 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

Special graduate status provides an opportunity for those who have baccalaureate degrees to earn up to nine graduate credit hours per semester. Special graduate students are not degree candidates and are not eligible for assistantships, fellowships, and student employment. The Graduate Dean will serve as the advisor for special graduate students. 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 the graduate program.

Advisor and Advisory Committee

Each regular and provisional graduate student will be assigned a temporary advisor by the department from the student’s major field of study at the time of first registration. The student will formalize a thesis, dissertation, or independent-study advisor and an advisory committee by the end of the student’s second semester of residency. The student’s academic advisor must be a regular faculty member of the department in which the student is pursuing his or her degree. 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 online and from the Graduate Office. At the M.S. level, the advisory committee consists of at least the academic advisor and two other members. At the Ph.D. 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 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.

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 no later than the end of the second semester of residency. The course program is reported on the committee report form, available online and from the Graduate Office.

Course Load

Regular and provisional graduate students are required to continue registration each semester until certified for the degree. Registration for distance students must conform to the plan of study developed with their advisory committee and on file in the Graduate Office. 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. 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. Graduate students registered for twelve or more credit hours may audit up to three credit hours each semester. Audit credits apply to the semester course requirements.

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 work authorization, assistantship, or fellowship support, may elect to become a part-time student for one semester. While in this category, the student must enroll for at least three credit hours of thesis, independent study, or dissertation.

Grades

At the time of graduation, the cumulative GPA must be 3.0 for all courses numbered 300 or above with no grade less than “C.” Grades in courses designated for the degree must average “B.” Thesis (numbered 591), independent study (590), or dissertation (595) courses will be graded with an “S” only upon fulfillment of graduate degree requirements. Prior to completion, these courses will be awarded “NR” if performance for that semester is acceptable or “U” if performance is unacceptable. Directed research (course number 500) and other courses taken on an S/U basis may not be used to fulfill graduate degree requirements.

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 of Science or Ph.D.
degrees. Tech 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 Graduate Office. A candidate for the
Ph.D. degree must be registered as a regular full-time graduate
student for at least two semesters. During this time the individual
will be on leave from the regular position at Tech, but may apply for
an assistantship or other form of financial aid. 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:
1) earn a grade-point average of 3.0 or better each semester,
2) receive no grade less than C for those courses in which a standard
letter grade is received;
3) formalize their advisory committee by the end of their second
semester as a regular graduate student; and
4) establish their Course Program no later than the end of the
second semester of residency.

In addition, 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
Course Load, page 31); part-time students must be registered for
eight or fewer credits each semester.

Assistantships or fellowships are subject to immediate
termination if satisfactory academic progress is not achieved. 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 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 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. Detailed instructions for
completion of the thesis manuscript are available online at:
www.nmt.edu/~grad/studentinfo/manuscript.html

Master’s theses and Ph.D. dissertations must be publicly
presented and defended. After a successful defense, a thesis or
dissertation must be immediately submitted to the Graduate Office
for publication online, through the Joseph R. Skeen Library, and be
made available for publication elsewhere. 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. Forms to document this
understanding are available through the Graduate Office and must
be on file with the Graduate Office prior to the beginning of graduate
student’s involvement in the research project.

Deposit

Completed digital and printed theses or dissertations and
digital copies of independent study abstracts must be submitted to
and approved by the Graduate Office no later than two weeks prior
to the end of the semester in which the requirements for the degree
are to be completed.

Digital Theses 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 dissertations or
portions thereof that are undergoing copyright approval by the
author must be uploaded, but will be circulated locally or held.
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
Graduate Office for information on submission of digital
manuscripts.

Bound Volumes

Three printed copies must be submitted to and approved by
the Graduate Office two weeks prior to the end of the semester in
which the requirements for the degree are to be completed. These
three volumes must be printed using permanent ink or toner on 20-
 pound bond paper, or a high quality, low acid photocopier paper.
The text must be double-spaced and all materials (text, tables, and
diagrams) must be within page margins of one and one-half inches
for the left (bound) margin, and one inch for the top, bottom, and
right margins. Photographic reproductions must be of a permanent
nature and be securely bonded to each page. Complete guidelines
for manuscript preparation are available online at infohost.nmt.edu/
~grad/studentinfo/manuscript.html.

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
New Mexico Tech online digital thesis and dissertation database 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
appeal

Graduate Degree Requirements

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 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. The advisory committee may determine that a student’s previous academic experience has provided breadth and may recommend modification of this requirement;
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.

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 thesis and independent study research projects.
4) Coursework to be applied toward the degree must be approved by the graduate student’s advisory committee.

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 first option.

1) M.S. with Independent Study requires:
   a) Completion of at least 27 credit hours of approved course work, with at least 15 credit hours of 500-level courses;
   b) Completion of at least three credit hours of independent study; and
   c) Submission of a formal paper describing the results of the research to the candidate’s advisor and advisory committee.
2) M.S. with Thesis requires:
   a) Completion of at least 24 credit hours of approved course work, with at least 12 credit hours of 500-level courses;
   b) Completion of at least six credit hours of thesis work;
   c) Satisfactory oral defense of the thesis research; and
   d) Submission of three final copies of the thesis to the Graduate Office.

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

Three 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:

- Earth Science: Five-Year Program (page 72),
- Hydrology: Five-Year Program (page 80),
- Mathematics: Five-Year Program (page 102),
- Electrical Engineering: Five-Year Program (page 129).

Students admitted to five-year programs must apply for admission to the graduate program during their junior year. During their senior year, these students will be dual registered (page 30).
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, in other areas of New Mexico. For requirements, see page 132.

Master of Science Teaching Degree

The graduate program in science teaching provides graduate-level classroom and laboratory instruction for secondary school teachers of science and mathematics and leads to the Master of Science Teaching degree. Courses for science teachers are offered on the campus during the summer session and through distance education during the academic year. For requirements, see page 119.

Departmental Certification

The appropriate department must certify to the Graduate Office 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 Graduate Office on forms provided by the Graduate Office. These forms are:
1) The Advisory Committee Form, and
2) 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 Graduate Office. When all the requirements are completed, the record of the program is sent to the Registrar. 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 Council for recommendation to the Regents.

General Requirements for a Second Master of Science Degree at Tech

Students who wish to earn a second master’s degree at Tech must:
1) Satisfy the specific course requirements in both fields, and
2) Complete either:
   a) 9 additional approved credit hours plus a thesis (6 credit hours) in the second field, or
   b) 12 additional approved credit hours plus an independent study (3 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.

The doctoral student can expect to spend 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 accumulation of dissertation credits, typically after completion 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.

Admission to Candidacy

A doctoral student may apply for candidacy upon completion of a minimum of one year of study at Tech. 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.

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 completing the candidacy exam. A minimum of 24 credit hours must be devoted to the dissertation. The student is encouraged to explore the various current research projects in his or her field of interest before choosing a dissertation subject. The dissertation must be defended before the Tech faculty under the supervision of the student’s advisory committee. Manuscript requirements are on page 32. An external examiner will be included on the defense committee. The candidate must be registered during the semester in which the completed dissertation is submitted to the Graduate Office. Doctoral candidates are required to present at least one departmental or general seminar on the dissertation during their tenure as a graduate student. 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.

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 Tech 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 Graduate Office.
Expenses

For current information on Tuition and Fees, check our web page at www.nmt.edu or call the Admission Office at 1-800-428-TECH.

The minimum estimated expenses which must be met per semester by single, full-time students living on campus at New Mexico Tech during the 2005–2006 school year are:

Undergraduate Costs per Semester

<table>
<thead>
<tr>
<th></th>
<th>Non-Resident</th>
<th>Resident</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$1,578</td>
<td>$4,988</td>
</tr>
<tr>
<td></td>
<td>$2,418</td>
<td>$2,418</td>
</tr>
<tr>
<td></td>
<td>$433</td>
<td>$433</td>
</tr>
<tr>
<td><strong>Total Estimated Minimum Costs per Semester</strong></td>
<td><strong>$5,337</strong></td>
<td><strong>$8,747</strong></td>
</tr>
</tbody>
</table>

Graduate Costs per Semester

<table>
<thead>
<tr>
<th></th>
<th>Non-Resident</th>
<th>Resident</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$1,648</td>
<td>$5,300</td>
</tr>
<tr>
<td></td>
<td>$2,418</td>
<td>$2,418</td>
</tr>
<tr>
<td></td>
<td>$433</td>
<td>$433</td>
</tr>
<tr>
<td><strong>Total Estimated Minimum Costs per Semester</strong></td>
<td><strong>$5,398</strong></td>
<td><strong>$9,050</strong></td>
</tr>
</tbody>
</table>

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 (page 36).

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.

Schedule of Charges

Nonrefundable Charges

<table>
<thead>
<tr>
<th>Application Fees</th>
<th>Undergraduate $15 $16 $30 Graduate (for mailed international applications)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission Fees</td>
<td>Undergraduate $50 $25 Graduate</td>
</tr>
<tr>
<td>Graduation Fees</td>
<td>Associate’s Degree $20 Bachelor’s Degree $20 Master’s Degree $30 Ph.D. Degree $40 Thesis or Dissertation Defense Fee</td>
</tr>
<tr>
<td>Miscellaneous Fees</td>
<td>Challenge Examination Fee (per semester hour) $10 I.D. Card Replacement $5 Late Registration Fee (each day) $25 Late Validation Fee (each day) $25 Orientation Fee $6 Transcript (per transcript) $3.50 Withdrawal Fee</td>
</tr>
</tbody>
</table>

Refundable Charges

Tuition per semester (full-time students)

<table>
<thead>
<tr>
<th>Resident</th>
<th>Undergraduate (12–18 hrs) $1,577.49 $1,648.00 Graduate (9–13 hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonresident</td>
<td>Undergraduate (12–18 hrs) $4,937.50 $5,300.00 Graduate (9–13 hrs)</td>
</tr>
<tr>
<td>Total Estimated Minimum Costs per semester</td>
<td>$4,987.50 Undergraduate (12–18 hrs) $5,300.00 Graduate (9–13 hrs)</td>
</tr>
</tbody>
</table>

Tuition (per semester hour for part-time students)

<table>
<thead>
<tr>
<th>Resident</th>
<th>Undergraduate $131.48 Graduate $183.11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonresident</td>
<td>Undergraduate $415.63 Graduate $588.89</td>
</tr>
<tr>
<td>Fees and Deposits (per semester)</td>
<td>Auxiliary Services Fee $63.60 Institute Activities Fee $9.60 Laboratory Usage Fee $48.00 Sports Activities Fee</td>
</tr>
<tr>
<td>Undergraduate Student Activities Fee $71.23 Students taking 7 hours or more $35.61 Part-time Students (6 hours or fewer)</td>
<td></td>
</tr>
<tr>
<td>Graduate Student Activities Fee $62.81 Students taking 9 hours or more $31.40 Part-time Students (8 hours or fewer)</td>
<td></td>
</tr>
<tr>
<td>$51.36 Student Center Fee $100 Room Reservation/Damage Deposit</td>
<td></td>
</tr>
<tr>
<td>$200 Housing Deposit (Student Family Housing)</td>
<td></td>
</tr>
</tbody>
</table>

Housing Charges per semester (2004-2005 rates. 2005-2006 rates are not set until after this catalog goes to press.)

| Room (double occupancy) | $960 |
| Room (single occupancy) | $1,275 |
| Guest House | $1,500 |
| Four-bedroom apartment (furnished) | $1,700 |
| Two-bedroom apartment (furnished) | $1,825 |
| Family Housing (per semester) | $2,440 |

Board Charges per semester (2004-2005 rates. 2005-2006 rates are not set until after this catalog goes to press.)

| 225 block meal plan | $1,310 |
| 200 block meal plan | $1,222 |
| 175 block meal plan | $1,175 |
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 Admission Office 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. See page 48 for information on changing your residency.

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

Prior to 5 p.m. on the third Friday after classes begin

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:

| 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 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 27.

Room (Apartment or Residence Hall) Cancellation Policy

All refunds are based upon the student being formally released from the housing agreement.

The $100 Room Reservation/Damage Deposit serves as both a reservation fee and contractual guarantee. Refunds are made as follows:

- The student may cancel his or her agreement without penalty by June 1 for the fall semester; December 1 for the spring semester; and May 1 for the summer semester.
- The student who cancels his or her agreement after the above dates but before the beginning of the term will be charged a $250 fee for breaking the contract. The Room Reservation/Damage Deposit will be released into the student’s account.
- The student who cancels his or her agreement after the beginning of the term will receive a refund based on the following schedule:
  [Detailed refund schedule]

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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 withdraw from any or all summer classes after the first Friday after classes begin.

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- The student who cancels his or her agreement after the beginning of the term will receive a refund based on the following schedule:
  [Detailed refund schedule]
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, Child Care Center, and Student Activity Center.

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, cap, gown, and miniature diploma. Students completing the master's and doctoral degrees are charged designated graduation fees. Graduate students who are not registered when they defend their thesis or dissertation must pay an additional defense fee.

I.D. Card Replacement
A fee is charged for the replacement of a broken or lost student identification card.

*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 Fee
Students who fail to validate their registration on the day of registration 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.

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 175 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 upon payment of an additional fee and when Tech offers interim housing. The halls are generally closed between fall and spring semesters and may be closed at other times between terms when conditions warrant. Altamirano Apartments, Desert Willow Apartments, Mountain Springs Apartments, and Guest House remain open during semester breaks. Schedules for residence halls and dining facilities are published at the beginning of each residence period.

*Regular students registered for fewer than 12 credit hours pay one-twelfth the fee per credit hour.
Room Reservation/Damage Deposit

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 semester), 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 36). 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 Student Union Building (SUB).

Transcript Fee

Students are entitled to one official transcript of their academic records without charge per lifetime. A fee is charged for further copies. Free unofficial transcripts are available to currently enrolled students. Unofficial transcripts are not issued between semesters.

Withdrawal Fee

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

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. (See Change of Student Status, page 39.)

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 page 21 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. The Registrar’s Office must be notified that the student is dropping from full-time enrollment at the time the change of program card is returned to the Registrar’s Office.

Further information can be obtained in the Registrar’s Office.

*Regular students registered for fewer than 12 credit hours pay one-twelfth the fee per credit hour.
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 Admission Office. Students admitted under special status, who do not otherwise qualify for regular admission, may apply to the Admission Office for regular status after successful completion of 30 credit hours at Tech.

See Applying for Admission, page 21, 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.

Orientation

Orientation for incoming students begins the transition to New Mexico Tech and, for some, to living away from home. You'll have a chance to meet other students, tour the campus, talk to faculty and staff, meet with your advisor and set up your semester schedule.

Orientation is held at the beginning of each semester and summer session. A fee is charged.

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.

<table>
<thead>
<tr>
<th>ACT Math Score</th>
<th>SAT Math Score</th>
<th>Initial Math Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 or lower</td>
<td>490 or below</td>
<td>MATH 101</td>
</tr>
<tr>
<td>21 to 23</td>
<td>500 to 550</td>
<td>MATH 103</td>
</tr>
<tr>
<td>24 to 25</td>
<td>560 to 580</td>
<td>MATH 103 and 104 (concurrently)</td>
</tr>
<tr>
<td>26 to 29</td>
<td>590 to 660</td>
<td>MATH 104</td>
</tr>
<tr>
<td>30 or higher</td>
<td>670 or higher</td>
<td>MATH 131</td>
</tr>
</tbody>
</table>

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

Specific days are set aside for registration (see Academic Calendar). You may register online through the second Friday of instruction or in person through the third Friday of instruction, but you will be charged a late registration fee. 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 in hard copy or 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 Tech Business Office before you can complete registration.
Prerequisites and Corequisites

Some courses have prerequisites, 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 that should be taken during the same semester.

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.
- Undecided students work with the Advising Resource Center to determine the best placement until the major is declared.
- Each student works with his or her advisor each semester to plan the next semester’s courses. The advisor must approve the selected coursework and sign the registration form.
- Students seeking to minor in a subject must obtain a faculty advisor for the minor.
- Advisor/Major changes are initiated in the Advising Resource Center, Wells Hall, room 113.
- 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 33) and the specific requirements of the major department.

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 on the day of registration 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 must show proof of valid health and hospitalization insurance with another U.S.-based insurance company before registering for classes for the first time. Students are responsible for notifying the Student Health Center of any changes in their medical insurance.

Student who do not have coverage under another insurance plan can purchase insurance at www.StudentResources.com.

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 third Friday following the beginning of classes of a fall or spring semester or the first week of a summer session. During the first three weeks of the semester, 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 first week 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 41 for numerical equivalents of grades.

If you received

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

Then

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 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.

IN (incomplete)

You must complete the class within the time agreed upon with the instructor. Do not register for the class again. This is not considered a repeat.

The old grade will continue to appear on your transcript, but only the new grade will be calculated in your GPA. Students may not repeat courses at other institutions.

Withdrawing from a Course

(See also Withdrawal without Prejudice, page 41.)

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. (This option is only available for students who have successfully completed 30 or more credit hours.)
- Change to Audit.

(See page 41 for information on both S/U and audit grades.)

You are required to file the appropriate form with the Registrar’s Office in order to withdraw from a course or change to S/U or Audit.
Academic Policies

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 Tech is as follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Grade Points per Semester Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.00</td>
</tr>
<tr>
<td>A-</td>
<td>3.67</td>
</tr>
<tr>
<td>B+</td>
<td>3.33</td>
</tr>
<tr>
<td>B</td>
<td>3.00</td>
</tr>
<tr>
<td>B-</td>
<td>2.67</td>
</tr>
<tr>
<td>C+</td>
<td>2.33</td>
</tr>
<tr>
<td>C</td>
<td>2.00</td>
</tr>
<tr>
<td>C-</td>
<td>1.67</td>
</tr>
<tr>
<td>D+</td>
<td>1.33</td>
</tr>
<tr>
<td>D</td>
<td>1.00</td>
</tr>
<tr>
<td>F</td>
<td>0</td>
</tr>
<tr>
<td>S</td>
<td>Satisfactory (C- or better)</td>
</tr>
<tr>
<td>U</td>
<td>Unsatisfactory (D+ or worse)</td>
</tr>
<tr>
<td>SA</td>
<td>Satisfactory Audit</td>
</tr>
<tr>
<td>UA</td>
<td>Unsatisfactory Audit</td>
</tr>
<tr>
<td>IN</td>
<td>Incomplete</td>
</tr>
<tr>
<td>W</td>
<td>Withdrawal</td>
</tr>
<tr>
<td>WO</td>
<td>Withdrawal without Prejudice</td>
</tr>
<tr>
<td>NR</td>
<td>No Report</td>
</tr>
<tr>
<td>NG</td>
<td>No Grade Issued</td>
</tr>
</tbody>
</table>

An “I” preceding a grade indicates that the student originally received an Incomplete (IN) in the course. The grade points awarded are identical to those grades not preceded by an “I.”

Grade Point Average (GPA)

The total semester hours in which grades of A, A-, B+, B, B-, C+, C, C-, D+, D, and F have been received at this institution divided into the corresponding total grade points earned is the student’s cumulative grade-point average (GPA) (see page 5). 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.

Satisfactory/Unsatisfactory (S/U)

After completing 30 credit hours, any student in good standing may take up to a total of 18 credit hours on an S/U basis in undergraduate courses not normally graded S/U. (Transfer credits from other institutions are not included in the 18-hour maximum.) Courses may not be taken in this manner without consent of 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. Students who receive a grade of U will not receive credit for the course. Special students must have successfully completed 30 or more credit hours to register for courses on S/U basis unless the course is offered S/U only.

Incomplete (IN)

An Incomplete (IN) may be given in lieu of a grade when circumstances beyond a student’s control have prevented completing a significant portion of the work of a course within the allotted time. The student’s performance in the course must otherwise be satisfactory. Students must not register for a course in which they received a IN. An incomplete may be removed in a manner and within the time determined by the instructor concerned. At the completion of the course, the student will receive the appropriate grade preceded by an “I” to indicate the original incomplete status of the course. The grade points awarded are identical to those grades not preceded by an “I.”

An incomplete may not be continued beyond one year from the end of the term in which the IN is awarded. Failure of the student to remove the IN by that date will result in an automatic grade of F. In no case can an IN become a withdrawal (W).

No Report (NR)

No grade was issued by the instructor. This is a temporary grade which will be replaced by the actual grade when it is reported.

Withdrawal (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 40). Under no circumstances can an instructor assign a W in a course.

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. 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

Students seeking grade changes must speak first with the instructor, next with the department chair, and finally with the vice president for academic affairs. 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 Registrar’s Office.

Withdrawal without Prejudice (WO)

(See also Withdrawing from a Course, page 40.)

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. Such a petition must be presented in writing with supporting documentation (i.e., statement from a physician, obituary, etc.) before the end of the semester to the Vice President for Academic Affairs for review and consideration. 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 Academic 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 Tech, and
2) to facilitate the maintenance of high academic standards at Tech.

Good Standing

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

<table>
<thead>
<tr>
<th>Total semester hours attempted (cumulative)</th>
<th>Minimum semester GPA needed to maintain good standing</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-29</td>
<td>1.60</td>
</tr>
<tr>
<td>30-59</td>
<td>1.80</td>
</tr>
<tr>
<td>60 or more</td>
<td>2.00</td>
</tr>
</tbody>
</table>

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, or W. Transfer credits are not used in computing the GPA.

Academic Probation

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

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 Tech for the specified period of time. Credits earned at another institution during the period of suspension at New Mexico Tech will not be accepted for transfer at Tech without prior approval.

Duration of Suspension

The first suspension from Tech will be for one regular (fall or spring) semester. Second and subsequent suspensions will be for one calendar year.

Students may appeal suspension by petitioning for readmission. The Academic Standards and Admission Committee will review complete petitions on the Monday of registration.

Readmission

See conditions for readmission on page 24. Deadlines for all readmission materials are July 1 for fall semester, December 1 for spring semester, and June 1 for summer session.

If accepted for readmission, a student on academic probation or suspension will be automatically placed on probation. Failure to meet the minimum GPA requirement will result in suspension from Tech.

Notification of Probation and Suspension

Notification to the student of academic probation or suspension will appear on the student’s grade report at the end of each grading period. Academic probation and suspension will appear on the student’s official transcript.

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. Petitions must be submitted to the Registrar’s office by registration day, when the Academic Standards and Admission Committee meets.

Academic Honesty Policy

1. Introduction

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.” (See page 8.) Academic dishonesty is therefore unacceptable and will not be tolerated at this Institute.

In the following, the Dean shall mean the Dean of Students when undergraduate students are involved and the Graduate Dean when graduate students are involved; the term shall also mean the respective Dean’s designated representative. Similarly, in the sections reproduced from the Student Handbook, the term Dean of Students shall mean the Dean of Students when undergraduate students are involved and the Graduate Dean when graduate students are involved. The term the Deans shall mean both the Dean of Students and the Graduate Dean. The term number of days shall mean the number of working days.

The Student Handbook reminds students that “Dishonesty, such as cheating, plagiarism”, is one of the causes for “disciplinary measures”; it also describes a “Student Discipline Policy” (reproduced below in Section 6) governing such measures. However, as far as academic honesty is concerned, this policy, entitled “Academic Honesty” shall take precedence over any overlapping provisions of the Student Handbook. In case of any unforeseen conflict between this policy and any other, the President of the Institute shall determine the applicable policy and inform the Dean of the aforesaid conflict.

2. Academic Dishonesty

Academic dishonesty is defined as an act of academic fraud. It could be any of the following:
- **cheating**: the use of unauthorized material during a test, or the act of copying from another student;
- **plagiarism**: the unauthorized use or use without proper citation of either someone’s published work, unpublished material in someone else’s computer files or material derived from the Internet;
- **theft**: any form of unauthorized procurement of academic documents, e.g., exams, student reports;
- **falsification**: any form of illegal alteration of academic documents for any purpose including improper alteration of experimental data obtained in the laboratory;
- **impersonation**: the act of permitting another person to substitute for oneself at an examination;
- **obstruction**: interference with or sabotage of the work of any other person through vandalism or theft;
- **assistance**: the act of helping another to commit fraud in any of the above-mentioned ways.
3. Fostering Academic Honesty

The need to foster academic honesty imposes a nexus of responsibilities on the Institute, its students and faculty. 

The Institute: The Institute’s responsibility is to publish relevant policies, ensure that all such publications are consistent with each other, and implement the policies in a consistent manner.

Students: Each student’s responsibility is to understand for every academic assignment what is expected from him/her and what would indicate academic dishonesty.

Faculty: It is the responsibility of the instructor of a course to clearly articulate any special case of academic dishonesty that is relevant to that course but not covered in Section 2 above.

The following recommendations are intended to help in discharging these responsibilities.

Recommendations for the Institute:
- Compile useful articles on academic honesty and plagiarism and publish them on the Web.
- Ensure that graduate students, who are typically engaged in learning, teaching, and research, receive guidance about ethical issues in each activity.

Recommendations for students:
- Attend all classes; in case a class is missed, talk to the instructor and find out about assignments given and topics covered.
- Time management is crucial. When study time is planned, the possibility of last-minute panic is minimized along with the consequent temptation to take unethical shortcuts.
- Unless explicitly prohibited in a course, sharing and discussing ideas with other students is encouraged as it can facilitate learning. But make sure that you do not share what you turn in for individual assignments.
- Do not keep open books or course material in close proximity to you while you take a test unless it is explicitly allowed.

Recommendations for faculty:
- Mention this section of the catalog in your syllabus and in your introductory lecture.
- In the syllabus you hand out in the beginning of the course, list any special policies relevant to your course. For example, you could clarify what you mean by a restricted use of a resource like the Internet; you could set guidelines for non-standard assignments like group work, field trips, and ungraded papers. Furthermore, if you could include this syllabus in a Web page for the course, it could benefit students as well as other faculty.

4. Dealing with Incidents of Academic Dishonesty

If a dishonest action is discovered by, or brought to the attention of, a teaching assistant assigned to a course, he/she shall play the role of instructor as described below only if explicitly authorized by the faculty supervisor of that course; otherwise, the teaching assistant shall immediately convey the specific details to the faculty supervisor who will fill that role. The department chair or his/her designated representative shall substitute for an absent faculty supervisor.

When a case of academic dishonesty is detected, it is the instructor’s responsibility to (a) distinguish between a minor infraction and a major one, and (b) to take action appropriate to this judgment of severity. For example, a missed reference in an otherwise well-cited paper should be treated as carelessness; one unattributed remark in an ungraded paper should be considered minor. On the other hand, copying a substantial part of a term paper off a document available on the Internet should be considered a major violation; falsification of laboratory work by a student engaged in research should also be considered major.

Minor infractions repeated in spite of warnings may be treated as major.

Three classes of actions are available to the instructor. The instructor may
a) only warn, i.e., issue a warning to the student(s) without any penalty in grades;

b) only penalize the assignment in question, e.g., decrease the student’s grades for that academic work (perhaps a zero for the entire assignment or a part thereof) and/or ask the student to re-do the assignment;

c) penalize the course, i.e., directly change the course grade, e.g., drop a letter grade or assign an ‘F’ for the course.

The instructor must make every effort to discuss with the student(s) the violation detected and any grade penalty being imposed.

In cases (b) and (c), the instructor must write in a memo to the Dean that the grade for the course has been affected partly or wholly by an act of academic dishonesty, specify the nature of the violation and indicate its severity, give details as to time, place, and persons involved, provide any available supporting evidence, and state the specific grade penalty imposed. Further, the instructor may recommend in the memo that the Dean should impose an appropriate disciplinary action on the student. The term disciplinary action refers to a penalty listed under Disciplinary Action in Section 6.4. The Dean shall respond to the instructor as outlined later in this section.

If the dishonesty does not involve any course, e.g., when a student employed under an externally funded research grant falsifies laboratory data, the faculty supervisor must write a memo to the Dean as in case (c) above.

Notifications from the Instructor to the Dean must be sent within ten days of the discovery of the dishonesty or by the day when final grades are due, whichever is earlier.

Recommendations for the Faculty:
- Gather some evidence for the violation, e.g., copies of assignments exhibiting plagiarism, a witness in case of cheating during an in-class exam, a hard copy of a plagiarized Web page.

The Dean’s responsibility is to decide on the imposition of disciplinary action, i.e., whether or not disciplinary action should be imposed and, if so, which specific penalty (listed in Section 6.4) is appropriate. The Dean will follow the procedures described under The Dean’s Investigation (Section 6.3) with the following additions and clarifications:

1. On receiving a notification of dishonesty, the Dean shall look up the student’s record of past incidents of dishonesty.

2. The Dean shall convey to the student involved both the specific charge made by the instructor and the grade penalty imposed, inform the student about the provisions of this policy, and give him/her an opportunity to discuss the incident with the Dean.

3. If the current incident has been judged minor by the instructor but the student has a past record of dishonesty, the Dean shall determine whether or not this time the infraction shall be treated as major. Based on this determination, the Dean may elect to impose disciplinary action.

4. If the current incident has been judged major by the instructor, the Dean shall decide on the imposition of disciplinary action after considering the instructor’s recommendation, the evidence presented, the student’s account of the case, and any other fact the Dean finds pertinent. The absence of past incidents shall not be construed as a dilution of the seriousness of a major violation. For example, a graduate student who has falsified research results should not be treated leniently solely because it is his/her first incident of academic dishonesty.

5. The Dean shall consider requests from the student for additional time to gather evidence.

6. The Dean shall notify the student and the instructor whether or not disciplinary action is being imposed within ten days of the receipt of the instructor’s notification or five days from the end of any additional time period granted to the student.
Notifications of incidents of academic dishonesty from instructors shall remain in the student’s file in the Dean’s Office until one year after the student has graduated or has been expelled, at which point it shall be destroyed.

Annually, early in the Fall semester, the Deans shall present to the Faculty Senate the number of instances of academic dishonesty reported to them along with their breakdown by cases (b)/(c) of instructor notifications, instructor recommendations of disciplinary action, categories of infractions, disciplinary actions imposed, appeals, and their outcomes. In addition, they shall communicate any observations from the President regarding conflicts of this policy with any other so that they may be rectified.

5. Students’ Right to Appeal

A student who feels strongly that an academic grade is unjust can pursue the Grievance Policy described in Section 7. However, when the grade in question is the direct result of action(s) taken to address academic dishonesty, as also when the student wishes to appeal a disciplinary action imposed by the Dean, the procedures of the Student Discipline Policy described in Section 6 and modified below must be followed.

The student may request a hearing before the Discipline Committee; the request must be made in writing to the Dean; an undergraduate student must send a copy of the request to the Student Association while a graduate student must send a copy to the Graduate Student Association; the request must be made within five days of the receipt of the notification from the Dean.

The procedures listed under Hearing (Section 6.6) shall apply with the following additions and exclusions.

Additions
- The Dean shall submit the instructor notification plus any previous records of academic dishonesty of the student as evidence before the Discipline Committee.
- The instructor who brought charges of dishonesty may choose to act as a witness though he/she is not required to do so.
- If the committee decides that a grade penalty should be reversed, the instructor shall be required to submit a fresh grade computed by removing the penalty.

Exclusions
- If no disciplinary action is involved, i.e., only a grade penalty is being appealed, legal counsel will not be permitted and no tape recording will be made of the hearing.

The decision of the Discipline Committee may be appealed as described under Appeal of discipline committee decision (Section 6.7) with the following additions and exclusions.

Additions
- The instructor who brought charges of academic dishonesty may appeal the decision of the Discipline Committee.
- The President shall communicate the final outcome of the appeal to the student, the Dean, and the instructor who brought charges of academic dishonesty.

Exclusions
- If no disciplinary action is involved, i.e., only a grade penalty is involved, the decision of the Discipline Committee may not be appealed unless it was based on a tie.

The composition of the Discipline Committee shall be as described under Discipline Committee (Section 6.9) with the following modification.
- When the appeal is by a graduate student, the ratio of undergraduate to graduate students shall be reversed, i.e., the student members shall consist of two members of the Graduate Student Association and one alternate designated by the President of the Graduate Student Association and one member of the Supreme Court of the Student Association and one alternate (another member of the Supreme Court).

The following sections appear in the Student Handbook under General Campus Rules

6. Student Discipline Policy

The New Mexico Tech Student Discipline Policy has two primary purposes. First, it is intended to ensure that the student charged with disciplinary infractions is granted due process of law consistent with the principles of the United States Constitution. Due process means a fundamentally fair procedure based upon reasonable principles impartially applied. Second, the policy is intended to educate the student in question regarding the standards of conduct expected at New Mexico Tech and throughout society as a whole. The campus judicial process is not intended to mimic a genuine adversarial court proceeding but is based upon sound judicial practices. Students violating General Campus Rules are subject to disciplinary action in accordance with the following procedures:

6.1 Bringing of charges

Charges of violations of the General Campus Rules may be brought by any member of the student body or staff, including, but not limited to, members of the administration. Charges must be in writing, must specify the nature of the violation, and must give details as to time, place, and persons involved. This statement must be given to the Dean of Students within ten days of the incident(s) in question or the report of a violation. In all cases, “number of days” means that number of school days. The term “Dean of Students” shall be construed to mean the Dean of Students or the Dean’s designated representative.

6.2 Notification of charges

Students charged with violations of the General Campus Rules must be notified in writing by the Dean of Students of the charge within five school days of the bringing of charges. This notice must contain the particulars specified in the written statement of charges and a copy of this Discipline Policy.

6.3 The Dean’s investigation

The Dean of Students will investigate the charges and may impose disciplinary penalties as stated in the “Disciplinary Action” section. The action taken shall constitute the Dean’s decision. Regardless of the action taken by the Dean of Students, the student has the right of hearing and appeal.

6.4 Disciplinary action

A student who is found to have violated a General Campus Rule may be subject to one or more of the following penalties:
- Costs for damage to school property
- Removal from campus housing
- Disciplinary probation, not to exceed one calendar year (recorded in the student’s file in the Dean of Students’ Office)
- Interim suspension (see “Interim Suspension”)
- Disciplinary suspension, not to exceed one calendar year (recorded in the student’s permanent file in the Office of the Registrar)
- Permanent dismissal (recorded in the student’s permanent file in the Office of the Registrar)

If none of the above penalties is deemed appropriate, a student may be given an oral or written warning or statement that no disciplinary action is warranted. Disciplinary action may be taken in cases where students are convicted of breaking criminal or civil law off campus. The Dean of Students may also proceed with disciplinary action against a student or students without waiting for the results of off-campus criminal proceedings. The decision whether or not to take action shall belong to the Dean of Students.
6.5 Interim Suspension

At times, on the basis of his investigation, the Dean of Students may conclude that it is necessary to suspend a student immediately, prior to a hearing on the matter. This may be the case when the student in question is dangerous to himself or herself, to others, or to property. Under such circumstances, the Dean of Students, with the concurrence of the Vice President for Academic Affairs, or in his/her absence, a person designated by the Institute President, may impose an interim suspension pending written notice with a hearing to be set at a later date.

An interim suspension may not be imposed unless it is based upon facts which clearly show that the student’s continued presence on campus constitutes a danger to the student, to others, or to property. An interim suspension may not be based upon mere suspicion of guilt. Any student suspended on an interim basis has the right to a hearing before the Discipline Committee. The student suspended on an interim basis must present a written request for a hearing to the Dean of Students within five days of the effective date of the interim suspension. The hearing must be held within five days of the suspended student’s request for a hearing unless the student charged requests a delay, in which case the times specified in the following section shall apply.

The interim suspension shall terminate when the hearing is held. The Dean of Students may impose regular disciplinary penalties at this point in the proceedings.

6.6 Hearing

Upon request by the Dean of Students or by the student charged and subjected to disciplinary action, the case will be heard by the Discipline Committee. Requests for a hearing before the Discipline Committee must be presented in writing to the Dean of Students within five days of the effective date of the disciplinary action.

The hearing is not intended to be a full-fledged adversarial proceeding; it is intended to be a fair hearing with ample opportunity for both parties (the student and the Institute) to present the facts. The Institute will be represented by the Dean of Students.

The following procedures shall apply:
1. Both parties will be notified of the date of the hearing at least five days prior to the hearing (except in the case of interim suspension). In exceptional cases the Discipline Committee may choose to hold the hearing at an earlier time, but only with the express agreement of both parties.
2. Both parties shall be permitted to inspect, at least 24 hours in advance of the hearing, any documentary evidence which the other party intends to submit at the hearing.
3. Each party is permitted, but not required, to be represented by legal counsel. The other party must be advised of the intent to have counsel present at least five days before the hearing.
4. Both parties or their counsel may question any witness who testifies at the hearing.
5. A tape recording will be made of the hearing. A more formal record by a court reporter may be arranged by either party at their own expense.
6. The hearing shall be private if so requested by the student charged.
7. The student charged is not required to testify in his/her own defense and failure to testify shall not be held against the student.
8. The Discipline Committee will base its findings and decision solely on the evidence presented at the hearing.
9. The Discipline Committee shall give a written copy of its findings and decision to the parties within a reasonable amount of time. A copy of the findings and decision will also be kept on file in the Dean of Students’ Office.
10. The Discipline Committee may affirm, reverse or modify the decision of the Dean of Students. The decision of the Discipline Committee shall be final unless appealed and reversed or modified.

6.7 Appeal of discipline committee decision

Either the student charged or the Dean of Students may appeal the decision of the Discipline Committee. This appeal, which must be in writing, will be sent to the Vice President of Academic Affairs of the Institute within ten days of the date of the Discipline Committees written decision. The Vice President of Academic Affairs’ review shall be limited to a review of the record made before the Discipline Committee, including all documentary evidence, if any, admitted. However, the Vice President of Academic Affairs may allow such additional testimony and/or documentary evidence to be presented to him/her as he/she may, at his/her sole discretion, determined necessary in order to clarify the facts and/or the respective position of the parties. The Vice President of Academic Affairs may recommend to the President affirmation, reversal, or modification of the Discipline Committee’s decision to the President. Following this, the decision of the President shall be binding. The decision of the Vice President of Academic Affairs shall be returned in a timely manner. Should the President be a party to the dispute, a person selected by the Regents shall perform the duties assigned to the President.

6.8 Records of disciplinary actions and hearings

1. A letter of warning placed in a student’s file in the Dean of Students’ Office shall be removed from the file and destroyed after one year unless further disciplinary action has been taken against the individual as a result of other separate charges prior to the expiration of the year. In the latter event, all disciplinary records will be removed from the student’s file and destroyed one year after the latest disciplinary action.
2. A record of disciplinary probation in a student’s file in the Dean of Students’ Office will be removed and destroyed at the end of the probationary period.
3. A record of disciplinary suspension in a student’s file in the Dean of Students’ Office will be removed and destroyed one semester following the student’s readmission to the college. A record of disciplinary suspension will, however, remain in the student’s permanent file in the Office of the Registrar.
4. Two years following the hearing of a charge, the report of the Discipline Committee and the tape recording or other record of the hearing will be destroyed.
5. Any student may examine his or her own file and may request that records of disciplinary action be removed and destroyed. Such requests will be reviewed by the Dean of Students and must be honored if the relevant period specified in the paragraphs 1, 2, 3, and 4 above has expired.

6.9 Discipline committee

1. The Discipline Committee shall hear cases of students charged with violations of General Campus Rules and subject to disciplinary penalties if requested by either the student charged or the Dean of Students. The committee will then make its decision following a hearing on the matter.
2. The Discipline Committee shall be composed of:
   • two members of the Supreme Court of the Student Association and one alternate (another member of the Supreme Court)
   • one member of the Graduate Student Association and one alternate as designated by the President of the Graduate Student Association
   • three members of the Faculty Council and two alternates (not members of the administration other than chairpersons of academic departments) elected by the Faculty Council
3. Either party to the dispute may disqualified one member of the Discipline Committee. Members may also disqualify themselves and should do so if they are aware of any reason they would not be able to render a fair and impartial decision.
4. The Discipline Committee shall establish its own procedures and shall select its own Chairperson, except that a quorum shall consist of all six members of the committee. (In the event that one or more committee members are unable to meet at times consistent with the provisions of previous sections titled Interim Suspension and Hearings, an alternate member shall serve.) The Chairperson must vote on each and every issue. In case of a tie vote on the charges, the student shall be found innocent, and in case of a tie vote on the discipline imposed, the less serious disciplinary action shall be recommended to the Dean of Students.

7. Grievance Policy

Occasionally students may have reason to disagree with an academic decision or feel that they have a legitimate grievance against an instructor or staff member at Tech.

Students should be aware that the Dean of Students is available to all students to discuss and advise on any troublesome matter of academic concern and frequently helps to expedite resolution of such matters.

7.1 Academic Grievance

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

- The student first should discuss the grievance, orally or in writing, with the instructor in question.
- If the student is not satisfied, he or she should then consult with the instructor’s department chair. If the grievance 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 grievance to the Vice President for Academic Affairs or his/her designated representative.

Requesting a Transcript

In order for your transcript to be released, you must have a zero or credit balance at New Mexico Tech.

Our goal is to have your transcript ready to be picked up or mailed within two working days after your request, except during peak processing periods.

The cost is $6.00 per transcript, with an additional $3 charge if 1) you want the transcript faster than two working days or 2) you want the transcript faxed.

Information Needed

You must provide the following information to request a transcript:

- Transcript Request Form or a letter requesting your transcript
- Your name. If your name has changed, be sure to tell us the name you had when you attended Tech.
- Your address and phone number.
- Your Tech ID or Social Security number
- The approximate years you attended Tech
- Complete address(es) of where you want transcript(s) sent
- If transcript is to be sent to you, whether you want it in a sealed envelope. (Transcripts used for applications usually need to be in a sealed envelope.)
- YOUR SIGNATURE!

Methods

You can request a transcript:

- In person at the Registrar’s Office, Brown Hall 100. Pay your fee at the Cashier’s Office.
- By mail. Include a check for $6.00 (U.S.) per transcript, made out to New Mexico Tech.
  Send your request to:
  Registrar’s Office
  New Mexico Tech
  801 Leroy Place
  Socorro, N.M. 87801
- By fax. Include your MasterCard, Visa, or Discover card number and expiration date. If you are using a parent’s card, that person should write “I’m authorizing [your name] to use my credit card,” and add their signature. Our fax number is (505) 835-6511.
- By e-mail. We can only accept a transcript request by e-mail if the e-mail contains a scanned copy of your signature. Follow the instructions above for requesting a transcript by fax. Send your e-mail to registrar@admin.nmt.edu.

Rush and Faxed Transcripts

You can request a quicker turn-around than two working days. The fee is an additional $3 (total $9.00). The transcript is usually sent out within one working day.

You can also request that we fax a copy of your transcript to a recipient. However, we require the recipient’s physical address and will follow the fax with an official copy of your transcript. The fee is an additional $3 (total $9.00).
Other Policies

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.

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 students: see page 31 for information about academic 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 College (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 in the Office of the Registrar.

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. Illness or other circumstances that necessitate extended absence from class work should be reported as promptly as possible to the Dean of Students, who will notify the student’s instructors.

Students on Military Active Duty must notify the Dean of Students 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 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.

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 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 35). 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, including all courses taken in residence and by correspondence, must not exceed 18 credit hours without the advisor’s approval. Any student who is enrolled for a correspondence course must report this fact in writing to the Vice President for 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 Tech. 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 awarded. 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.

Directed Study Courses

To be included as part of a student’s declaration of courses fulfilling degree requirements, directed study courses (courses numbered 391 or 491) 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.

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 faculty and staff with a legitimate educational interest. 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 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, 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. Tech will honor your request to withhold directory information but cannot assume responsibility to contact you for subsequent permission to release them. Regardless of the effect upon you, Tech assumes no liability for honoring your instructions that directory information be withheld.

For more information, contact the Registrar’s Office, Brown 101, (505) 835-5000.
**Changing Your Residency**

If you are over 18 years of age, you may become a legal resident of New Mexico for tuition purposes by meeting the following basic requirements:

1. You must physically reside in the state for the 12 consecutive months immediately preceding the term for which resident status is petitioned.
2. You must be financially independent of your parents or legal guardians when the latter are nonresidents of New Mexico.
3. You must sign a written declaration of intent to relinquish residency in another state and to establish it in New Mexico.
4. You must complete several "overt" acts which support the written declaration of intent to become a resident, including:
   - if employed, present evidence that employment was within the state of New Mexico
   - if employed in New Mexico, present evidence of payment of New Mexico state income tax;
   - obtain New Mexico driver’s license
   - obtain New Mexico vehicle registration; and
   - register to vote in New Mexico

Any act considered inconsistent with being a New Mexico resident will cause the request for resident classification to be denied. Other relevant factors may be considered in addition to the items listed above. For example, additional documentation which may be requested may include: 1) evidence of a long established bank account of at least six months in New Mexico, or 2) evidence of residential property ownership in New Mexico or evidence of a rental agreement within the state.

You must meet the requirements of all of the overt acts listed in this section unless you can sufficiently demonstrate why you are unable to do so. 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, New Mexico Tech will afford the student an opportunity to provide other documentary evidence or reasonable explanation which demonstrates that you have established permanent residency.

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 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 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 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 Tech.

**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 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 Advising Resource Center and at the Graduate Office);
4. complete an exit interview with the Financial Aid Office; and
5. notify the Registrar's Office 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 40).

If you do not complete these steps, your transcript and/or diploma will 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 41 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 Tech.

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

- Discipline
- Drug and Alcohol
- Grievance
- Privacy Rights
- Quiet
- Vehicles
Graduation Requirements

To graduate, 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) a) To qualify for all bachelor’s degrees, except the Bachelor of General Studies degree, the student must complete the General Degree Requirements as stated on page 53.
   b) Requirements for advanced degrees can be found on pages 33–34.
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 130.
5) New Mexico Tech’s Community College classes (designated by the letter “C” in the course number) may not be used to fulfill the General Degree Requirements for a Bachelor of Science degree (page 53). 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 5) 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 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 Council.
9) All fees and financial obligations to Tech must be paid before a student will be awarded a degree. All students who complete a campus check-out form are required to have a release from the Financial Aid Office.
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 a 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 4 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 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 Council 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.

The Office of the Registrar sends out degree audits for juniors and seniors during the fall and spring semesters.

Commencement

Commencement ceremonies are held each year in early May. If you finish your degree requirements in August or December, you may participate in ceremonies held the following May. Students must complete all degree requirements in order to participate in commencement. The only exception is for the geology major who needs to complete GEOL 480, Field Methods, during the summer immediately following commencement.

See pages 50–51 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 13 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 may be named a “Tech Scholar” upon the recommendation of the advisor and the approval of the Vice President for Academic Affairs. The student must have completed 65 or more credit hours at 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. In recognition of scholarly competence, the Tech Scholar may:

- register for courses without the required prerequisites when the student, the advisor, and the instructor agree that sufficient achievement is likely to be made;
- obtain a passing grade of a higher course in a sequence and thus waive the lower course degree requirement (with departmental approval) where the lower course is a prerequisite for the higher course (no credit shall be given for the waived lower course);
- request a grade of S (satisfactory) or U (unsatisfactory) in such a course, rather than the usual letter grade (this request must be received by the instructor in writing by the 12th week of the semester; the grades of S and U shall not be counted in the GPA);
- register for graduate courses on the same basis as outlined above;
- register early at preregistration.

Commencement Awards

Graduation with Honors

Any undergraduate student who has earned a cumulative GPA of 3.0 or higher at 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

Honors are calculated using the fall GPA. A student with fewer than the two final years in residence at Tech must have attained the required average overall, as well as at 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 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 $500 prize.

Cramer Award

This award was established to honor Tom Cramer, an engineer and a member of the 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 $200 prizes. The recipients are chosen by the Faculty Council 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 Tech through scholarship, research, and involvement in campus affairs. The recipient is chosen by faculty nomination and Faculty Council election. The award consists of a plaque and a $400 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 Institute Senate’s Honorary Degrees and Awards Committee. The award is named in honor of Irving Langmuir (Nobel Laureate, 1932) who conducted extensive research with Tech staff. The award consists of a plaque and a $200 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 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 of Directors 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 who have contributed outstanding service. Recipients are selected by the Alumni Association Board of Directors 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 Tech faculty or staff nominated by their colleagues and chosen by a committee of fellow researchers.
## Department Awards

The Alumni Scholastic Scholarship is given to the graduating senior with the highest GPA in a number of departments, including, biology, chemistry, computer science, electrical engineering, environmental engineering, humanities, materials engineering, mathematics, mechanical engineering, and physics.

<table>
<thead>
<tr>
<th>Department</th>
<th>Name of Award</th>
<th>Criteria and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>David K. Shortess Prize</td>
<td>Awarded to the outstanding graduating student in biology.</td>
</tr>
<tr>
<td>Chemistry</td>
<td>Morris F. Stubbs Award</td>
<td>Given in honor of Morris F. Stubbs, professor emeritus.</td>
</tr>
<tr>
<td>Computer Science</td>
<td>Patrick Orr Memorial Award</td>
<td>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.</td>
</tr>
<tr>
<td>Earth and Environmental Science</td>
<td>Albuquerque Gem &amp; Mineral Club Scholarship</td>
<td>Given to a junior or senior majoring in earth science who displays academic excellence in the field.</td>
</tr>
<tr>
<td></td>
<td>Anton and Anita Budding Graduate Research Scholarship</td>
<td>Given to a graduate student in good standing in the earth and environmental science department.</td>
</tr>
<tr>
<td></td>
<td>Estwing Award</td>
<td>Given to a senior graduating with a degree in earth science. The award consists of a rock hammer and certificate.</td>
</tr>
<tr>
<td></td>
<td>New Mexico Geological Society Lucille Pipkin Undergraduate Scholarship</td>
<td>Given to a junior or senior earth science student, with preference to students with interests in subsurface, sedimentary, and/or petroleum geology.</td>
</tr>
<tr>
<td></td>
<td>New Mexico Geological Society Registration Award</td>
<td>Given to a student majoring in earth science. The award pays for registration for the New Mexico Geological Society’s Fall Field Conference.</td>
</tr>
<tr>
<td></td>
<td>NM Geological Society Robert Wellnitz Memorial Scholarship</td>
<td>Given to a master’s or doctoral earth science student for excellence in field-oriented research.</td>
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<tr>
<td></td>
<td>New Mexico Geological Society Grant-in-Aid</td>
<td>Given to a student majoring in earth science who is doing research in New Mexico. A cash award of up to $500.</td>
</tr>
<tr>
<td></td>
<td>Roswell Geological Society Award</td>
<td>Given to a graduate student or a graduating student who is majoring in earth science.</td>
</tr>
<tr>
<td>Environmental Engineering</td>
<td>Paige Ashman Memorial Prize</td>
<td>Given to a graduating senior who has demonstrated excellence in environmental engineering and is active in the student environmental club.</td>
</tr>
<tr>
<td>Humanities</td>
<td>Howard Sylvester Prize</td>
<td>Given to the member of the graduating class who has shown high achievement in the Humanities.</td>
</tr>
<tr>
<td>Information Technology</td>
<td>Addy and Ravi Bhasker Award</td>
<td>Given to the graduating student with the highest GPA in information technology.</td>
</tr>
<tr>
<td>Materials &amp; Metallurgical Engineering</td>
<td>Paige Ashman Memorial Prize</td>
<td>Given to B.S., M.S., and Ph.D. students who have demonstrated excellence in the field and who are active in the departmental societies.</td>
</tr>
<tr>
<td></td>
<td>Ron Roman Scholarship</td>
<td>Given to a student who has demonstrated excellence in materials engineering and contributed to Tech’s research effort.</td>
</tr>
<tr>
<td>Mineral Engineering</td>
<td>AIME Award (the Central New Mexico section of the American Institute of Mining, Metallurgical, and Petroleum Engineers)</td>
<td>Given to a mineral engineering student, who is a junior, senior, or graduate student. The student must reside in Albuquerque, Farmington, Gallup, Grants, Los Alamos, Questa, Raton, Santa Fe, Socorro, or Taos.</td>
</tr>
<tr>
<td></td>
<td>Old Timers Award</td>
<td>Given to a graduating senior who is interested in the coal mining industry.</td>
</tr>
<tr>
<td>Petroleum Engineering</td>
<td>John M. Kelly Fellowship</td>
<td>Given to an outstanding graduate student.</td>
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<tr>
<td></td>
<td>Langdon B. Taylor Award</td>
<td>Given to a student who has rendered outstanding service to the student chapter of the Society of Petroleum Engineers.</td>
</tr>
<tr>
<td>Physics</td>
<td>Abraham and Esther Brook Prize</td>
<td>Given to a student who has demonstrated excellence in physics. The $650 prize is given at the end of the junior year.</td>
</tr>
<tr>
<td></td>
<td>Leslie Fallon Award</td>
<td>Given to the graduate student who does the best job of teaching freshman physics laboratory.</td>
</tr>
<tr>
<td></td>
<td>Marvin Wilkening Award</td>
<td>Given to the graduating physics student who has demonstrated excellence in experimental physics. The technical tool kit is valued between $600 and $700.</td>
</tr>
</tbody>
</table>
Courses 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.

Credit Hours

Following the course title, you will find the number of credit hours (cr) you will receive for completing the course. Credit hours 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 and is equivalent to one (1) credit hour. "3 lab hrs" equals about three hours per week in the laboratory and is also equivalent to one (1) credit hour.

In addition to class and lab time, you 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. 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.

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 GEOL 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 2005 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.

New Mexico Tech’s community college classes (designated by the letter “C” in the course number) may not be used to fulfill the General Degree Requirements for a Bachelor of Science degree (listed on page 53). However, these classes may be used to fulfill elective credit for some programs.

Degree Requirements

In order to graduate, every student enrolled in a Bachelor of Science program must complete Tech’s General Degree Requirements, which are listed on page 53. This core set of requirements contains courses in humanities, mathematics, and basic science or engineering.

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.

Sample Curricula

Each program provides 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.
General Degree Requirements for a Bachelor of Science Degree

To fulfill the general education requirements for the Bachelor of Science degree from New Mexico Tech, each student must complete the following courses. Where there are options, the student should consult with his or her appointed advisor. These requirements do not apply to the Bachelor of General Studies degree (page 87).

Purpose of the General Degree Requirements

New Mexico Tech views its general degree requirements as the foundation for a broad and meaningful educational experience for all its undergraduates. The New Mexico Tech general degree 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 degree 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 degree requirements are designed specifically to achieve these objectives and to prepare students for success in subsequent courses.

Learning Objectives of the General Degree Requirements

- An ability to communicate well
- An ability to reason well
- An ability to evaluate and apply information
- Development of analytical and quantitative skills
- Competency of the fundamentals of mathematics and basic sciences
- An understanding of human societies and cultures
- A recognition of responsible values and ethics

GPA Requirements

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

General Degree Requirements for a Bachelor of Science Degree

I) Humanities and Social Sciences
   A) English (total 9 hours (6 hours if ENGL 111 is waived))
      1) ENGL 111* (3), 112 (3) College English
      2) ENGL 341 (3) Technical Writing
   * ENGL 111 is waived for students who have a high enough ACT or SAT score (see page 24). These students must take another course to replace the three credit hours; however, that course does not have to be an English course.

B) Humanities (6 hours from the following)
   1) Literature courses numbered ENGL 300 and above
   2) Art History courses
   3) Music courses excluding performance ensembles
   4) Philosophy courses

C) Social Sciences (9 hours from the following)
   1) History
   2) Economics
   3) Political Science
   4) Psychology

D) Humanities and Social Science Elective (3 additional credit hours from the following)
   1) Courses chosen from the above list of Humanities or Social Science courses (Sections I.B. and I.C. above);
   2) A foreign language course numbered 200 or above
   3) HUMA 481

Note: Electrical Engineering majors must also satisfy a depth requirement in the humanities or social sciences. See page 128.

II) Mathematics and Basic Sciences
   A) Mathematics
      1) Basic mathematics, if necessary
      2) College algebra and trigonometry, if necessary
      3) MATH 131 (4), 132 (4) Calculus
   B) PHYS 121 & 121L (5), 122 & 122L (5) General Physics
      (With the permission of the major department, students may substitute the sequence PHYS 131 & 131L (5), 132 & 132L (5).)
   C) CHEM 121 & 121L (4), 122 & 122L (4) General Chemistry (CHEM 121 may be replaced by CHEM 103 and 104.)
   D) A total of eight (8) credit hours in courses with associated laboratories from the disciplines of
      1) biology
      2) Earth science
      3) engineering
      Note: Students majoring in biology, Earth science, environmental science, psychology, and any engineering discipline fulfill this portion of the general degree requirements while fulfilling their major requirements.

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.
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 Teaching (MST) program. MST requirements are listed on page 120.

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.
Atmospheric Sciences
Interdepartmental Graduate Program

A number of departments at 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 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, Krebbiel, 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
- GEOC 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
- 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, Special Problems in Atmospheric 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

Environmental Engineering
- Cal—Air Quality Engineering and Science

Materials and Metallurgical Engineering
- G. Bond—Carbon Dioxide Remediation

Physics
- Eack—Atmospheric Physics, Atmospheric Electricity
- Krebbiel—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:
Professor Cormack (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 requirements for the Bachelor of Science degree (page 53).

- Of the minimum 130 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.
- The foreign language requirement is six credit hours in a single language.
- Of the total credit hours required, at least 42 must be in courses numbered 300 or above.

Biology

Professors Kieft (Chair of the Department), Smoake
Associate Professors Kirk, Reiss, Rogelj
Assistant Professor Shors
Adjunct Faculty: Bhasker, Gonzales, Markwell

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 Biochemistry

The central focus of the biology program is to prepare 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 116.) 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 his or her 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.

A small greenhouse and modern animal care facilities are available for the maintenance of research plants and animals.

Undergraduate Program

Bachelor of Science in Biology

Minimum credit hours required—130

In addition to the General Degree Requirements (page 53), the following courses are required:

- BIOL 111 (3), 111L (1), 112 (3), 112L (1), 311 (3), 311L (1), 331 (3), 333 (3), 333L (1), and BIOL 471 or 472 (1)
- At least 6 credit hours from:
- At least 6 credit hours from:
  - BIOL 343 (3), 343L (1), 344 (3), 344L (1), 446 (3), 447 (3), 447L (1)
- 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: CS 111 (4) or MATH 283 (3)
- Electives to complete 130 hours

Biology laboratories are required when the course is specifically required by the biology curriculum or when used as a technical elective towards a degree in biology. Any required class or technical elective used towards a B.S. in Biology may not be taken on an S/U basis. 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 Chemistry Elective
- 3 Social Science
- 3 CS 111 (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 53), the following courses are required:

- At least 6 credit hours from: BIOL 341 (3), 341L (1), 351 (3), 352 (3), 353L (2), 354L (2), 355 (2), 355L (1), 356 (2), 356L (1), 431 (3), 437 (3)
- At least 12 credit hours from: BIOL 343 (3), 343L (1), 344 (3), 344L (1), 446 (4), 494 (3), 495 (3), 412 (3)
- Additional Biology (6) 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), 331L (1), 333L (1), 334L (1), 422 (3–4), 441 (3–4)
- Computer Science or Mathematics: CS 111 (4) or MATH 283 (3)
- Electives to complete 130 hours

Biology laboratories are required when the course is specifically required by the biology curriculum or when used as a technical elective towards a degree in biology. Any required class or technical elective used towards a B.S. in Biology may not be taken on an S/U basis. 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 Degree Requirements (page 53), the following courses are required:

- and one of the following options:
  - BIOL 311 & 311L (4)
  - BIOL 331 (3) and 333 (3)
  - BIOL 351 (3) and 352 (3)
  - CHEM 311 & 311L (4), 333L (1), 333L (1), 334L (1), 422 (3–4), 441 (3–4)
  - Computer Science or Mathematics: CS 111 (4) or MATH 283 (3)
  - Electives to complete 130 hours

Internship (30) 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.

**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 33). 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, Topics in Cell and Molecular Biology.

**Graduate Work in Biochemistry**

Biochemical studies and research are important parts of both the biology and chemistry programs at New Mexico Tech. Students interested in the application of biochemistry to research emphases in biology or chemistry should contact either department for further information.
Biology Courses:

BIOL 101, Issues in Biological Science, 1 cr, 1 cl hr  
Prerequisite: BIOL 105  
GraDPS/U  
Introduction to modern topics in biotechnology, biodiversity, and biocomplexity. Discussion of career options in the biological sciences.

BIOL 102, Issues in Medical Practices, 1 cr, 1 cl hr  
Prerequisite: BIOL 101  
GraDPS/U  
Discussion of social, political, legal, and economic issues encountered by individuals in health care professions.

BIOL 111, 111L, General Biology, 4 cr, 3 cl hrs, 2 lab hrs  
Corequisite: 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.

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.

BIOL 311, 311L, Genetics, 3–4 cr, 3 cl hrs, 3 lab hrs  
Prerequisites: BIOL 111 & 111L  
Overview of the storage, transmission and expression of biological information. Mendelian principles to molecular genetics. Genetics of fruit flies, fungi, microbes and humans. Mendelian analysis and fluorescent analysis of human DNA.

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 plant and animal 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 341, 341L, Introductory Microbiology, 3–4 cr, 3 cl hrs, 3 lab hrs  
Prerequisite: BIOL 111  
GraDPS/U  
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 333 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, Physiology I, 3 cr, 3 cl hrs  
Prerequisite: BIOL 112, 331  
Principles and mechanisms of vertebrate function, emphasizing mammalian systems. Includes membranes, receptors, muscle and nerve function, water and ion homeostasis, and cardiovascular physiology.

BIOL 352, Physiology II, 3 cr, 3 cl hrs  
Prerequisite: BIOL 351  
Continuation of BIOL 351. Includes respiratory, gastrointestinal, and reproductive physiology.

BIOL 353L, Experimental Physiology I, 2 cr, 1 cl hr, 3 lab hrs  
Corequisite: BIOL 351  
Development of physiology techniques to investigate transport and contraction mechanisms, and cardiovascular physiology. Students will design some experiments.

BIOL 354L, Experimental Physiology II, 2 cr, 1 cl hr, 3 lab hrs  
Prerequisite: BIOL 351, 353L  
Corequisite: BIOL 352  
Continuation of BIOL 353L. Experiments involve respiratory, reproductive, and digestive physiology. Students will design some experiments.

BIOL 355, 355L, Embryology, 2–3 cr, 2 cl hrs, 3 lab hrs  
Prerequisite: BIOL 112  
A study of the development of the organs of the chick and pig. Also explores the mechanisms of differentiation and mammalian reproduction.

BIOL 356, 356L, Developmental Biology, 2–3 cr, 2 cl hrs, 3 lab hrs  
Prerequisites: BIOL 331, 333  
Explores the mechanisms of embryonic development, differentiation, and cancer.

BIOL 362, Animal Behavior, 3 cr, 3 cl hrs  
Prerequisites: PSY 121; BIOL 112; or consent of instructor  
General overview of ethological and physiological approaches to the study of animal behavior. (Same as PSY 362)

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 431, 431L, Virology, 3–4 cr, 3 cl hrs, 3 lab hrs  
Prerequisite: BIOL 331  
Corequisite: BIOL 311  
Molecular biology of viral infection, replication, and pathogenesis. Animal viruses emphasized.

BIOL 437, Infection and Immunity, 3 cr, 3 cl hrs  
Prerequisite: BIOL 341  

BIOL 446, 446L, 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 447, Limnology and Oceanography, 3 cr, 3 cl hrs  
Prerequisite: BIOL 344  
Ecology of lakes and oceans with an emphasis on species interactions and ecosystem ecology.

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 460, Biotechnology, 4 cr, 1 cl hr, 9 lab hrs  
Prerequisites: BIOL 333 and consent of instructor  
A research-oriented course using modern biological techniques to explore fundamental principles in biology in collaboration with a biology faculty member.

BIOL 471, 472, Life Sciences Seminar, 1 cr, 1 cl hr each semester  
Prerequisite: Upper class standing in biology or consent of instructor  
Review, discussion, and presentation of the current literature in biology.

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 488, Biology of Cancer, 3 cr, 3 cl hrs  
Prerequisites: BIOL 331 and 333  
Principles and molecular mechanisms of carcinogenesis. Involves elements of cell biology, genetics, molecular biology, immunology, biochemistry, virology, pharmacology, physiology, developmental biology, and pathology.
Biol 489, Special Topics in Biology, cr and hrs to be arranged
Prerequisites: Two semesters of advanced courses and consent of instructor
Special readings or course in biology.

Biol 491, Special Problems, cr and hrs to be arranged
Prerequisites: Two semesters of advanced courses and consent of instructor
An introduction to methods of research. Problems are chosen from the fields of biology and may be small independent investigations or part of a research program being directed by the advisor.

Biol 493, Directed Study in Environmental Biology, cr and hrs to be arranged
Prerequisites: Senior student majoring in Biology—Environmental Science Option, and consent of instructor
A student-designed study of local problems and processes occurring during interaction between biological systems and their physico-chemical environment including literature review, field and laboratory research, and result presentation by written report and seminar.

Biol 500, Directed Research, cr to be arranged
This course may not be used to fulfill graduate degree requirements.
Research under the guidance of a faculty member.

Biol 501, Topics in Cell and Molecular Biology, 1–3 cr (credits to be set by instructor)
Prerequisite: Graduate-level standing or consent of instructor
Special topics in cell and molecular biology not covered in cell biology, genetics, or biochemistry. Contains updates in principles, theory, and biotechnology.

Biol 502, Introduction to Research, 1 cr, 1 cl hrs
Prerequisite: Graduate-level standing
Basic principles of biological research.

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, but is graded separately and additional graduate-level work is required.

Biol 531, Virology, 3 cr, 3 cl hrs
Prerequisite: BIOL 331
Corequisite: BIOL 311
Molecular biology of viral infection, replication, and pathogenesis. Animal viruses emphasized. Shares lecture with BIOL 431, but is graded separately and additional graduate-level work is required.

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, but is graded separately and additional graduate-level work is required.

Biol 542, Advanced Microbiology, 3 cr, 3 cl hrs
Prerequisite: BIOL 341 or consent of instructor
A study of the current concepts in function and structure of microorganisms with emphasis on cellular energy, biosynthetic and ecological response.

Biol 551, Membranes and Intracellular Signala, 3 cr, 3 cl hrs
Prerequisite: Graduate-level standing or consent of instructor
Discussion of composition, structure, and synthesis of cell membranes. Properties and kinetics of plasma membrane receptors, generation and actions of second messengers.

Biol 552, Physiology of Hormones, 3 cr, 3 cl hrs
Prerequisite: Graduate-level standing or consent of instructor
A study of the synthesis, secretion, transport, and action of hormones. Emphasis will be on the mechanisms of the action of hormones. Includes a special laboratory project.

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.

Biol 566, Biotechnology, 4 cr, 1 cl hr, 9 lab hrs
Prerequisite: BIOL 333 or consent of instructor
A research-oriented course in which students use modern biological techniques to explore fundamental principles in biology in collaboration with a biology faculty member. 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, but is graded separately and additional graduate-level work is required.

Biol 587, 587L Advanced Virology, 3–4 cr, 3 cl hrs, 3 lab hrs
Prerequisite: BIOL 431 or 531
An in-depth study of one or two viruses, e.g., HIV, Ebola, influenza; viral vectors for gene therapy; and herpes or hemorrhagic fever viruses. The laboratory section of the course will include viral propagation in tissue culture and methods to investigate the molecular biology of viral infection.

Biol 588, Biology of Cancer, 3 cr, 3 cl hrs
Prerequisites: BIOL 331 and 333
Principles and molecular mechanisms of carcinogenesis. Involves elements of cell biology, genetics, molecular biology, immunology, biochemistry, virology, pharmacology, physiology, developmental biology, and pathology. Graduate students are required to write a grant proposal.

Biol 591, Thesis (master’s program), cr to be arranged

Staff Research Interests

Bhasker—Medical Professions
Gonzales—Veterinary Professions
Kieft—Microbiology, Environmental Biology
Kirk—Biology of Aging, Evolutionary Ecology
Markwell—Medical Professions
Reiss—Molecular Biology, Evolution
Rogelj—Cell Biology, Immunology, Adhesive Interactions between Cells
Shors—Innate Immune Response to Viral Infection, Small Pox
Vaccine Design, Pathogen Detection
Smoake—Animal Physiology, Endocrinology
Chemistry

Professors Pietralla (Chair of the Department), Werbelow
Associate Professor Heagy
Assistant Professors Ewing, Kornienko, Pullin, Steelant, Wingenter, Zhang
Adjunct Faculty: Bruyneel, Buckley, Fukushima, Schwab, Tierney
Emeritus Professors: Brandvold, Brower, Hatch, C. Popp

Degrees Offered: B.S. in Chemistry, Chemistry with Environmental Option, Chemistry with Biochemistry Option, and Chemistry with Pre-Medicine or Pre-Veterinary Program; M.S. in Chemistry and M.S. in Chemistry with Biochemistry Option; Ph.D. in Chemistry and Geochemistry (see Earth and Environmental Science)

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, as well as atmospheric, environmental, explosives, and medicinal chemistry. 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.

Undergraduate Program

Bachelor of Science in Chemistry

Minimum credit hours required—130

In addition to the General Degree Requirements (page 53), the following courses are required:

• MATH 231 (4)
• CHEM 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), 443 (3), 443L (1), 493 (1), 494 (2);
• Advanced Chemistry courses: Any three chosen from CHEM 422 (3), 427 (3), 442 (3), 445 (3), 446 (3)
• Advanced Chemistry labs: Any two chosen from CHEM 422L (1), 441L (1), 442L (1), 445L (2)

This leaves a minimum of 20 credit hours of electives. The Chemistry Department promotes a diverse set of electives for a well-founded education. Recommended electives include CS 111, MATH 254, MATH 335, ES 110, ChE 326, MATE 202, and GEOL 211. The probable sequence of electives should be discussed with the student’s advisor during the freshman year.

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 and interests.

Semester 1
• CHEM 121 & 121L (general)
• ENGL 111 (college English)
• MATH 131 (calculus)
• BIOL 111 or GEOL 101 (general)
1-2 Electives
16-17 Total credit hours

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

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

Semester 4
• CHEM 334 & 334L (organic)
• CS 111 (programming)
• Humanities
• Social Science
3 Electives
17 Total credit hours

Semester 5
• CHEM 331 & 331L (physical)
• Biology/Geology
• Humanities
• Social Science
3 Electives
17 Total credit hours

Semester 6
• CHEM 332 & 332L (physical)
• ENGL 341 (technical writing)
• Social Science
6 Electives
16 Total credit hours

Semester 7
• CHEM 411 & 411L (instrumental)
• CHEM 441 (biochemistry)
• Advanced Chemistry
• CHEM 493 (senior thesis)
• Humanities/Social Science
3 Electives
18 Total credit hours

Semester 8
• CHEM 443 & 443L (inorganic)
• Advanced Chemistry
• CHEM 494 (senior thesis)
6 Electives
16 Total credit hours
Bachelor of Science in Chemistry with Environmental Science Option

Minimum credit hours required—130

In addition to the General Degree Requirements (page 53), requirements include the courses listed for the Bachelor of Science in Chemistry and the following courses:

- 12 credit hours from the following: CHEM 422; BIOL 343, 344, 446, or 447; HYD 412; Special Problems in Environmental Chemistry.

Bachelor of Science in Chemistry with Biochemistry Option

Minimum credit hours required—130

In addition to the General Degree Requirements (page 53), requirements include the courses listed for the Bachelor of Science in Chemistry and the following courses:

- CHEM 441L (1), 442 (3), 442L (1)
- Six credit hours of upper-division biology courses

Bachelor of Science in Chemistry with Pre-Medicine or Pre-Veterinary Program

Chemistry students may receive excellent preparation for medical or veterinary school by selecting most of their electives from the following:

- BIOL 111 and 204 (general requirements), 331, 341, 351, 355, 411, and 453.
- Upper-division chemistry course requirements should be filled by CHEM 441 and 442.

Students interested in such a program should consult their advisor and the pre-medical advisor.

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 entrance examinations prior to their first registration. If deficiencies are determined, appropriate undergraduate coursework will be required. The student’s course of study must be approved by the student’s advisory committee and must fulfill the general degree requirements for the respective advanced degree (pages 33–34).

Master of Science in Chemistry

A minimum of 30 credit hours is required. These hours should be distributed as follows:

- **Coursework: 24 credit hours**
  - 500-level chemistry courses 15 cr hrs minimum
  - CHEM 501 plus two courses chosen from any two of the following five groupings: CHEM 513 or 526; CHEM 521 or 523; CHEM 524 or 525; CHEM 531 or 532; CHEM 545 or 546. CHEM 500, 529, 530, 581, 590 cannot be used to fulfill this requirement.
  - CHEM 529, 530 (Seminar) 2 cr hrs
  - CHEM 581 (Directed Study) 2 cr hrs maximum
  - 400-level chemistry courses 6 cr hrs maximum
  - 300-level chemistry courses 3 cr hrs maximum
  - Upper-division/500-level courses from another department

- **Thesis: 6 credit hours**

The student’s advisory committee may also allow additional 500-level courses chosen from another department, depending on the student’s program needs. Credits earned in these 500-level courses may also fulfill the 15-hour 500-level requirement with advisory committee approval. The requirement for a Master of Science degree should be completed within three (3) calendar years of the date of first registration. Special cases may be considered as outlined in the New Mexico Tech Graduate Guide. M.S. students are required to take CHEM 529 or 530 for credit for at least two semesters and to register as auditors for other semesters.

Master of Science in Chemistry with Biochemistry Option

Students earning a Master of Science degree in Chemistry can receive a Biochemistry Option through cooperation with the Biology Department. The requirements for the biochemistry option are the same as those for a Master of Science in Chemistry, except that:

- A minimum of six (6) credit hours of the 15 credit hours minimum of 500-level chemistry classes must be selected from CHEM 521, 522, and 523.
- A maximum of two (2) credit hours of CHEM 581 or BIOL 581 (directed study) may be used toward the degree.
- A minimum of six (6) credit hours of upper-division/500-level courses in biology, selected from the following, must be completed: BIOL 331, 333, 351, 352, 356, 488, 501, 552, 588.

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 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 second year. Research fields appropriate for the Ph.D. candidate are all major areas of chemistry. Current specializations include atmospheric, environmental, medicinal, pharmaceutical, theoretical, and green chemistry, as well as spectroscopic techniques. Interdisciplinary programs with other science departments, such as physics or biology, can be pursued.
No Prior Master's Degree

A minimum of 72 semester hours is required. These hours should be distributed as follows:

**Coursework**

- 500-level chemistry courses: 48 cr hrs
  - CHEM 501 plus three courses chosen from any three of the following five groupings: CHEM 513 or 526; CHEM 521 or 523; CHEM 524 or 525; CHEM 531 or 532; CHEM 545 or 546. CHEM 500, 529, 530, 531, 590 cannot be used to fulfill this requirement.
- CHEM 529, 530 (Seminar): 4 cr hrs
- CHEM 581 (Directed Study): 6 cr hrs maximum
- 400-level chemistry courses: unlimited
- 500-level chemistry courses: 3 cr hrs maximum
- 400- and 500-level courses from another department: 6 cr hrs

**Dissertation (CHEM 995)**

For Ph.D. students with no prior M.S. degree, the Ph.D. degree should be completed within six calendar years of the first registration.

Prior Master's Degree in Chemistry

A minimum of 42 additional credit hours is required. Students with M.S. degrees other than in chemistry will be considered on an individual basis. In recommending courses to be taken, the student's M.S. coursework will be considered. In most cases, the hours should be distributed as follows:

**Coursework**

- 500-level chemistry courses: 18 cr hrs
  - CHEM 501 plus three courses chosen from any three of the following five groupings: CHEM 513 or 526; CHEM 521 or 523; CHEM 524 or 525; CHEM 531 or 532; CHEM 545 or 546. CHEM 500, 529, 530, 531, 590 cannot be used to fulfill this requirement.
- CHEM 529, 530 (Seminar): 3 cr hrs
- CHEM 581 (Directed Study): 3 cr hrs maximum
- 400-level chemistry courses: unlimited
- 400- and 500-level courses from another department: 6 cr hrs maximum

**Dissertation (CHEM 995)**

For Ph.D. students with prior M.S. degrees, the Ph.D. degree should be completed within four calendar years of the date of first registration after completion of the M.S. degree.

Chemistry Courses:

**CHEM 103, Fundamental Chemistry I, 2 cr, 2 class hrs, 1 recitation hr**

- **Prerequisite:** MATH 101
- **Offered fall semester**
  - Fundamental principles of chemistry, including units, stoichiometry, nomenclature, thermochemistry, and problem solving. The recitation hour allows time for practice on problems and principles presented during the lecture hour.

**CHEM 104, Fundamental Chemistry II, 2 cr, 2 cl hrs, 1 recitation hr**

- **Prerequisite:** CHEM 103
- **Corequisite:** CHEM 121L
- **Offered spring semester**
  - Fundamental principles of chemistry. Continuation of CHEM 103. Study of gases, atomic structure, bonding, molecular structure, redox reactions, and problem solving. Completion of this course enables a student to register for CHEM 122. The CHEM 103/104 sequence is equivalent to CHEM 121.

**CHEM 121, General Chemistry I, 3 cr, 3 cl hrs**

- **Prerequisite:** MATH 103 (or equivalent, passed with grade 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.

**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.

**CHEM 122, General Chemistry II, 3 cr, 3 cl hrs**

- **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.

**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.

**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 411, Advanced Instrumental Methods, 3 cr, 3 cl hrs
Prerequisite: CHEM 311 and 332 or consent of instructor
Corequisite: CHEM 411L
Offered fall semester
Instrumental design, operation and advanced techniques of chemical analysis. Emphasizes gas chromatography; atomic absorption; ultraviolet, visible, and infrared spectroscopy; specific ion electrodes; 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 422, Environmental Chemistry, 3 cr, 3 cl hrs
Prerequisites: Any two of the following: CHEM 311, 331, or 333
Offered in spring semester, even years, or on sufficient demand
Application of chemical principles to the study of the environment. Includes natural processes and pollution problems related to water, air, and soil. (Same as GEOC 422)

CHEM 422L, Environmental Chemistry Laboratory, 1 cr, 3 lab hrs
Corequisite: CHEM 422; a lab usage fee is charged
Offered spring semester, even years, or on sufficient demand
Laboratory experiments related to the principles in CHEM 422.

Chem 427, Molecular Reaction Dynamics, 3 cr, 3 cl hrs
Prerequisite: CHEM 331, 332
Offered fall semester, odd years, or 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. This course is recommended for all students wishing to pursue a graduate degree in the chemical sciences.

CHEM 441, Biochemistry I, 3 cr, 3 cl hrs
Prerequisite: CHEM 331 and 334; or consent of instructor
Corequisite: CHEM 441L
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
Corequisite: CHEM 442L
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. Emphasis on bioanalytical techniques.

CHEM 443, Intermediate Inorganic Chemistry, 3 cr, 3 cl hrs
Prerequisite: CHEM 332
Corequisite: CHEM 443L
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 445, Intermediate Organic Chemistry, 3 cr, 3 cl hrs
Prerequisite: CHEM 334
Corequisite: CHEM 445L
Offered spring semester, odd years, or 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 spring semester, odd years, or on sufficient demand
Study of the preparation, properties, and uses of macromolecules.

CHEM 491, Special Problems, 1-3 cr
Prerequisite: CHEM 493
Offered fall semester
Problem-oriented research under the direction of a faculty member. Research topics must be approved and started so as to allow two semesters for completion. Projects will consist of and be graded on three criteria: the research work itself, a write-up in thesis form, and two oral presentations of the project.

CHEM 494, Senior Research and Thesis, 2 cr
Prerequisite: CHEM 493
Offered spring semester
Continuation of research begun in CHEM 493.

All courses numbered 500 and above require the consent of the instructor.

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
Prerequisite: CHEM 332, 334, and 443 or equivalent
Offered fall semester
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 511, Advanced Topics in Analytical Chemistry, 3 cr, 3 cl hrs
Prerequisite: CHEM 513
Offered spring semester
Study of special topics not otherwise treated in analytical chemistry. Normally related to a research field at Tech.

CHEM 513 Separation Science, 3 cr, 3 cl hrs
Offered spring semester
Theory and practice of separation science. Topics include selective mass transport, extraction, chromatography, and electrophoresis.

CHEM 521, Advanced Topics in Biochemistry I, 3 cr, 3 cl hrs
Prerequisite: CHEM 523
Offered spring semester
Study of special topics not otherwise covered in CHEM 521.
CHEM 524 Statistical Thermodynamics, 3 cr, 3 cl hrs
Offered alternate years

CHEM 525, Molecular Quantum Mechanics, 3 cr, 3 cl hrs
Molecular structure; theories of the chemical bond; perturbation and variation methods; electronic and magnetic properties of molecules.

CHEM 526, Chemical Spectroscopy, 3 cr, 3 cl hrs
Principles and applications of electronic, molecular, and spin spectroscopies, laser spectroscopy; transitions; elements of group theory; quantitative correlations and analytical chemistry.

CHEM 528, Advanced Topics in Physical Chemistry
Study of special topics not otherwise covered in physical chemistry.

CHEM 529 (Fall), 530 (Spring), Graduate Seminar, 1 cr each semester

CHEM 531, Chemistry of Aquatic Systems, 3 cr, 3 cl hrs
Aqueous chemistry of natural water systems with emphasis on surface freshwater. Thermodynamics, kinetics, equilibria, colloids, surface chemistry, and biological effects. Effects and transport of material. Analytical chemistry as related to aquatic systems.

CHEM 532, Atmospheric Chemistry, 3 cr, 3 cl hrs
Chemistry of the atmosphere. Important chemical reactions and their effects on surface and ground water. Effects of anthropogenic inputs on the atmosphere. Distribution of chemical species in the atmosphere, etc.

CHEM 533, Global Biogeochemical Cycles, 3 cr, 3 cl hrs
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.

CHEM 540, The Chemistry of Energetic Materials, 3 cr, 3 cl hrs
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 542, Organometallic Chemistry, 3 cr, 3 cl hrs
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.

CHEM 543, Advanced Topics in Inorganic Chemistry, 3 cr, 3 cl hrs
Study of special topics otherwise not covered in inorganic chemistry.

CHEM 544, Advanced Topics in Organic Chemistry
Study of special topics not otherwise covered in organic chemistry.

CHEM 545, Advanced Organic Synthesis, 3 cr, 3 cl hrs
Principles and practices of organic synthesis.

CHEM 546, Physical Organic Chemistry, 3 cr, 3 cl hrs
Physical aspects of organic chemistry. Emphasizes reaction mechanisms, reaction kinetics, and electronic theories.

CHEM 547, Medicinal Chemistry, 3 cr, 3 cl hrs
Molecular-level mechanisms of drug action and rational drug design. Material is drawn from the recent primary literature.

CHEM 548, Experimental NMR Spectroscopy
A lab usage fee is charged
Introduction to NMR instrumentation, data-acquisition, and processing.

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

CHEM 595, Dissertation (doctoral degree program), cr to be arranged

Faculty Research Interests

Ewing—Analytical Chemistry, Mass Spectroscopy, Ion Mobility Spectrometry
Kornienko—Synthetic Organic Chemistry, Biological Chemistry
Pietrala—Inorganic Chemistry, Physical Chemistry, Nuclear Magnetic Resonance Spectroscopy
Pullin—Aqueous Environmental Chemistry, Natural Organic Carbon and Metal Ions in the Environment, Analytical Methods for Natural Waters
Steelant—Biochemistry, Biomembrane Structure, Signal Transduction
Werbelow—Chemical Physics, Theoretical Chemistry, Spectroscopy
Wingert—Atmospheric and Ocean Chemistry
Zhang—Bioanalytical Chemistry, Fluorescence, Nanomaterials

Adjunct Faculty Research Interests

Bruyneel—Cell-Cell Adhesion and Cancer Cell Invasion
Buckley—Petroleum Chemistry
Fukushima—Physics, Nuclear Magnetic Resonance Spectroscopy
Schwab—Development of General Chemistry Demonstrations and Laboratory Experiments, Metal Recovery and Analysis, Ore and Mineral Analysis
Tierney—Bioinorganic Chemistry, Electron Spin Resonance Spectroscopy

Emeritus Faculty Research Interests

Brandvold—Biophysical Chemistry, Enzyme Mechanisms, Environmental Chemistry, Atmospheric Chemistry
Brower—Physical Organic Chemistry, Explosives Chemistry
Hatch—Organic Chemistry, Polymer Chemistry
Popp—Environmental Chemistry, Geochemistry
Computer Science

Professor Sung (Chair of the Department)
Associate Professors Mazumdar, Soliman
Assistant Professors Liebrock, Qin, Shin
Visiting Professor Clausen
Adjunct Faculty Anselmo, Lassez
Emeritus Faculty Stavely

Degrees Offered: B.S., M.S., and Ph.D. in Computer Science

Computer Science is an exciting discipline that has been shaped by a rapidly growing body of knowledge and a constantly changing emphasis. The curriculum of the Department of Computer Science includes courses in both theoretical and applied computer science and strives to cover the current concepts and major applications of the field.

The Bachelor of Science program emphasizes fundamental principles and provides 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 areas. Graduates of the computer science bachelor's program will be well prepared for industry employment or graduate study.

The Master of Science program is designed for students who wish to further broaden or deepen their knowledge of computer science. Both thesis and non-thesis options are offered; an independent study report is required for the non-thesis option. Master’s students usually participate in faculty research projects to complete their thesis or independent study.

New Mexico Tech's Department of Computer Science also offers a Ph.D. program. This program gives students the opportunity to take courses, to select committee members, to use the resources of the department, and to pursue research in a fairly large number of areas within computer science. The department is certified with the National Security Agency's designation as a Center of Academic Excellence in Information Assurance.

The department has its own network of computers and servers plus a variety of other equipment in several laboratories. In the same building, the Tech Computer Center supports a much 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.

Undergraduate Program

Bachelor of Science in Computer Science

Minimum credit hours required—130

In addition to the General Degree Requirements (page 53), the following courses are required:

- CS 111 (4), 122 (3), 221 (3), 222 (2), 324 (3), 325 (4), 331 (3), 342 (3), 344 (3), 353 (3), 382 (3), 423 (4)
- MATH 221 (3), 382 (3)
- Technical Electives—A sequence of 12 hours of Computer Science courses numbered 300 or higher, approved by the student’s advisor, the undergraduate advisor, and the department chair.

Pre-approved sequences include the following:

- Security and Assurance Track  (Note: same track exists for IT majors)
  - CS 441 (3), 453 (3), 463 (3), IT 462 (3)
- Engineering Computing Track
  - CS 328 (3), 356 (3), 453 (3), 464 (3)
- Software and Data Analysis Track
  - CS 328 (3), 373 (3), 454 (3), 464 (3)

Each of the above courses must be completed with a grade of C or better.

Electives to complete 130 credit hours.

Sample Curriculum for the Bachelor of Science in Computer Science

<table>
<thead>
<tr>
<th>Semester</th>
<th>Courses</th>
<th>Credit Hours</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>4 MATH 131 (calculus) 4 CS 111 (intro to comp sci) 4 CHEM 121</td>
<td>15</td>
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<tr>
<td></td>
<td>2 &amp; 121L (general) 3 ENGL 111 (college English)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>4 MATH 132 (calculus) 3 CS 122 (algorithms and data structures) 4 CHEM 122</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>2 &amp; 122L (general) 3 ENGL 112 (college English) 3 Social Science</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3 CS 221 (computer systems) 4 Biology/Geology/Engineering with lab 5 PHYS 121 &amp; 121L</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>(general) 3 MATH 221 (discrete mathematics)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2 CS 222 (systems programming) 3 CS 324 (programming languages) 5 PHYS 122 &amp; 122L</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>(general) 3 Humanities 3 CS 353 (data and computer communications)</td>
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<tr>
<td>5</td>
<td>3 CS 331 (computer architecture) 3 CS 344 (algorithms) 3 MATH 382 (probability) 3 ENGL 341 (technical writing) 3 Technical Elective</td>
<td>18</td>
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<tr>
<td></td>
<td>3 Electives</td>
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<tr>
<td>6</td>
<td>4 CS 325 (operating systems) 3 CS 342 (formal languages) 3 CS 382 (social issues) 3 Social Science 3 Technical Elective</td>
<td>17</td>
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<td></td>
<td>1 Electives</td>
<td></td>
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<tr>
<td>7</td>
<td>4 CS 423 (compiler writing) 3 Humanities 3 Social Science 3 Technical Elective 3 Electives</td>
<td>16</td>
</tr>
<tr>
<td>8</td>
<td>4 Biology/Geology/Engineering with lab 3 Humanities/Social Science 3 Technical Elective 6 Electives*</td>
<td>16</td>
</tr>
</tbody>
</table>
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 the Information Technology Option through cooperation with the Information Technology faculty.

Master of Science Degree in Computer Science

Without Thesis:
- Students must have demonstrated proficiency in the core undergraduate curriculum including the topics normally covered by CS 324, 325, 331, 342, 344, and 423. Proof of proficiency usually requires grades of B or better in these courses or in equivalent courses approved by the department.
- Course work approved by the student’s advisory committee fulfilling the general requirements of 27 credit hours for the master’s degree. At least 15 credit hours must be in computer science courses numbered 500 or above, not including CS 590 (Independent Study) or 591 (Thesis). Three of these hours must be CS 585 (Graduate Seminar).
- CS 590: 3 credit hours.

With Thesis:
- Students must have demonstrated proficiency in the core undergraduate curriculum including the topics normally covered by CS 324, 325, 331, 342, 344, and 423. Proof of proficiency usually requires grades of B or better in these courses or in equivalent courses approved by the department.
- Course work approved by the student’s advisory committee fulfilling the general requirements of 24 credit hours for the master’s degree. At least 15 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 CS 585 (Graduate Seminar).
- CS 591 (Thesis): 6 credit hours.

Master of Science Degree in Computer Science with Information Technology Option

Students earning a Master of Science degree in Computer Science can receive an Information Technology Option through cooperation with the Information Technology Faculty. The requirements for the Information Technology Option are the same as those for a Master of Science in Computer Science, except that:
- Students must demonstrate proficiency in the topics normally covered by CS 324, 331, and 344. Proof of proficiency usually requires grades of B or better in these courses or in equivalent courses approved by the department.
- Course work approved by the student’s advisory committee fulfilling the general requirements of 24 credit hours for the master’s degree. At least 15 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 CS 585 (Graduate Seminar).
- CS 590 (Independent Study): 3 credit hours; or CS 591 (Thesis): 6 credit hours.

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 the Information Technology Option. 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.

Doctor of Philosophy in Computer Science

Students of exceptional ability as demonstrated in previous course work are encouraged to pursue a doctorate. 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-based systems, and computational intelligence. The department also encourages interdisciplinary work with other departments at Tech and offers specialization in other areas through the New Mexico Cooperative Ph.D. Program in Computer Science (which includes Tech, the University of New Mexico, and New Mexico State University) and in cooperation with researchers at Los Alamos and Sandia national laboratories.

As computer science 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 CS 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 the description of the Graduate Program, page 34, for further details.

Computer Science Courses:

CS 111, Introduction to Computer Science and Programming, 4 cr, 3 cl hrs, 3 lab hrs
Corequisite: MATH 103 or equivalent
Introduction to the discipline of computer science: 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. The lab will focus on an introduction to programming in a structured language (e.g., C): problem solving, algorithm development, top-down design, modular programming, control structures including selection, iteration and recursion, data types including arrays, strings, and dynamic structures. Concepts implemented through extensive programming using good programming style. (Same as IT 111)

CS 122, Algorithms and Data Structures, 3 cr, 3 cl hrs
Prerequisite: CS 111
Fundamental data structures such as linked lists, trees, and hash tables. Algorithms for sorting, searching, and other fundamental operations. Introduction to recursive algorithms. (Same as IT 122)

CS 209, Programming Language Practicum, 1 cr, 3 lab hrs
Prerequisite: knowledge of elementary programming
A practical course teaching the use of a programming language of current interest. May be repeated for credit with different languages.
CS 221, Computer System Organization, 3 cr, 3 cl hrs  
Prerequisites: CS 122  
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)

CS 222, Systems Programming, 2 cr, 1 cl hr, 3 lab hrs  
Prerequisite: CS 222  
Programming at the systems level. Using operating system services. Network and web programming. Substantial programming projects.

CS 231, 231L, Digital Electronics, 4 cr, 3 cl hrs, 3 lab hrs  
Co-requisites: PHYS 121 & 121L or PHYS 131 & 131L. CS 231 & 231L are corequisites of each other.  
Logic circuits and logic design, logic maps, combinatorial and sequential circuits, algorithmic state machines. Use of logic families and programmable logic devices.  
(Same as EE 231 & 231L)

CS 324, Principles of Programming Languages, 3 cr, 3 cl hrs  
Prerequisite: CS 122  
Introduction to the definition of syntax and semantics. Data types, control structures, concurrency, declarations, procedures. Recursion and recursive definitions. Procedural and data abstraction. Examples from current programming languages.

CS 325, Principles of Operating Systems, 4 cr, 3 cl hrs, 2 lab hrs  
Prerequisites: CS 221 and 222  
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.

CS 328, Secure Software Construction, 3 cr, 2 cl hrs, 1 lab hr  
Prerequisite: CS 222  
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)

CS 331, Computer Architecture, 3 cr, 3 cl hrs  
Prerequisite: CS 221  
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.

CS 342, Formal Languages and Automata, 3 cr, 3 cl hrs  
Prerequisite: MATH 221  
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.

CS 344, Design and Analysis of Algorithms, 3 cr, 3 cl hrs  
Prerequisites: CS 122, MATH 221  
Interplay of data structures and algorithms. Time and space complexity of algorithms. Design paradigms and analysis techniques. Fundamental algorithms; combinatorial and graph algorithms; numerical algorithms. Introduction to the theory of NP-completeness.

CS 351, Complex System Modeling and Simulation, 3 cr, 3cl hrs  
Prerequisite: CS 122, MATH 221  
Characteristics and examples of complex systems. Fundamental simulation, modeling, and optimization algorithms. Advanced computational techniques for complex system modeling and analysis.  
(Same as IT 351)

CS 353, Data and Computer Communication, 3 cr, 3 cl hrs  
Prerequisites: CS 122, 221  
(Same as IT 353)

CS 356, Multimedia Signal Processing, 3 cr, 2 cl hrs, 1 lab hr  
Prerequisites: CS 325, 353  
Basic digital signal processing techniques. Introduction to multimedia data types and methods for multimedia creation, storage, transformation, manipulation, and transmission. Current technologies for digital multimedia signal processing in Internet applications. Hardware and software tools for multimedia. OS and network support for multimedia communication.

CS 373, Introduction to Database Systems, 3 cr, 3 cl hrs  
Prerequisite: CS 122  
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)

CS 382, Legal, Ethical, and Social Issues of Information Technology, 3 cr, 3 cl hrs  
Prerequisite: Upper-division standing in the CS or IT program; or consent of instructor  
A survey of current legal IT (and general business and management) issues. Social and ethical issues associated with IT and management of secure information systems.  
(Same as IT 382)

CS 391, Directed Study, cr and topics arranged

CS 423, Compiler Writing, 4 cr, 3 cl hrs, 2 lab hrs  
Prerequisites: CS 324, 342, 344.  
Corequisite: CS 331  
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.

CS 427, Zero-Defect Software Development, 3 cr, 2 cl hrs, 2 lab hrs  
Prerequisites: CS 222, MATH 221  
The development of very high-quality software using the best available methods of specification, verification, and testing. Group programming projects.

CS 428, Software Workshop, 2 cr, 4 lab hrs  
(May be retaken for credit with permission of instructor)  
Prerequisite: CS 325, 328, or 423  
Participation, as part of a team, in one or more phases of a large software development project. Lectures in software development practices as needed.

CS 432, VLSI Design, 3 cr, 3 cl hrs  
Prerequisite: CS 311  
Introduction to MOS technology and MOS circuit design process. Subsystem design and layout scaling of MOS circuits. PLAs and finite state machines. Aspects of system design. Memory registers and system timing. The real world of VLSI design. The future of fast VLSI circuits and systems. Students will be required to design and test a RISC machine at layout level.
CS 441, Cryptography and Applications, 3 cr, 3 cl hrs (Same as IT 441)  
Prerequisites: CS 122, MATH 221  
Basic theory of encryption and decryption. The RSA algorithm and the public/private key system. Cryptography systems in use for Internet and business applications. (Same as IT 441)

CS 452, Introduction to Parallel Processing, 3 cr, 3 cl hrs  
Prerequisites: CS 222, 344  
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 452)

CS 453, Computer Networks and the Internet, 3 cr, 3 cl hrs  
Prerequisite: CS 353  
Layering of protocols (ISO, ITU and TCP/IP stacks) and network architectures. Fiber optics technology and high speed networks. Internetworking: global addresses/names and translation, virtual networks and tunnels, routing, subnetting, IPv6, multicasting, Mobile IP, End-to-end protocols, TCP and UDP. Congestion control and resource allocation. Socket interfacing, client-server and API. The OSI mechanism integrated/differentiated). ATM QoS, Network security: information and link security, encryption, internetworking security. IPsec, firewalls, VPN, wireless security. (Same as IT 453)

CS 454, Computer Graphics, 3 cr, 3 cl hrs  
Prerequisites: CS 222, MATH 254  
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.

CS 455, Internet Security and Applications, 3 cr  
Prerequisite: CS 453  

CS 461, Artificial Intelligence, 3 cr, 3 cl hrs  
Prerequisites: CS 222 and 324, MATH 221  
Production systems. Search strategies. The role of logic in formulating and solving problems. Expert systems. Rule-based deduction and plan-generating systems. LISP and PROLOG programming in these and related areas such as natural language processing and belief revision.

CS 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 IT 463)

CS 464, Introduction to Soft Computing, 3 cr, 3 cl hrs  
Prerequisites: CS 344, MATH 382  

CS 485, 486, Computer Science Seminar, 1 cr, 1 cl hr  
Reviews and discussion of current topics and literature in computer science.

CS 491, Directed Study, cr and topics arranged  

CS 523, Advanced Compiler Writing, 3 cr, 3 cl hrs  
Prerequisite: CS 423  
Advanced topics in compilation, such as theory of parsing, error recovery, optimization, semantics-directed translation, and hardware-independent and hardware-specific code generation.

CS 525, Advanced Operating Systems, 3 cr, 3 cl hrs  
Prerequisites: CS 525 and 331, 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.

CS 528, Formal Methods in Software Development, 3 cr, 3 cl hrs  
Prerequisites: CS 423; Computer Science 325 or 329 or 423 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.

CS 531, Advanced Computer Architecture, 3 cr, 3 cl hrs  
Prerequisite: CS 331  
Advanced topics in computer architecture.

CS 542, Advanced Formal Language Theory, 3 cr, 3 cl hrs  
Prerequisite: CS 532  
Extensive study of context-sensitive and recursively enumerable languages; closure properties, decidability, and ambiguity of various language classes. Special topics as time permits.

CS 544, Analysis of Algorithms, 3 cr, 3 cl hrs  
Prerequisite: CS 344  
Analysis of correctness and complexity of asymptotically efficient algorithms. Set partitioning, dominators of dags (with applications in code optimization), Strassen’s matrix multiplication algorithm, FFT, Schonhage-Strassen integer multiplication algorithm, pattern matching, NP complete problems (both time and space), lower bounds. Discussion of problems for which no efficient algorithms exist.

CS 546, Theory of Computation, 3 cr, 3 cl hrs  
Prerequisite: CS 342  
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.

CS 551, Advanced Parallel Processing, 3 cr, 3 cl hrs  
Prerequisites: CS 451; 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.

CS 553, Advanced Computer Networks, 3 cr, 3 cl hrs  
Prerequisite: CS 453  

CS 554, Advanced Visualization, 3 cr, 3 cl hrs  
Prerequisites: CS 454; or 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, volume rendering, surface extraction and rendering. Students will develop visualizations of large problems and/or complex systems.
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 Aster, Bowman (Chair of the Department), Campbell, Condie, Hendrickx, Kyle, Norman, Phillips, Wilson
Associate Professors Axen, Boston, Harrison, Johnson, McIntosh, McPherson, Mozley, Tobin
Assistant Professors Blek, Vivoni
Emeritus Professors Balk, Budding, G. Gross, Lattman, Sanford
Adjunct faculty: Austin, Barker, Bauer, Broadhead, Buckley, S. Cather, Chamberlin, Chapin, Connell, Dunbar, Fehtler, Fletcher, Glass, Goodwin, Haneberg, Hawley, Heizler, Jaksha, Kelley, D. Love, McCord, McLemore, Ralser, Retter, Scholle, Small, Stephens, Turin, Ulnen-Scholle, Whitworth

Degrees Offered: B.S. in Earth Science with options in Geology, Geochemistry, Environmental Geology, and Geophysics; M.S. in Geochemistry, Geology, Geophysics (Solid Earth), and Hydrology; Ph.D. in Earth and Environmental Science with Dissertation in 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 in theoretical or applied aspects of earth science. Graduate students become actively involved in research projects in ore genesis; the origin of magmas, volcanoes, mountain belts, and continents; the exploration for geothermal sources of energy; the recharge, flow patterns, 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; faults and fluid flow; radioactive dating; and regional tectonics. Many staff members of the New Mexico Bureau of Geology and Mineral Resources participate in the graduate program by offering courses and supervising research work for theses and dissertations.

Many students who enter earth science professions will become involved with water resources in the semi-arid and arid regions of the world. An increasing number will seek solutions to such environmental problems as the protection of water quality and the assessment of geologic hazards. Others will find careers working to find new sources of energy and raw materials.

Staff Research Interests

Anselmo—Strategic Management, Decision Theory, Risk Analysis
Clausen—Software Construction, Internet via Satellite, Multimedia/Internet Technologies, Embedded Systems
Lassez—Constraint and Logic Programs, Dynamical Systems, Bioinformatics
Liebrock—Parallel Processing, High Performance Computing, Information Assurance, Well Posedness Analysis, Graphics and Visualization
Mazumdar—Databases, Information Systems, Conceptual Modeling, Software Integrity
Applied Cryptography
Soliman—Programming Languages, Computer Networks, Neural Networks
Stavely—Formal Methods in Software Engineering, Programming Languages, Computational Logic
Sung—Computational Intelligence and Its Applications, High Performance Computing, Algorithms, Information Assurance
Undergraduate Program

Bachelor of Science in Earth Science

Minimum credit hours required—132
Courses taken to fulfill mathematics and basic science requirements of the General Degree Requirements, and courses in Geology, Geochemistry, Geophysics, and Hydrology 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

- GEOP 308 (3)

Bachelor of Science in Earth Science with Geology Option

Minimum credit hours required—132
In addition to the General Degree Requirements (page 53), the following courses are required:
- GEOL 480 (6) or (GEOL 481 (3) and 482 (3))
- GEOP 308 (3)
- Mathematics/Computer Science: Six credit hours selected from CS 111 and/or mathematics courses numbered 200 and above.
- Earth Science electives: Minimum of 15 credit hours in courses numbered 400 and above.
- Technical electives: Minimum of 9 credit hours in courses numbered 200 and above selected from the following fields: additional earth and environmental science other than geology, mathematics, biology, computer science, physics, chemistry, and engineering.
- Approved foreign language: six credit hours
- Electives: To complete 132 credit hours

Sample Curriculum for the Bachelor of Science in Earth Science with Geology Option

Semester 1
4 CHEM 121 & 121L (general)
4 MATH 131 (calculus)
3 ENGL 111 (college English)
4 GEOL 101 & 101L (earth processes)
15 Total credit hours

Semester 2
4 CHEM 122 & 122L (general)
4 MATH 132 (calculus)
3 ENGL 112 (college English)
4 GEOL 102 & 102L (earth history)
15 Total credit hours

Semester 3
4 GEOL 211 (mineralogy)
3 GEOL 337 (stratigraphy & paleontology)
3 Mathematics/Computer Science
5 PHYS 121 & 121L (general)
15 Total credit hours

Semester 4
3 GEOL 318 (sedimentary rocks)
3 Mathematics/Computer Science
5 PHYS 122 & 122L (general)
3 Social Science
3 GEOP 308 (geophysical earth)
17 Total credit hours

Summer
3 GEOL 481 (field methods)

Semester 5
3 GEOL 319 (igneous & metamorphic petrology)
3 GEOL 341 (environmental)
3 ENGL 341 (technical writing)
3 Humanities
3 Foreign Language
15 Total credit hours

Semester 6
3 GEOL 306 (surficial processes)
3 GEOL 353 (structure)
3 Earth Science Elective
3 Technical Elective
3 Social Science
3 Foreign Language
18 Total credit hours

Summer
3 or 6 GEOL 482 or GEOL 480 (field methods)

Semester 7
6 Earth Science Electives
3 Technical Electives
3 Humanities
3 Social Science
15 Total credit hours

Semester 8
3 GEOL 468 (earth evolution)
6 Earth Science Electives
4 Technical/Free Electives
3 Humanities/Social Science
16 Total credit hours

Bachelor of Science in Earth Science with Environmental Geology Option

Minimum credit hours required—132
In addition to the General Degree Requirements (page 53), the following courses are required:
- GEOL 480 (6) or (GEOL 481 (3) and 482 (3))
- GEOP 308 (3)
- GEOP 445 (3) or HYD 466 (3)
- GEOC 443 (3)
- HYD 403 (3)
- CHEM 311 (3), 333 (3)
- Mathematics/Computer Science: Six credit hours selected from CS 111 and/or mathematics courses numbered 200 and above.
- Earth Science Electives: Minimum of 15 credit hours in courses numbered 400 and above selected from the following fields: earth and environmental science, mathematics, biology, computer science, physics, chemistry, and engineering.
- Approved Foreign Language: Six credit hours
- Electives: To complete 132 credit hours
ARTS & SCIENCES

Bachelor of Science in Earth Science with Geochemistry Option

Minimum credit hours required—132

In addition to the General Degree Requirements (page 53), the following courses are required:

- GEOL 480 (6) or (GEOL 481 (3) and 482 (3))
- GEOP 308 (3)
- Mathematics/Computer Science: Six credit hours selected from CS 111 and/or mathematics courses numbered 200 and above.
- CHEM 311 (3), 311L (1), 331 (3), 333 (3)
- GEOC 443 (3) and two courses chosen from GEOC 422 (3), 431 (3), 444 (3)
- Technical Electives: Minimum of six credit hours in courses numbered 200 and above selected from the following fields: earth and environmental science, mathematics, biology, computer science, physics, chemistry, and engineering.
- Approved foreign language: Six credit hours

Sample Curriculum for the Bachelor of Science in Earth Science with Environmental Geology Option

Semester 1
4 CHEM 121 & 121L (general)
4 MATH 131 (calculus)
3 ENGL 111 (college English)
4 GEOL 101 & 101L (earth processes)
15 Total credit hours

Semester 2
4 CHEM 122 & 122L (general)
4 MATH 132 (calculus)
3 ENGL 112 (college English)
4 GEOL 102 & 102L (earth history)
15 Total credit hours

Semester 3
4 GEOL 211 (mineralogy)
3 GEOL 337 (stratigraphy & paleontology)
5 PHYS 121 & 121L (general)
3 CHEM 311 (quantitative)
15 Total credit hours

Summer
3 GEOL 481 (field methods)

Semester 5
3 GEOL 319 (igneous & metamorphic petrology)
3 GEOL 341 (environmental)
3 CHEM 333 (organic)
3 ENGL 341 (technical writing)
3 Foreign Language
15 Total credit hours

Semester 6
3 GEOL 306 (surficial processes)
3 GEOL 353 (structure)
3 Humanities
3 Social Science
3 Mathematics/Computer Science
3 Foreign Language
18 Total credit hours

Summer
3 or 6 GEOL 482 or GEOL 480 (field methods)

Semester 7
3 GEOP 445 (exploration methods)
3 HYD 403 (groundwater)
3 GEOC 443 (principles)
3 GEOL 403 (soils)
3 Humanities/Social Science
15 Total credit hours

Semester 8
10 Technical/Free Electives
3 Humanities
3 Social Science
16 Total credit hours

Sample Curriculum for the Bachelor of Science in Earth Science with Geochemistry Option

Semester 1
4 CHEM 121 & 121L (general)
4 MATH 131 (calculus)
3 ENGL 111 (college English)
4 GEOL 101 & 101L (earth processes)
15 Total credit hours

Semester 2
4 CHEM 122 & 122L (general)
4 MATH 132 (calculus)
3 ENGL 112 (college English)
4 GEOL 102 & 102L (earth history)
15 Total credit hours

Semester 3
3 GEOL 319 (igneous & metamorphic petrology)
3 GEOL 341 (environmental)
3 CHEM 333 (organic)
3 ENGL 341 (technical writing)
3 Foreign Language
16 Total credit hours

Summer
3 GEOL 481 (field methods)

Semester 4
3 GEOL 306 (surficial processes)
3 GEOL 353 (structure)
3 Humanities
3 Social Science
3 Mathematics/Computer Science
3 Foreign Language
17 Total credit hours

Semester 5
3 GEOL 319 (igneous & metamorphic petrology)
3 GEOL 341 (environmental)
3 CHEM 333 (organic)
3 ENGL 341 (technical writing)
3 Foreign Language
15 Total credit hours

Semester 6
3 GEOL 306 (surficial processes)
3 GEOL 353 (structure)
3 Humanities
3 Social Science
3 Mathematics/Computer Science
3 Foreign Language
18 Total credit hours
Bachelor of Science in Earth Science with Geophysics Option

Minimum credit hours required—133

- GEOP 308 (3), 445 (3), 446 (3), 448 (3), plus six credit hours chosen from GEOP 325, 342, 370, 420, 466, or any geophysics course numbered 500 and above
- Three credit hours of approved field experience or senior project (GEOP 492)
- PHYS 242 (4), 333 (3)
- MATH 231 (4), 254 (3), 332 (3), 335 (3)
- Earth and Environmental Science Electives: Nine additional credit hours chosen from the upper-division courses offered by the Earth and Environmental Science Department.
- Technical Electives: Six credit hours chosen from any of the upper-division classes offered by the departments of physics, mathematics, computer science, chemistry, and the various engineering curricula.

Sample Curriculum for the Bachelor of Science in Earth Science with Geophysics Option

Semester 1
4 GEOL 101 & 101L (earth processes)
4 CHEM 121 & 121L (general)
4 MATH 131 (calculus)
3 ENGL 111 (college English)
15 Total credit hours

Semester 2
4 GEOL 102 & 102L (earth history)
4 CHEM 122 & 122L (general)
4 MATH 231 (calculus)
3 ENGL 112 (college English)
15 Total credit hours

Semester 3
4 GEOL 211 (mineralogy)
5 PHYS 121 & 121L (general)
4 MATH 231 (calculus)
3 Social Science
16 Total credit hours

Semester 4
3 GEOL 318 (sedimentary rocks)
3 GEOP 308 (geophysical earth)
5 PHYS 122 & 122L (general)
3 MATH 254 (linear algebra)
3 Humanities
17 Total credit hours

Semester 5
3 GEOL 319 (igneous and metamorphic petrology)
3 GEOL 337 (stratigraphy & paleontology)
3 ENGL 341 (technical writing)
3 Humanities
3 Social Science
18 Total credit hours

Semester 6
3 GEOL 353 (structure)
3 GEOP 445 (exploration geophysics I)
4 PHYS 242 (waves and vibrations)
3 Social Science
3 MATH 332 (vector analysis)
16 Total credit hours

Summer
3 GEOP 492 (senior project or field experience)

Semester 7
3 GEOP 342 (reflection seismology)
3 GEOP 446 (exploration)
3 MATH 335 (applied analysis I)
3 Earth & Environmental Science Elective
3 Technical Elective
3 Social Science/Social Science
18 Total credit hours

Semester 8
3 GEOP 448 (general)
3 PHYS 333 (electricity and magnetism)
6 Earth & Environmental Science Elective
3 Technical Elective
15 Total credit hours

Minor in Earth Science

Minimum credit hours required—18

The following courses are required:
- GEOL 101 & 101L (4)
- GEOL 102 & 102L (4)
- GEOL 211 (4)
- Minimum of six (6) hours chosen from: GEOL 306, 317, 318, 319, 337, 341, 353, 403; GEOC 443, 444; GEOP 308

Geology

Five-Year Program: Earth Science with Environmental Geology Option B.S./Geology M.S. Degree Program

The degrees Earth Science with Environmental Geology Option and Geology M.S. are achieved in five years by fulfilling the requirements for a B.S. degree in Earth Science with the Environmental Geology Option in four years and an M.S. degree in Geology the following year. A minimum of 158 credit hours is required to complete both degrees.

Students should apply to the Environmental Geology five-year program at the end of their sophomore year. Admission is contingent upon the acceptability of a proposed course of study, academic performance, and on the number of vacancies in the program. Students who have upper-division standing may also be considered, depending upon prior course work.

Once admitted to the program, every undergraduate student will work with a research group. Required courses include: GEOL 403 or 503, 405 or 505 (may substitute GEOL 430 or 530), 409 or 509, 491 (one credit hour per semester for three semesters), 592 (2 credit hours); GEOP 445 or HYD 466; GEOC 443, 525; HYD 403, 503L; CHEM 311 and 333. Recommended courses include GEOC 422; HYD 412 and 533.
Students in the Environmental Geology five-year program must apply for graduate standing, normally in their seventh semester. Graduate admission will be contingent upon adherence to the approved program of studies, a 3.0 minimum cumulative grade point average, and a 3.0 earned grade point average in mathematics, science, and engineering courses. Graduate status will be granted upon fulfillment of the requirements for the B.S. degree.

**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 student’s advisory committee and must fulfill the general requirements for the master’s degree with thesis and must include GEOL 480 or the equivalent, if not previously satisfied, two credits of GEOL 592, at least six credit hours of GEOL 591, and at least four credit hours of GEOL 593, unless the degree is completed in a shorter time. Credits earned in GEOL 592 and 593 may not be applied towards the 30 credits required for the M.S. degree.

**Without Thesis:**

The student’s course of study must be approved by the student’s advisory committee and must fulfill the general requirements for the master’s degree without thesis and must include GEOL 480 or the equivalent, if not previously satisfied, two credits of GEOL 592, at least three credit hours of GEOL 590, and at least four credit hours of GEOL 593, unless the degree is completed in a shorter time. Credits earned in GEOL 592 and 593 may not be applied towards the 30 credits required for the M.S. degree.

**Doctor of Philosophy in Earth and Environmental Science with Dissertation in Geology**

Students of exceptional ability, as demonstrated in previous courses or in a master’s degree program, may pursue a program leading to the doctoral degree.

The prospective doctoral candidate in earth and environmental science with specialization in geology should develop a good background in geology, chemistry, physics, and mathematics, in addition to achieving a high level of competence in the field of specialization. Ph.D. students must include 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 under the Graduate Program (page 34).

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 Courses:**

**GEOL 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 GEOL 101L or GEOL 103L.

**GEOL 101L, Earth Processes Laboratory, 1 cr, 3 lab hrs**

*Corequisite: GEOL 101*

For students majoring in earth sciences. Identification of rocks and minerals, maps and map reading, and measurement and interpretation of geologic features. Field trips.

**GEOL 102, Earth History, 3 cr, 3 cl hrs**

*Prerequisite: GEOL 101*

*Offered spring semester*

Evolution of the lithosphere, hydrosphere, atmosphere, and biosphere in the context of plate tectonic theory. Application of geological/biological processes and products to the formation and evolution of the Earth.

**GEOL 102L, Earth History, 1 cr, 3 lab hrs**

*Prerequisite: GEOL 101L or 103L*

*Corequisite: GEOL 102*

Laboratory intended to accompany GEOL 102 for students majoring in the earth sciences and related engineering fields; involves field exercises which illustrate the evolution of the Earth, development of geochronology, geologic mapping, and interpretation of crustal history. Field trips.

**GEOL 103L, Earth Processes Laboratory for Non-Majors, 1 cr, 3 lab hrs**

*Corequisite: GEOL 101*

Laboratory to accompany GEOL 101 for students not majoring in the earth sciences. Identification of rocks and minerals, maps and map reading, and measurement and interpretation of geologic features.

**GEOL 104L, Earth History Laboratory for Non-Majors, 1 cr, 3 lab hrs**

*Prerequisite: GEOL 101L or 103L*

*Corequisite: GEOL 102*

Laboratory intended to accompany GEOL 102 for students not majoring in the earth sciences and related engineering fields; laboratory-oriented course that includes exercises which illustrate geological and paleontological processes, products, and principles involved in the evolution of the Earth. Several short field excursions will occur during laboratory hours.

**GEOL 120, Introductory Oceanography, 3 cr, 3 cl hrs**

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. (Same as GEOP 120)

**GEOL 130, Spaceship Earth, 3cr, 3 cl hrs**

*Alternate years, spring semester*

Study of Earth as an immense system composed of a gigantic rocky mass, a planet-dominating ocean, an active atmosphere, and an abundance of life. Consideration of subsystems interacting across time and space. Discussion of possible mechanisms that may control this megasystem including controversial topics, e.g. co-evolution, homeostatic feedback mechanisms, and the Gaia Hypothesis.

**GEOL 130L, Spaceship Earth Lab, 1 cr, 3 lab hrs**

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

**GEOL 211, Introduction to Mineralogy, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisite: GEOL 101*

*Corequisite: CHEM 121*

*Offered fall semester*

Introduction to crystal structures, crystal chemistry, optical mineralogy, and mineral occurrence. The laboratory teaches mineral identification of major rock-forming and ore minerals based on physical and optical properties.
GEOL 306, Surficial Processes, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: GEOL 102, 102L
Offered spring semester
Study of the major processes controlling the development of landforms and landscapes. Emphasizes the influence of these processes on our environment. Field trips.

GEOL 317, Survey of Sedimentary Rocks and Processes, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: GEOL 101 or consent of instructor
Offered fall semester
Study of sedimentary processes, materials, and depositional environments. Field trips. This class is for non-majors only; earth science majors must enroll in GEOL 318.

GEOL 318, Sedimentary Rocks and Processes, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: GEOL 102 and 211 or consent of instructor
Offered spring semester
Study of sedimentary processes, materials, depositional environments, and the petrography of sedimentary rocks. Field trips.

GEOL 319, Igneous and Metamorphic Petrology, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: GEOL 211 and 318 or consent of instructor
Offered fall semester

GEOL 333, Introductory Stratigraphy, 1 cr, 1 cl hr, 1 lab hr
Prerequisite: GEOL 101
Offered fall semester
Principles of litho-, bio-, and chronostratigraphy with an emphasis on sequence stratigraphy; and the designation, identification, and correlation of stratigraphic units. Field trip.

GEOL 337, Stratigraphy and Paleontology, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: GEOL 102
Offered spring semester
Introduction to stratigraphic principles; survey of geologically important invertebrate biota preserved as fossils; their modes of preservation, collection techniques, taxonomy, paleobiology, paleoecology, and biostratigraphic utility. Field trips.

GEOL 341, Environmental Geology, 3 cr, 3 cl hrs
Prerequisites: GEOL 101, CHEM 121
Offered fall semester
Study of the influence of geologic processes and hazards on human activities. Emphasis will be placed upon topics of interest to students considering careers in environmental science and engineering.

GEOL 353, Structural Geology, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites (Earth Science majors): GEOL 102 & 102L; GEOL 317, 318 or 319; PHYS 121 or 131; or consent of instructor
Prerequisites (Mineral Engineering majors): ME 360 & 360L; PHYS 121 or 131; or consent of instructor
Corequisite (Mineral Engineering majors): ME 462
Offered spring semester
Study and interpretation of geologic structures. Processes of fracturing, faulting, folding, and flow of rocks; stress and strain; and elementary concepts of tectonics. Lab includes solution of map problems and use of stereographic projections. Field trips.

GEOL 403, Introduction to Soils, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: GEOL 102, 102L
Offered fall semester
Introduction to soil formation, pedogenic processes, and soil description and mapping techniques.

GEOL 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.

GEOL 409, Soil Geomorphology, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: GEOL 306 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.

GEOL 411, Experimental Mineralogy, 3 cr, 5 lab hrs
Prerequisite: GEOL 211
Offered spring semester, alternate years
Study of the principles of mineralogy through experimentation in the laboratory. Techniques taught include hand sample identification, optical mineralogy, x-ray diffraction, thin section preparation, and mineral synthesis.

GEOL 420, Paleomagnetism, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: GEOL 101 and PHYS 122 or equivalents; upper-class or graduate standing
Offered on demand
Paleomagnetic theory, methods, and application to geologic problems. Laboratory includes field collection of samples and acquisition, analysis, and interpretation of data. (Same as GEOP 420)

GEOL 422, Advanced Igneous Petrology, 3 cr, 3 cl hrs
Prerequisite: GEOL 319
Offered on demand
Application of phase diagrams, experimental petrology, and field and petrographic relationships to the origin of magmas. Field trips.

GEOL 424, Sedimentary Petrography, 3 cr, 4 lab hrs
Prerequisite: GEOL 318
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.

GEOL 430, Active Tectonics, 3 cr hrs
Prerequisites: GEOL 306, 353
Offered 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.

GEOL 432, 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.

GEOL 434, Introduction to Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: PHYS 122 or 132 or consent of instructor
Offered on demand
Introduction to the theory and practical use of remotely sensed satellite images. Principles of radiation physics; sensor systems; data acquisition; image analysis; classification schemes. Remote sensing applications to atmospheric sciences, hydrology, mineral and oil exploration, natural hazards monitoring, and land and resources management. Laboratory exercises deal primarily with computer analysis of remotely-sensed images with some field exercises. GEOL 434 and 534 share lecture/lab, but GEOL 534 is graded separately and additional graduate-level work is required. (Same as GEOP/HYD 434)

GEOL 445, Volcanology, 3 cr, 2-3 cl hrs, 1-3 lab hrs
Prerequisite: GEOL 319 or consent of instructor
Offered on demand
Study of volcanic processes, eruptive products and their mechanism of formation. Volcanic hazards and the environmental impact of volcanism. Field trips to nearby volcanic fields.
GEOL 460, Subsurface and Petroleum Geology, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: GEOL 317 or 318 or consent of instructor
Offered spring semester
Principles and techniques of subsurface geology with emphasis on subsurface mapping, facies analysis, fluid-related rock properties, composition, movement and entrapment of subsurface fluids (oil, natural gases, water), and petroleum source rocks. Laboratory work emphasizes subsurface analysis and mapping with logs, cuttings, and cores. Applications to hydrocarbon exploration and development.

GEOL 462, Mineral Deposits, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: GEOL 211
Offered spring semester, alternate years
Geologic and geochemical characteristics of metallic mineral deposits; theories of origin and classification.

GEOL 463, Geology of the Colorado Plateau, 3 cr, 2 cl hrs, field trips
Prerequisites: GEOL 318; or consent of instructor
Offered spring semester
Discussion of geology, archeology, and ecology of the Colorado Plateau, emphasizing the Canyonlands region. Geological topics include geomorphology, sedimentology, tectonics, igneous rocks, and surficial processes. Field trips are an important part of the course, and hiking is required.

GEOL 466, Geologic River Trip, 1–2 cr, field trip
Offered spring semester and summer session
This course includes one or more whitewater raft trips on rivers in the Southwest with discussions of local geology, archaeology, and ecology. During the spring semester, the course also includes weekly seminars. Students may register for the course more than once, but only four (4) credit hours can be applied towards an earth science degree.

GEOL 468, Evolution of the Earth, 3 cr, 3 cl hrs, field trip
Prerequisites: GEOL 318, 319, 337
Offered spring semester
Origin of the solar system and of the earth; the evolution of continents, atmosphere, and oceans; comparative planetary evolution; tectonic regimes in geologic history. Field trip required.

GEOL 470, Geology of the Cayman Islands and Field Trip, 3 cr
Prerequisites: GEOL 318 and 335 or consent of instructor
Offered spring semester alternate years
Investigation of modern and ancient reefs in an easily accessed area, as well as study of the environmental implications of living on an island. Weekly meeting followed by an end-of-semester seven to nine day field trip. Students are expected to complete field exercises, make oral presentations, and write a paper on a topic such as reef ecology through time on the Cayman Islands, the tectonic evolution of the Caribbean and the Caymans, or environmental concerns of island life.

GEOL 480, Field Methods in Earth Science, 6 cr
Prerequisites: GEOL 318, 319, 337, 353
Offered summers (6 weeks)
Collection, processing, and interpretation of field data developed by geologic mapping in sedimentary, igneous, and metamorphic terranes. Presentation of geologic reports involving maps, cross sections, and sample data.

GEOL 481, Field Methods in Earth Science I, 3 cr
Prerequisites: GEOL 318 and 337
Offered summers (3 weeks)
Collection, processing, and interpretation of field data developed by geologic mapping of sediments and sedimentary rocks. Presentation of geologic reports involving maps, cross sections, and sample data. Students should register for this class in the spring semester.

GEOL 482, Field Methods in Earth Science II, 3 cr
Prerequisites: GEOL 319, 353, and 481
Offered summers (3 weeks)
Collection, processing, and interpretation of field data developed by geologic mapping of sedimentary, igneous, and metamorphic terranes. Presentation of geologic reports involving maps, cross sections, and sample data. Students should register for this class in the spring semester.

GEOL 491, Advanced Problems, hrs and crs to be arranged
Detailed investigation of a limited area of a problem; presentation of a written report. Work may extend over one or more semesters or a summer session.

GEOL 492, Senior Thesis, 3 cr
Prerequisites: 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.

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 503, Introduction to Solis, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: GEOL 102
Offered fall semester
Introduction to soil formation, pedogenic processes, and soil description and mapping techniques. Shares lecture/lab with GEOL 403, but is graded separately and additional graduate-level work is required.

GEOL 507, Ore Deposit Seminar and Field Trip, 1–6 cr
Offered spring semester
Ore deposits and geology of a specific geographic area are studied in a weekly seminar and a one- to two-week field trip. The field trip will generally be international in alternate years. A paper is required. Students may register for the course more than once for a total of six credit hours.

GEOL 509, Soil Geomorphology, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: GEOL 306 and 403; or consent of instructor
Offered spring semester, alternate years
Introduction to soil formation, pedogenic processes, and soil description and mapping techniques. Shares lecture/lab with GEOL 403, but is graded separately and additional graduate-level work is required.

GEOL 512, 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. (Same as ENVS 412)

GEOL 520, Paleomagnetism, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: GEOL 101 and PHYS 122 or equivalent; upper-class or graduate standing
Offered on demand
Paleomagnetic theory, methods and application to geologic problems. Laboratory includes field collection of samples and acquisition, analysis, and interpretation of data. Shares lecture/lab with GEOL 420, but is graded separately and additional graduate-level work is required.

GEOL 521, Hydrogeologic Processes, 3 cr, 3 cl hrs
Prerequisites: GEOL 102, 102L, HYD 503, 507, 508
Geologic controls of the occurrence, movement, and quality of groundwater. Hydrologic properties of earth materials. Theory and study of specific hydrogeologic processes including water resource evaluation and well hydraulics, barometric and tidal responses of aquifers, regional groundwater flow, coupled groundwater and heat flow, fracture flow, saturated multiphase flow such as petroleum migration, diagenesis and reactive groundwater flow, couples groundwater flow and rock deformation, and other issues. (Same as HYD 521)
GEOL 522, Advanced Igneous Petrology, 3 cr, 3 cl hrs
Prerequisites: GEOL 319 and graduate standing; or consent of instructor
Offered on demand
Applications of phase diagrams, experimental petrology, and field and petrographic relationships to the origin of magmas, Field trips. Shares lecture/lab with GEOL 421, but is graded separately and additional graduate-level work is required.

GEOL 524, Sedimentary Petrography, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: Graduate standing
Offered spring semester, alternate years
Petrographic analysis and interpretation of sedimentary rocks, with emphasis on siliciclastics. Topics include: grain identification and provenance; identification of diagenetic minerals and textures, and interpretation of porosity and permeability characteristics. Shares lecture/lab with GEOL 424, but is graded separately and additional graduate-level work is required.

GEOL 530, Active Tectonics, 3 cr hrs
Prerequisites: GEOL 306, 353, 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 GEOL 430, but is graded separately and additional graduate-level work is required.

GEOL 532, Interdisciplinary Field Research, 3 cr, 8 lab hrs
Prerequisite: Consent of instructor
Offered fall semester
Introduction to field-based research. Activities include proposal writing, data collection, interpretation, and preparation of a written report. Field work is an important part of the course, and hiking is required. The course is team-taught by several instructors. Shares lecture/lab with GEOL 432, but is graded separately and additional graduate-level work is required.

GEOL 534, Introduction to Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: PHYS 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. Laboratory exercises deal primarily with computer analysis of remotely-sensed images with some field exercises. GEOL 434 and 534 share lecture/lab, but GEOL 534 is graded separately and additional graduate-level work is required. (Same as GEOP/HYD 534)

GEOL 535, Crustal and Mantle Evolution, 3 cr, 3 cl hrs
Origin and evolution of continents and evolution of the mantle. (Same as GEOC 535)

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. (Same as ENV 438/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 546, Advanced Volcanology, 3 cr, 3 cl hrs
Prerequisites: GEOL 445; graduate standing or consent of instructor
Offered on demand
Seminar discussions of selected topics in volcanology, such as environmental impact of volcanism, magma chambers, emplacement of ignimbrites, volatiles in magmas, and volcanic processes and products.

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 550, Cave and Karst Systems, 3 cr, 3 cl hrs
Prerequisites: CHEM 121 & 122, and either GEOL 101 or BIOL 111
Offered spring semester, every year
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. GEOL 450 and 550 lectures shared, but 550 is graded separately and additional graduate-level work is required.

GEOL 550L, Cave and Karst Lab, 1 cr, 3 lab hrs
Offered spring semester, every year
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.

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 556, Fluids in Faults and Shear Zones, 3 cr, 3 cl hrs
Prerequisite: Graduate standing or consent of instructor
Offered fall semester, alternate years
A seminar class. Processes by which permeability along faults and shear zones is decreased or enhanced, evidence and mechanisms of fluid movement in faults and shear zones, fault valve behavior, water weakening of minerals, and geochemical processes near the surface and at depth. (Same as GEOP 556, HYD 556)

GEOL 558, Mechanics of Earthquakes and Faulting, 3 cr, 3 cl hrs
Prerequisites: GEOL 553 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 561, Ore Genesis, 3 cr, 3 cl hrs
Offered spring semester, alternate years
Principles of the geochemistry of ore deposits including stable isotopes, lead isotopes, solution geochemistry, and element partitioning. Review of recent tectonic and geochemical generic models of hydrothermal, magmatic, and sedimentary ore deposits. (Same as GEOC 561)

GEOL 562, Ore Genesis, 3 cr, 3 cl hrs
Offered fall semester, alternate years
Principles of the geochemistry of ore deposits including stable isotopes, lead isotopes, solution geochemistry, and element partitioning. Review of recent tectonic and geochemical generic models of hydrothermal, magmatic, and sedimentary ore deposits. (Same as GEOC 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, 572, 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
In this course, the student must clearly demonstrate the ability to organize and pursue research. A written final report is required. At the discretion of the instructor, other faculty members may be requested to review the final 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 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 GEOC 593, GEOP 593, HYD 593)

GEOL 595, Dissertation (doctoral degree program), cr to be arranged

Geophysics (Solid Earth)
The Geophysics program offers an undergraduate degree in Earth Science with Geophysics option. See page 72.

Graduate Programs
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 student’s advisory committee and must fulfill the general requirements for the master’s degree with thesis and must include (unless taken in undergraduate work): GEOP 445, 446, 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, 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): GEOP 445, 446, 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 GEO 590, two credit hours of GEOP 592, 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 geophysics beyond the M.S. degree, three credit hours of GEOP 592, 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 Courses:

GEOP 120, Introductory Oceanography, 3 cr, 3 cl hrs
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. (Same as GEOL 120)

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

GEOP 308, The Geophysical Earth, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: PHYS 121; GEOL 101
An introductory survey of solid Earth geophysics covering fundamental physical processes shaping the Earth and geophysical techniques used to study Earth structure. Formation and internal structure of the Earth, plate tectonics, gravitational and magnetic fields, heat flow, earthquakes, and seismotectonics.

GEOP 325, Geophysical Methods of Shallow Exploration, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: PHYS 121; GEOL 101

GEOP 336, Archeological Geophysics, 3 cr, 1 cl hr, 6 lab hrs
Prerequisite: GEOP 235
General archeological background of pre-European civilization in central New Mexico. Class and field instruction in the use of geophysical techniques for non-intrusive archeological exploration of the numerous 800 to 1500 A.D. Native American occupational sites near New Mexico Tech.

GEOP 370, Formation Evaluation, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: PHYS 122
Corequisite: GEOL 353
The qualitative and quantitative interpretation of electric, sonic, and radioactive well logs. Physical and electrical properties of saturated rock. Formation testing and analysis. Laboratory exercises in log reading and interpretation. Preparation of subsurface maps for estimation of reserves. (Same as PETR 370)
GEOP 420, Paleomagnetism, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: GEOL 101 and PHYS 122 or equivalent; upper-class or graduate standing
Offered on demand
Paleomagnetic theory, methods, and application to geologic problems. Lab includes field collection of samples and acquisition, analysis, and interpretation of data. (Same as GEOL 420)

GEOP 434, Introduction to Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: PHYS 122 or equivalent
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. GEOP 434 and 534 share lecture/lab, but GEOP 534 is graded separately and additional graduate-level work is required. (Same as GEOL./HYD 434)

GEOP 445, Exploration Geophysics I, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: PHYS 121 or equivalent; GEOL 101; upper-class standing
An introductory course on seismic refraction and reflection imaging of the subsurface, including methods of data acquisition, processing, and interpretation in two and three dimensions. Designed for students with a range of earth science and engineering backgrounds.

GEOP 446, Exploration Geophysics II, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: PHYS 122 or equivalent; GEOL 101; upper-class standing
Introduction to gravity, magnetic, electrical and electromagnetic methods of geophysical exploration. Surface and subsurface methods. Physical principles, applications, inversion methods.

GEOP 448, General Geophysics, 3 cr, 3 lab hrs
Prerequisites: PHYS 122 or equivalent; GEOL 101; upper-class standing
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.

GEOP 491, Advanced Problems, hrs and crs to be arranged

GEOP 492, Senior Field Experience, hrs and crs to be arranged
Prerequisite: GEOP 325 or 445 or 446; consent of instructor
Individual field-based research planned and carried out by the student under the direction of a geophysics program faculty member. Work will be evaluated based on a written report documenting the research goals, field methods used, and data analysis and interpretation. Alternatively, this requirement may be satisfied by successful completion of a summer geophysical field course approved by the faculty.

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 505, Analysis of Time Series and Spatial Data, 3 cr, 3 lab 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 and HYD 587)

GEOP 523, 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 seismograph source parameters.

GEOP 525, Tectonophysics, 3 cr, 3 cl hrs
Offered on demand
An analytical study of the problems of earthquake generation, faulting, mountain building, and volcanism. Emphasis is placed upon the formulation of mathematical models which explain the physical observations.

GEOP 529, Geophysical Inverse Methods, 3 cr, 3 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 equivalent
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. GEOP 434 and 534 share lecture/lab, but GEOP 534 is graded separately and additional graduate-level work is required. (Same as GEOL./HYD 534)

GEOP 543, 544, 545, Geodynamics, 3 cr, 3 cl hrs each course
Offered on demand
Applications of continuum physics to geologic problems. Topics include plate tectonics, stress and strain, elasticity and flexure, heat transfer, gravity, fluid mechanics, rock rheology, thermal subsidence of sedimentary basins, faulting, and flow in porous media.

GEOP 556, Fluids in Faults and Shear Zones, 3 cr, 3 cl hrs
Prerequisite: Graduate standing or consent of instructor
Offered on demand
A seminar class. Processes by which permeability along faults and shear zones is decreased or enhanced, evidence of and mechanisms of fluid movement in faults and shear zones, fault valve behavior, water weakening of minerals, and geochemical processes near the surface and at depth. (Same as GEOL 556, HYD 556)

GEOP 558, Mechanics of Earthquakes and Faulting, 3 cr, 3 cl hrs
Prerequisites: GEOL 353 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 570, Current Topics in Earthquake Seismology, 3 cr, 3 cl hrs
Prerequisite: consent of instructor
Offered in alternate years
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
In this course, the student must clearly demonstrate the ability to organize and pursue research. A written final report is required. At the discretion of the instructor, other faculty members may be requested to review the final report.

GEOP 591, Thesis (master’s program), cr to be arranged
Geochemistry Courses:

**GeoC 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. See page 16 for more information about this program.

**GeoC 422, Environmental Geochemistry, 3 cr, 3 cl hrs**
Prerequisites: Any two of the following: CHEM 311, 331, or 333
Offered in alternate years
- Application of chemical principles to the study of the environment.
- Includes natural processes and pollution problems related to water, air, and soil. (Same as CHEM 422)

**GeoC 431, Exploration and Environmental Trace Element Geochemistry, 3 cr, 2 cl hrs, 3 lab hrs**
Prerequisites: GEOL 102, 211; CHEM 122
Offered fall semester, alternate years
- Distribution of trace elements in surficial and deep-seated environments. Processes of trace element dispersion and mobility of trace elements in surficial environments. Trace element anomalies as guides to mineral deposits. A field project will be a required part of the course work. Field trips.

**GeoC 443, Principles of Geochemistry, 3 cr, 3 cl hrs**
Prerequisites: CHEM 122; GEOL 211
Offered spring semester, even-numbered years
- Application of chemical principles to geologic processes.

**GeoC 444, Principles of Isotope Geochemistry, 3 cr, 3 cl hrs**
Prerequisites: CHEM 122; GEOL 211
Offered fall semester, odd-numbered years
- Principles of radiogenic isotope geochemistry and applications to geologic dating and to the petrogenesis of rock suites.

**GeoC 491, Advanced Problems, hrs and cr to be arranged**
Detailed investigation of a limited area of a problem; presentation of a written report. Work may extend over one or more semesters or a summer session.

**GeoC 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.

**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
Pre- or Corequisite: HYD 403 or 503
- 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. (Same as HYD 507)

**GeoC 516, 40Ar/39Ar Geochronology, 4 cr, 3 cl hrs, 3 lab hrs**
Prerequisite: Geochemistry 444
Offered spring semester, alternate years
- Principles and applications of 40Ar/39Ar geochronology and thermochronology, including field and laboratory methods.

**GeoC 517, Advanced 40Ar/39Ar Geochronology, 3 cr, 3 cl hrs**
- Advanced topics, specialized applications, and current research in 40Ar/39Ar geochronology.

**GeoC 533, Crustal and Mantle Evolution, 3 cr, 3 cl hrs**
Origin and evolution of continents and evolution of the mantle. (Same as GOL 533)

**GeoC 543, Mineral Equilibria, 3 cr, 2 cl hrs, 3 lab hrs**
Offered spring semester, alternate years
- Application of chemical thermodynamics to mineral stabilities in aqueous systems.

**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 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 GEOC 593, GEOC 593, HYD 593)

**GeoP 595, Dissertation (doctoral degree program), cr to be arranged**

**Geochemistry**

The Geochemistry program offers an undergraduate degree in Earth Science with Geochemistry Option. See page 71.

**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 Geochemistry 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, and six credit hours in upper-division or graduate chemistry courses. As part of the degree requirements, students must have completed CHEM 331; GEOL 211; 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. Ph.D. students must include 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 under the Graduate Program (page 34).

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.
GEOC 552, X-ray Fluorescence Spectrometry, 1–2 cr, 3 lab hrs
Offered on demand
Theory and application of x-ray fluorescence to the analysis of geologic materials.

GEOC 554, Fluid Inclusions, 1–2 cr, 6 lab hrs
Offered on demand
Theory and application of thermometric analysis to fluid inclusions.

GEOC 558, Environmental Tracers in Hydrology, 3 cr, 3 cl hrs
Prerequisites: HYD 403 or 503; HYD 507
Offered in alternate years
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, chlorofluorocarbons and other environmental tracers to hydrologic problems. (Same as HYD 558)

GEOC 561, Ore Genesis, 3 cr, 3 cl hrs
Offered spring semester, alternate years
Principles of the geochemistry of ore deposits including stable isotopes, lead isotopes, solution geochemistry, and element partitioning. Review of recent tectonic and geochemical generic models of hydrothermal, magmatic, and sedimentary ore deposits. (Same as GEOL 561)

GEOC 562, Ore Genesis, 3 cr, 3 cl hrs
Offered fall semester, alternate years
Principles of the geochemistry of ore deposits including stable isotopes, solution geochemistry, and element partitioning. Review of recent tectonic and geochemical generic models of hydrothermal, magmatic, and sedimentary ore deposits. (Same as GEOL 562)

GEOC 565, Stable Isotope Geochemistry, 3 cr, 3 cl hrs
Offered spring semester
Principles of stable isotope geochemistry with applications to geologic systems.

GEOC 566, Practical Aspects of Mass Spectrometry, 3 cr, 1 cl hr, 6 lab hrs
Prerequisites: GEOC 565; consent of instructor
Offered fall semester
Theory and application of stable isotope mass spectrometry. Through lectures, problem sets, and laboratory exercises, students learn how to analyze geologic samples to determine stable isotope composition.

GEOC 571, 572, 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: GEOL 211; GEOL 318 or 319; consent of instructor
Principles, techniques and applications of electron microprobe analysis: X-ray theory, sample preparation techniques, hands-on analysis using the electron microprobe, techniques of instrument calibration and data reduction. Emphasis on analysis of geological samples. Class participation is required for students who plan to use the electron microprobe as part of their thesis research. Class time will be divided between 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
In this course, the student must clearly demonstrate the ability to organize and pursue research. A written final report is required. At the discretion of the instructor, other faculty members may be requested to review the final 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 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 GEOL 593, GEOP 593, HYD 593)

GEOC 595, Dissertation (doctoral degree program), cr to be arranged

Hydrology

Five-Year Program: Science or Engineering B.S./Hydrology M.S. Degree

The five-year B.S./Hydrology M.S. degrees are achieved by fulfilling the separate requirements of both an undergraduate degree in a science or engineering field and a graduate degree in hydrology in a five-year period. A minimum of 158 total credit hours is required to complete both degrees.

Students should apply to the program at the end of their sophomore year. Admission is contingent upon the acceptability of a proposed course of study, academic performance, and on the number of vacancies in the program. Students having upper-division standing may also be considered, depending upon prior course work.

Once admitted to the program, every undergraduate student will work with a research group. Required courses include:

- HYD 491 (one credit hour per semester for three semesters)
- HYD 503, 503L, 507, 508, 512, 512L, 517, 521, 533
- HYD 591 (at least six credit hours)
- HYD 592 (two credit hours)
- GEOL 102
- MATH 335 and 335L and either MATH 283 or 382

During the senior year, the student in this program must select a graduate advisory committee and formalize his or her graduate research topic.

Students in the Hydrology five-year program must normally apply for graduate standing at the end of their seventh semester. Graduate admission will be contingent upon adherence to the approved program of studies, a 3.0 cumulative grade point average, and a 3.0 earned grade point average in mathematics, science, and engineering courses. Graduate status will be granted upon fulfillment of the requirements for the B.S. degree.
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 student’s advisory committee and must fulfill the general requirement for the master’s degree and must include:

- HYD 503, 503L, 507, 508, 512, 512L, 517, 521, and 533
- HYD 591 (at least six credit hours)
- HYD 592 (two credit hours).
- GEOL 102 or equivalent
- MATH 335 and 335L and either MATH 283 or 382 or equivalents

Examples of courses other than hydrology which are appropriate for graduate programs in hydrology include, but are not limited to: BIOL 343, 442, 446; CHEM 331, 332, 333, 334; GEOC 443, 444, 543; GEOL 353, 403, 409, 460, 503, 509, 526; GEOP 370, 445, 446, 448, 505, 529; MATH 332, 382, 384, 410, 411, 415, 433, 434, 435, 436, 438, 483, 486, 488, 511, 512, 533, 534, 586, 587; PETR 445, 523, 526, 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 in graduate hydrology beyond the M.S. degree, three credits of HYD 592, 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 are 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.

Hydrology Courses:

**HYD 403, Groundwater Hydrology, 3 cr, 3 cl hrs**
Prerequisite: MATH 231 or consent of instructor; upper-class standing
Fundamentals of groundwater hydrology. The hydrologic cycle, Darcy’s law, aquifer parameters, steady and transient flow equations, well hydraulics, elementary multi-phase flow, groundwater recharge, vadose zone hydrology, field aquifers, and surface water bodies. Management of surface and groundwater systems. (Same as GEOL/GEOP 534)

**HYD 412, Surface Water Hydrology, 3 cr, 3 cl hrs**
Prerequisites: PHYS 121, MATH 132; upper-class standing
Theory, observations and modeling of the physical processes in the land-phase of the hydrologic cycle. Processes considered include atmospheric radiation, surface energy balance, precipitation, infiltration, runoff generation, streamflow and open channel hydraulics, evapotranspiration, rainfall interception, and snow melt and shallow subsurface flow. Catchment hydrologic processes illustrated through case study in the Rio Grande and its subbasins. Remote sensing, geographical information systems (GIS) and hydrologic model applications to surface hydrology. Shares lectures with HYD 512 but is graded separately.

**HYD 434, 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. HYD 434 and 534 share lecture/lab, but HYD 534 is graded separately and additional graduate-level work is required. (Same as GEOL/GEOP 434)

**HYD 491, Special Problems, 1–5 cr**
An introduction to methods of research. Problems are chosen from the field of hydrology and may be small independent investigations or a part of a research program being directed by the instructor.

**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 503, Groundwater Hydrology, 3 cr, 3 cl hrs**
Prerequisite: MATH 231 or consent of instructor
Fundamentals of groundwater hydrology. The hydrologic cycle, Darcy’s law, aquifer parameters, steady and transient flow equations, well hydraulics, elementary multi-phase flow, groundwater recharge, vadose zone hydrology, field aquifers, and surface water bodies. Management of surface and groundwater systems. (Same as GEOL/GEOP 534)

**HYD 503L, Groundwater Hydrology Laboratory, 1 cr, 3 lab hrs**
Pre- or corequisite: HYD 403 or 503
A series of experiments and problems illustrating flow and transport in porous media, together with applied problems.

**Hydrology 507, Hydrogeochemistry, 3 cr, 3 cl hrs**
Prerequisite: CHEM 122
Pre- or Corequisite: HYD 403 or 503
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. (Same as GEOL 507)

**HYD 508, Flow and Transport in Hydrologic Systems, 3 cr, 3 cl hrs**
Prerequisites: HYD 403 or 503; MATH 335 or HYD 533
Principles of flow and transport in groundwater aquifers, storage and compressibility, capillarity, and Darcy’s law in porous media. Single phase, two phase and Richard’s equations. Flow in fractures and streams. Transport of reactive chemical species by advection, diffusion and dispersion in porous and fractured media, and surface water bodies.

**HYD 512, Surface Water Hydrology, 3 cr, 3 cl hrs**
Pre- or Corequisites: MATH 335 or HYD 533; HYD 403 or 503
Theory, observation and modeling of the physical processes in the land-phase of the hydrologic cycle. Processes considered include atmospheric radiation, surface energy balance, precipitation, infiltration, runoff generation, streamflow and open channel hydraulics, evapotranspiration, rainfall interception, snow melt and shallow subsurface flow. Catchment hydrologic processes illustrated through case study in the Rio Grande and its subbasins. Remote sensing, geographical information systems (GIS) and hydrologic model applications to surface hydrology. Shares lectures with HYD 412 but is graded separately.

**HYD 512L, Surface Water Hydrology Laboratory, 1 cr, 3 lab hrs**
Pre- or Corequisite: HYD 412 or 512, or consent of instructor
Practical problems in surface water hydrology, including computer exercises in catchment hydrologic processes with data analysis, geographic information systems (GIS), remote sensing data and hydrologic models.
HYD 513, Hydrometeorology, 3 cr, 3 cl hrs  
Prerequisites: HYD 503, 508, 512  
Theory and observations of hydrometeorological processes in land-surface and atmosphere. Exchange of mass, heat, and momentum between the soil, vegetation, or water surface and the overlying atmosphere. Precipitation processes, radiation and clouds, atmospheric boundary layer dynamics, coupled balance of moisture and energy, soil moisture and climate feedback, hydroclimatology, monsoonal flow and thunderstorms. Emphasis on recent research and modern methods for data analysis and modeling.

HYD 517, Vadose Zone Hydrology, 3 cr, 3 cl hrs  
Prerequisite: HYD 508 or consent of instructor  
Physical processes governing fluid, vapor, heat, and solute movement between the land surface and the ground water table. Determination of soil physical properties in the laboratory and field. Application of the model HYDRUS1D for evaluation of water flow and contaminant movement in the vadose zone.

HYD 521, Hydrogeologic Processes, 3 cr, 3 cl hrs  
Prerequisites: GEOL 102, 102L; HYD 507, 508  
Geologic controls of the occurrence, movement, and quality of groundwater. Hydrologic properties of earth materials. Theory and study of specific hydrogeologic processes including water resource evaluation and well hydraulics, barometric and tidal responses of aquifers, regional groundwater flow, coupled groundwater and heat flow, fracture flow, saturated multiphase flow such as petroleum migration, diagenesis and reactive groundwater flow, coupled groundwater flow and rock deformation, and other issues. (Same as GEOL 521)

HYD 522, Advanced Hydrogeologic Processes, 3 cr, 3 cl hrs  
Prerequisite: HYD 521  
Offered on demand  
Advanced study of the effect of groundwater flow on geologic processes and vice-versa. Roles of groundwater within sedimentary basins, mountain massifs, the seafloor, faults, fractures, and other structures. Hydrothermal flow and its effect on petroleum generation and migration, ore formation. Fault and fracture formation, earthquakes and associated hydrogeologic processes. Emphasis on case studies, including recent research and modern methods of analysis.

HYD 532, Groundwater Modelling, 3 cr, 3 cl hrs  
Prerequisites: HYD 508  
Offered on demand  

HYD 533, Practicum in Quantitative Methods, 1 cr, 3 lab hrs  
Corequisite: HYD 403 or 503  
Instruction and practice in computational methods used to solve hydrological problems. Introduction to spreadsheets, graphics programs, and statistical packages. Vector and matrix operations and finite difference programming using mathematical packages. Introduction to structured programming and subroutine libraries. Graded on S/U basis; credits earned may not be used to apply to the 30 credit hours required for the M.S. degree.

HYD 534, 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. Laboratory exercises deal primarily with computer analysis of remotely-sensed images with some field exercises. HYD 434 and 534 share lecture/lab, but HYD 534 is graded separately and additional graduate-level work is required. (Same as GEOL/GEOP 534)

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. (Same as ENVS 436/GEOL 538)

HYD 542, Numerical Simulation of Groundwater Hydrology, 4 cr, 3 cl hrs  
Prerequisites: MATH 335; CS 410 or MATH 410; HYD 508; or consent of instructor  
Offered in alternate years  
An introductory course in finite difference methods and finite element methods for solving flow and transport problems in groundwater hydrology and petroleum engineering. Differential equations, finite difference approximations, finite element concepts. Applications to saturated, unsaturated, and multiphase flow, and to miscible displacement and pollutant transport.

HYD 543, Advanced Numerical Simulation Methods, 3 cr, 3 cl hrs  
Prerequisites: HYD 542 or PETR 523; MATH 511; and consent of instructor  
Offered on demand  
Focuses on selected topics (examples given below) from recent research on numerical simulation methods with applications to fluid flow and miscible displacement in groundwater and petroleum reservoirs. Equation solvers, including conjugate gradient, multi-grid, and adaptive grid methods; domain decomposition; sensitivity and uncertainty analysis; higher order finite differences and finite elements; mixed finite element methods; front tracking and backward method of characteristics.

HYD 545, Stochastic Methods in Groundwater Hydrology, 3 cr, 3 cl hrs  
Prerequisites: HYD 508; MATH 382, 586  
Offered in alternate years  
Selected topics from the theory of stochastic processes and random fields with applications to natural variability in groundwater hydrology; stochastic differential equations, spectral representation, perturbation methods, Monte Carlo simulation, Kalman filtering, kriging, Bayesian estimation, conditional simulation and related topics. Applications include estimation of aquifer parameters, effective properties of heterogeneous media, macroscopic dispersion, and monitoring network design.

HYD 546, Contaminant Hydrology, 3 cr, 3 cl hrs  
Prerequisites: HYD 403 or 503; HYD 507  
Prereq.: or Corequisite: HYD 508  
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.

HYD 548, Laboratory and Field Methods in Hydrology, 3 cr, 1 cl hr, 6 lab hrs  
Prerequisite: HYD 403 or 503; HYD 503L and 507  
Offered on demand  
Instrumentation and methodologies used in hydrological investigations, with an emphasis on contaminant hydrology. Experiments include sorption isotherms, miscible displacement, well installation, sample collection and storage, aquifer characterization, tracer tests, and physical and chemical characterization of sediments, soils, and aquifer materials.

HYD 552, Fluid/Surface Interactions, 3 cr, 3 cl hrs  
Prerequisite: Consent of instructor  
Offered in alternate years  
The physics and chemistry of interfaces, focusing on the behavior of multiluid 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 PETR 552)
HYD 554, Environmental Physics for Evapotranspiration, 3 cr, 3 cl hrs
Prerequisites: HYD 512, 517, or consent of instructor.
The first part of the course includes elements of environmental physics: radiation balance of the earth’s surface; transfer of momentum, heat, and mass; and crop micrometeorology. The second part focuses on vegetation water use and evapotranspiration: measurement methods; evaluation from meteorological observations; and prediction of spatial and temporal distribution of regional evapotranspiration using remote sensing.

HYD 556, Fluids in Faults and Shear Zones, 3 cr, 3 cl hrs
Prerequisite: Graduate standing or consent of instructor
Offered alternate years
A seminar class. Processes by which permeability along faults and shear zones is decreased or enhanced, evidence of and mechanisms of fluid movement in faults and shear zones, fault valve behavior, water weakening of minerals, and geochemical processes near the surface and at depth. (Same as GEOL 556, GEOP 556)

HYD 558, Environmental Tracers in Hydrology, 3 cr, 3 cl hrs
Prerequisites: HYD 403 or 503; HYD 507
Offered in alternate years
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, He, 14C, 3H, 18O, and other radionuclides. Application of Cl, Br, chlorofluorocarbons and other environmental tracers to hydrologic problems. (Same as GEOC 558)

HYD 560, Applied Groundwater Hydrology, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: HYD 508
Offered on demand
Topics for in-depth investigation may include well design, aquifer pumping test design and interpretation, groundwater flow simulations, and aquifer contamination. Field experiments, field trips, lab analysis, computer work, technical report preparation, and oral presentations.

HYD 564, Advanced Well Hydraulics, 3 cr, 3 cl hrs
Prerequisites: HYD 508 or PETR 445
Offered on demand
Discussion of well hydraulics theories for confined, unconfined, leaky, and fractured aquifers. Use of well hydraulics solutions to characterize aquifer hydrogeological features (formation evaluation) and to estimate important model parameters. Similarity overlaps in various well hydraulics theories developed in hydrogeology and petroleum reservoir engineering.

HYD 567, Advances in Flow and Transport, 3 cr, 3 cl hrs
Prerequisite: HYD 508
Offered on demand
Review of fundamental fluid mechanics: continuity, Euler, Bernoulli, potential flow, and Navier-Stokes equations; related applications. Ensemble averaging of flow and transport in fractures and porous media: tortuosity, effective properties, Darcy’s law, dispersion, multi-phase behavior, capillary percolation.

HYD 570, Seminar in Hydrology, 2 cr, 2 cl hrs
Review and discussion of papers relating to hydrology.

HYD 571, 572, Advanced Topics in Hydrology, 2–3 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 587, 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 and GEOP 505)

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 GEOC 592, GEOL 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. 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 595, Dissertation (doctoral degree program), cr to be arranged

Faculty Research Interests

Aster—Earthquake and Volcanic Seismology, Seismic Tomography, Network Seismology
Axen—Structural Geology, Tectonics and Neotectonics, Fault Mechanics and Shear-Zone Evaluation
Bilek—Earthquake Rupture Processes, Stresses and Structure of Fault Zones, Shallow Subduction Zone Processes, Tsunami
Bowman—Surface Chemistry, Solute Transport, Groundwater Contamination
Campbell—Metallic Ore Deposits, Stable Isotope Geochemistry
Condle—Trace Element and Isotope Geochemistry, Precambrian Studies
Condie—Trace Element and Isotope Geochemistry, Precambrian Studies
Johnson—Nuclear Geochemistry, Antarctic Geology, Volcanology
Johnson—Biostatigraphy, Paleoecological Environments
K Flood—Physical Properties of Sediments and Fault Zones, Geophysical Detection of Fluids and Faults, Reflection Seismology, Subduction Zone Tectonics
Vivoni—Hydrometeorology, Watershed Modeling, Surface Hydrology, Ecosystems, Environmental Fluid Mechanics, Turbulence
Wilson—Groundwater Hydrology, Numerical and Analytical Modelling, Stochastic Hydrology, Colloid and Bacteria Transport
Environmental Science

Environmental Science Advisory Committee:

Dr. Carl Popp, Chemistry
Dr. Bruce Harrison, Earth and Environmental Science
Dr. Rebecca Reiss, Biology
Dr. David Norman, Earth and Environmental Science
Dr. Clint Richardson, Environmental Engineering

Most 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 enough background to address specific aspects of those problems. To ensure that graduates are competitive in the marketplace, Environmental Science students take classes in all of the disciplines listed above. They also 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 in that discipline, should they choose.

An advisory committee, composed of faculty from the specific disciplines, is available to help students plan their programs.

Undergraduate Program

Core Requirements for the Bachelor of Science Degree in Environmental Science

In addition to the General Degree Requirements (page 53), 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)
- GEOL 102 & 102L (4), 341 (3)
- HYD 403 (3)
- ENV 201 (3), 302 (2)
- CS 111 (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 53), 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 53), 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 53), and the core Environmental Science Requirements (above), the following courses are required:
- GEOL 211 (4), 306 (3), 318 (3), 319 (3), 353 (3), 403 (3), 480 (6)
- 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 53), and the core Environmental Science Requirements (above), the following courses are required:
- HYD 403 (3), 412 (3), 466 (3), 503L (1)
- GEOL 306 (3), 317 (3), 353 (3)
- GEOP 370 (3)
- 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 53), and the core Environmental Science Requirements (above), a minimum of 25 credit hours from the following (at least 17 credit hours must be numbered 300 or above) are required:
- ES 332 (3)
- EE 211 (3), 212 & 212L (4), 231 & 231L (4), 308 & 308L (4), 321 & 321L (4)
- CHEM 331 & 331L (4), 411 & 411L (4)
- GEOL 353 (3)
- GEOP 370 (3)
- PHYS 434 (3), 493 (3)
- Electives to complete 135 credit hours

Environmental Science Courses:

ENVS 412, 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 but is graded separately.

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 but is graded separately.

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.
The following courses are required:

Minor in Education

Note: Requirements for the Master of Science Teaching degree are found on page 119.

Specific Requirements for Alternative Certification

- EDUC 323 (2), 340 (2), 343 (3), 401 (3), 403 (2), 411 (6)
- Passing scores on state-approved tests

Note: Requirements for the Master of Science Teaching degree are found on page 119.

Education Courses:

EDUC 323, Child and Adolescent Growth and Development, 2 cr, 2 cl hrs
The development of human behavior from conception through adolescence. Includes cognitive, social, personality, emotional, behavioral and physical development.

EDUC 340, Concepts in Education, 2 cr, 2 cl hrs
Brief survey of the history (especially modern history) of education together with the major philosophical schools of education. The application of general principles of psychology and modern technology to the goals of education.

EDUC 343, Classroom Management and Discipline, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: Permission of the instructor, consent of the chairman of the education department, consent of the public school principal.
The purpose and place of education in society. 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: Edu 340
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, 2 cr, 2 cl hrs
Must be taken immediately prior to EDUC 411
Prerequisites: Senior standing; enrollment in Alternative Licensure Program; EDUC 403; consent of the chair of the education department, and consent of the public school principal.
A study of essential principles, comprehensive lesson planning, teaching procedures, modern techniques, and resource materials.

EDUC 411, Directed Teaching, 6 cr
Prerequisites: Senior standing; enrollment in Alternative Licensure Program; EDUC 403; consent of the chair of the education department, and consent of the public school principal.
Methods and materials may be taught by the student’s major department prior to supervised teaching. All aspects of teacher training will be integrated and directed for the purpose of developing a high level of teaching competence.

Staff Research Interests

Austin—Teacher Growth and Development, Teaching and Learning of Math and Science, Cognition
Cormack—Psychophysics, Visual Perception, Sensory Mechanisms
Holson—Developmental Neurobiology, Neurotoxicology, Behavioral Teratology
Samuels—Cognitive Development, Reasoning and Problem Solving, Memory, Brain Injury and Rehabilitation
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 www.nmt.edu/~commcoll/ or call (505) 835-5511.

Fine Arts Courses:

The following sampling of Fine Arts courses are graded S/U and may be used for elective credit only. Classes may be taken multiple times for credit.

FA 100C, Stained Glass, 2 cr
FA 101C, Drawing I, 2 cr
FA 105C, Photography as an Art I, 3 cr
FA 106C, Photography as an Art II, 3 cr
FA 115C, Enameling I, 2 cr
FA 116C, Enameling II, 2 cr
FA 119C, Metal Arts/Lapidary, 2 cr
FA 120C, Armor Making, 2 cr
FA 121C, Knitting and Crochet, 2 cr
FA 135C, Ceramics I—Handbuilding, 2 cr
FA 136C, Ceramics II—Wheel Throwing, 2 cr
FA 145C, Technical/Perspective Drawing, 3 cr
FA 202C, Painting, 2 cr

General Studies

Administrative Committee for General Studies:
Professor Cormack (Chair)

Degrees Offered: Associate of General Studies, Bachelor of General Studies

Associate of General Studies

A two-year certificate, Associate of General Studies, may be awarded after completion of 65 credit hours of course work approved by the College with a grade-point average of 2.0 or above. A minimum of 30 credit hours must be earned at New Mexico Tech. The certificate will be awarded only after petition to the Vice President for Academic Affairs by the student. Minors are not awarded with the Associate of General Studies.

Bachelor of General Studies

The Bachelor of General Studies is not recommended as an initial degree program, but does provide an option for students not intending to seek graduate training or professional employment. This degree allows a student to plan a program of courses according to individual educational goals. The Bachelor of General Studies degree will be awarded upon satisfactory completion of 130 credit hours with a grade-point average of 2.0 or more. Forty credit hours of the 130 shall be in courses numbered 300 or above. A minimum of 30 credit hours must be earned at New Mexico Tech. There are no other course requirements. Minors are not awarded with the Bachelor of General Studies.

A candidate for this degree should consult with an advisor to plan the program and to obtain information regarding the advantages and limitations of the Bachelor of General Studies degree. The advisor will strive to make the student cognizant of courses relevant to the student’s individual goals.
Humanities

Professors Deming (Chair of the Department), Lara-Martinez, Yee
Associate Professors Dezember, Dunston, Field, Prusin, Zeman
Assistant Professors Ford, Harper, Jernigan, Mott, Walsh
Instructors Griffin, Stewart-Langley
Adjunct Faculty López
Emeritus Professors Campbell, Corey, Olsen, Wilson

Degree Offered: B.S. in Technical Communication

Minors Offered: Hispanic Studies, History, Literature, Philosophy, Technical Communication

Students wanting to minor in one of these disciplines must meet with an advisor of that minor. See the department chair or secretary for the advisor(s) of each minor. Each minor is described in its discipline.

The Humanities 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 experiences. To accomplish this mission, the department offers introductory and advanced courses in English composition, literature, history, art history, philosophy, foreign languages, political science, and music, in addition to the B.S. degree in technical communication.

The Humanities Department has established the following goals for humanities courses in general: to provide a foundation for further study, lifelong learning, and good citizenship. The department wishes students in humanities courses to gain knowledge of the material, intellectual excitement, curiosity, critical thinking, and a desire to continue to learn and to try to understand human experience.

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.

Bachelor of Science in Technical Communication

Minimum credit hours required—132

In addition to the General Degree Requirements (page 53), the following courses are required:

- Technical Communication—32 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 six credit hours of technical communication electives. All technical communication courses must be completed with grade C or better.
- Humanities: 12 credit hours in upper-division courses in excess of the general degree requirements
- MGT 330 (3)
- 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 132 hours

Sample Curriculum for the Bachelor of Science in Technical Communication

Semester 1
1. TC 101 (orientation)
2. ENGL 111 (college English)
3. MATH 131 (calculus)
4. CHEM 121 & 121L (general)
5. Foreign Language

___ Total credit hours

Semester 2
1. TC 151 (intro to visual communication)
2. ENGL 112 (college English)
3. MATH 132 (calculus)
4. CHEM 122 & 122L (general)
5. Foreign Language

___ Total credit hours

Semester 3
1. TC 202 (elements of editing)
2. PHYS 121 & 121L (general)
3. Biology/Geology/Engineering with lab
4. Humanities
5. Social Science

___ Total credit hours

Semester 4
1. TC 211 (rhetoric and advanced composition)
2. PHYS 122 & 122L (general)
3. Biology/Geology/Engineering with lab
4. Humanities
5. Social Science

___ Total credit hours

Semester 5
1. TC 100 (community service)
2. ENGL 341 (technical writing)
3. Humanities
4. Humanities/Social Science
5. Science or Engineering

___ Total credit hours

Semester 6
1. TC 421 (instructional writing)
2. Technical Communication Elective
3. Humanities
4. Social Science
5. Science or Engineering

___ Total credit hours

Semester 7
1. TC 321 (internship)
2. TC 411 (persuasive writing)
3. TC 420 (senior seminar)
4. MGT 330 (management and organizational behavior)
5. Science or Engineering

___ Total credit hours

Semester 8
1. Technical Communication Elective
2. TC 422 (senior thesis)
3. Science or Engineering
4. Electives

___ Total credit hours
Minor in Technical Communication

Minimum credit hours required—18
The following courses are required:

- TC 151 (3)
- TC 202 (3)
- TC 211 (3)
- Nine (9) additional credit hours of TC courses

Restriction:
- If a student takes more than one minor in the Humanities Department, only six (6) credit hours of one minor may be applied towards another minor.

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. (Same as SVC 100)

**TC 101, Orientation to Technical Communication, 1 cr, 1 cl hr**
Guest speakers introduce students to the myriad of activities and career paths of technical communicators.

**TC 151, Introduction to Visual Communication, 3 cr, 3 cl hrs**
Principles of electronic and print document design. Presentation of ideas through tables, charts, graphs, illustrations, and photographs. Use of computers in design and production. Presentation of final design project to technical communication students and humanities department faculty.

**TC 202, Elements of Editing, 3 cr, 3 cl hrs**
Prerequisites: ENGL 112; TC 151
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, Rhetoric and Media, 3 cr, 3 cl hrs**
Prerequisites: ENGL 112; TC 151
Application of rhetorical principles to a variety of media and writing projects done individually and in groups.

**TC 251, Practicum, 1–3 cr, variable class format**
Possible subjects of individual practice are photography, technical illustration, computer graphics, video-taping, print media, layout and design, and project management. The course may be repeated for credit whenever the topic changes. Visiting lecturers from industry will present some topics.

**TC 302, Article Writing for Mass Media, 3 cr, 3 cl hrs**
Prerequisite: ENGL 112
Researching, writing, and marketing publishable articles on scientific or technical subjects for general audiences. Practical, legal, and ethical aspects of professional writing.

**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 361, Digital Media Design, 3 cr, 3 cl hrs**
Prerequisites: TC 202 and 211 or consent of instructor
Evaluation and design of computer-based information, primarily focusing on hypertext and hypermedia. Includes discussion of theories of information design and technology. Final project requires design, completion, and presentation of a digital text.

**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 381, Studying Organizational Cultures, 3 cr, 3 cl hrs**
Prerequisites: TC 202 and 211 or consent of instructor
Learning the practice and process of participant observations within the cultures of organizations. Exploring the differences within cultures and writing those observations as narratives.

**TC 402, Advanced Technical Editing, 3 cr, 3 cl hrs**
Prerequisites: TC 202 and ENGL 341
Working with full-length drafts, the course applies theory to problems in editing, revising, and designing documents, working with authors in different organizational settings, and writing and designing for international audiences. Course includes a research project and presentation.

**TC 411, Persuasive Communication, 3 cr, 3 cl hrs**
Prerequisites: TC 202 and 211, 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, Instructional Writing, 3 cr, 3 cl hrs**
Prerequisites: TC 202 and 211, or consent of instructor
Theory and practice of producing instructional documents for a variety of purposes and audiences. Writing, designing, and project management are studied. Students gain practical experience working 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

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**Humanities**

**Art History Courses:**

The following courses may be used to fulfill the Humanities portion of the General Degree Requirements (page 53).

**ART 272, Art History, 3 cr, 3 cl hrs**
Prerequisite: ENGL 112
Using analysis and synthesis skills, students study works of art from prehistory to the 21st century, compare how these works interrelate, and discover how they are unique. Through study of artistic techniques, students learn how artists have created and responded to innovation and technological advancement.
**ART 372, Issues in Art History, 3 cr, 3 cl hrs**  
Prerequisite: ENGL 112  
Concentrated study of issues concerning the visual arts. Possible topics include Literature Inspired by Art; Visual and Other Arts; Modern Art and Reality; 1912 and 1913: the Titanic Year and the Gigantic Year in the Arts; Southwestern and Native American Art; Women Artists; the Renaissance—Art, Science, Literature, and Culture; 19th and 20th Century Art; Environment and the Arts; Arts around the World; Art Critics and Art; and Science Fiction, Fantasy, and Art. May be repeated for credit with different issues.

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**Literature**

**Minor in Literature**

Minimum credit hours required—18

The following courses are required:

- 18 credit hours in 300 and 400 level ENGL literature courses

**Restriction:**

- If a student takes more than one minor in the Humanities Department, only six (6) credit hours of one minor may be applied towards another minor.

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**English Courses:**

English courses numbered 300 and above, with the exception of ENGL 341, may be used to fulfill the Humanities portion of the General Degree Requirements (page 53).

**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 Degree Requirements, page 53.)

**ENGL 111, College English, 3 cr, 3 cl hrs**

The essentials of academic prose; techniques and mechanics of writing well; rhetorical strategies.

**ENGL 112, College English, 3 cr, 3 cl hrs**  
Prerequisite: ENGL 111 or equivalent passed with grade C or better  
A continuation of ENGL 111 with critical reading and writing; writing arguments; library research paper.

**ENGL 242, Speech, 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.

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

A multigenre course in writing poetry, fiction, and creative nonfiction; may include playwriting and screenwriting. Emphasis on reading and analyzing literature.

**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.

**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.

**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: Homer, Aeschylus, Sophocles, Euripides, Aristophanes, medieval Romance, Dante, Chaucer, Boccaccio, Rabelais, Cervantes.

**ENGL 326, World Literature, 3 cr, 3 cl hrs**  
Prerequisite: ENGL 112 or consent of instructor  
Literature of the West from Neoclassicism to Contemporary: Molière, Swift, Voltaire, Rousseau, Goethe, Balzac, Lermontov, Flaubert, Dostoyevski, Tolstoy, Ibsen, Conrad, Joyce, Kafka, Camus, Lessing; some non-Western authors: Soseki, Sahgal, Mistry.

**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.

**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.

**ENGL 341, 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 sophomore standing  
The form and structure of the technical report; analysis, interpretation, and evaluation of data; bibliographical and research methods; job application letters and résumés; technical proposals; oral presentations.

**ENGL 352, Contemporary Latin American Regional 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, Rea Bastos, Rulfo. (Same as Spanish 352)

**ENGL 391, Post-Colonial Literature, 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 authors.

**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, novels, and nonfiction writing. May be repeated for credit with different genres.

**ENGL 432, 20th Century American Drama, 3 cr, 3 cl hrs**  
Prerequisite: ENGL 112  
The study of some of the major plays and theatre groups of American drama in the 20th and early 21st centuries, ranging from early Eugene O’Neill, Sophocles, and Glaspell to the most up-to-date works of the 21st century.

**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 in Literature, 3 cr, 3 cl hrs**  
Prerequisite: ENGL 112 or consent of instructor  
Concentrated study of issues and ideas as they affect or are given embodiment in literature. Possible topics include, among others, Literature of the Southwest, Women Writers, Native American Writers, Literature and Gender, Ethnicity, Literature and Environment, Travel Literature, Sports Literature, and Science Fiction. May be repeated for credit with different issues.

**ENGL 437, Shakespeare, 3 cr, 3 cl hrs**  
Prerequisite: ENGL 112  
The study of some of Shakespeare’s major plays, including comedies, tragedies, romances, and problem plays.
ENGL 461, Western American Literature, 3 cr, 3 cl hrs
Prerequisite: ENGL 112 or consent of instructor
Regional writing of the American West.

ENGL 482, Period Studies, 3 cr, 3 cl hrs
Prerequisite: ENGL 112 or consent of instructor
Material chosen by the instructor.

ENGL 491, Directed Studies, hrs and cr to be arranged
Prerequisite: ENGL 112 or consent of instructor

**Humanities Course:**

The following course may be used to fulfill Section 1.D. of the General Degree Requirements (page 53).

HUMA 481, Capstone Seminar, 3 cr, 3 cl hrs
Prerequisites: Senior standing and must have completed at least 12 credit hours in Humanities/Social Science courses.
Topic varies. An interdisciplinary, team-taught, upper-division seminar. Students will examine the topic from a wide variety of perspectives and consider how it relates to their chosen field of study/profession. May include a final project that will be reviewed by an advisor from the student’s major department.

**Music**

The music program offers a variety of courses for college credit, ranging from introductory courses in history and theory to vocal and instrumental performance ensembles. Advanced courses examine various contemporary topics from an interdisciplinary viewpoint. The performance ensembles present a number of concerts each semester, both in Socorro and in nearby communities.

**Music Courses:**

The following courses may be used to fulfill the Humanities portion of the General Degree Requirements (page 53).

MUS 101, Survey of Music, 3 cr, 3 cl hrs
A survey of musical evolution from antiquity to the beginning of the Romantic period. Use of representative works in manuscripts and recordings to illustrate important stylistic/historical trends.

MUS 102, Survey of Music, 3 cr, 3 cl hrs
A survey of musical evolution from the early Romantic period to the present. Use of representative works in manuscripts and recordings to illustrate important stylistic/historical trends.

MUS 105, Fundamentals of Music, 3 cr, 3 cl hrs
An introduction to the basic materials of music: tones, rhythm, notation, singing, and composition.

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 202, Comprehensive Musicianship II, 3 cr, 3 cl hrs, 1 lab hr
Prerequisite: MUS 201 or its equivalent
Survey and application of the fundamentals of theory, harmony, form, ear training, and composition of music. Techniques of simple four-part harmony studied and practiced. The development of skills with harmonic and melodic forms are applied toward creative compositional efforts for keyboard and/or various ensembles.

MUS 311, Opera, 3 cr, 3 cl hrs, 3 lab hrs
Prerequisite: MUS 101, 102, 105, or consent of instructor
A musical and socio-historical exploration of selected great operatic works. A complete opera will be viewed weekly during the lab session.

MUS 361–362, Chamber Music, 1 cr
Prerequisite: MUS 331–332, Chamber Choir, 1 cr, 2 cl hrs
An introduction to chamber music, with an emphasis on the music of the 19th and 20th centuries. The music will be performed by small ensembles directed by the instructor.

MUS 331–332, Chamber Choir, 1 cr, 2 cl hrs
Prerequisite: Consent of instructor
The Chamber Choir 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
A detailed study of notation, keys, scales, intervals, chords, clefs, and transpositions. Practical application to keyboard, instruments, and voice.

MUS 401, Interconnections of Music and Science, 3 cr, 3 cl hrs
Prerequisite: MUS 101, 102, 105, or consent of instructor
A discussion of elements connecting music and science in theory and practice. Readings will be selected from a variety of contemporary musicalological, scientific, and philosophical sources.

**Music Performance Courses:**

The following performance ensembles may be taken for elective credit only. Auditions will be held the first week of the semester and are required for MUS 331–332, MUS 341–342, and MUS 351–352. These courses can be repeated for credit as determined by the instructor.

These course do NOT apply toward the General Degree Requirements (page 53).

MUS 171, 172, Beginning Group Voice, 1 cr, 1 cl hr
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 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
A detailed study of notation, keys, scales, intervals, chords, clefs, and transpositions. Practical application to keyboard, instruments, and voice.

MUS 351–352, Chamber Orchestra, 1 cr, 3 cl hrs
Prerequisite: Consent of instructor

MUS 361–362, Chamber Music, 1 cr, 1 cl hr
Prerequisite: MUS 273, 274, or consent of instructor
Practical and theoretical aspects of solo vocal performance.

**Philosophy**

**Minor in Philosophy**

Minimum credit hours required—18
The following courses are required:
- PHIL 231, Introduction to Philosophy
- Fifteen (15) additional credit hours in philosophy courses.

With the consent of the minor advisor, of these 15 credit hours, six (6) credit hours may be taken in upper-division courses that have a substantial philosophical focus and content.

**Restriction:**
- If a student takes more than one minor in the Humanities Department, only six (6) credit hours of one minor may be applied towards another minor.

**Philosophy Courses:**

The following courses may be used to fulfill the Humanities portion of the General Degree Requirements (page 53).

PHIL 231, Introduction to Philosophy, 3 cr, 3 cl hrs
Prerequisite: ENGL 112 or consent of instructor
Introduction to philosophical methods and vocabulary, and to major areas of philosophical interest, including metaphysics, epistemology, and ethics.

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 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 351, World Religions, 3 cr, 3 cl hrs
Prerequisite: ENGL 112 or consent of instructor
 Introduction to the theologies of Christianity, Judaism, Islam, Hinduism, Buddhism, and other religions.

PHIL 352, Asian Philosophy, 3 cr, 3 cl hrs
Prerequisite: ENGL 112 or consent of instructor
 Introduction to the philosophical outlooks of China (Confucianism), India (Hinduism), and Japan (Buddhism).

PHIL 353, Western Philosophy, 3 cr, 3 cl hrs
Prerequisite: ENGL 112 or consent of instructor
 Survey of major figures, methods, and schools of western philosophy.

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—such as Nietzsche, Foucault, Richard Rorty, or Charles Taylor—or a philosophical school—such as Romanticism, pragmatism, or postmodernism. May be repeated for credit with different figures or periods.

Service Course:
SVC 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. (Same as TC 100)

Languages

Students may take a challenge exam to waive the first or second semester of a language and receive three credits. The challenge exam is graded S/U only. Language courses numbered 200 and above are offered only upon sufficient demand.

Minor in Hispanic Studies

Minimum credit hours required—18
The following courses are required:
• One of the following course 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
  ○ SPAN 215 and 216, Intermediate Spanish I and II
  ○ SPAN/ENGL 352, Latin American Regional Novel
  ○ SPAN/HIST 389, Latin American Cultural History
  ○ HIST 432, History of New Mexico and the Southwest
  ○ Any other relevant course with the consent of the minor advisor

Restriction:
• If a student takes more than one minor in the Humanities Department, only six (6) credit hours of one minor may be applied towards another minor.

French Courses:

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.

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

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:

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.

GERM 211, Intermediate German I, 3 cr, 3 cl hrs
Prerequisite: GERM 114 or equivalent
Expansion of skills in German language through readings in German culture, conversation, and writing. Review of German grammar.

GERM 212, Intermediate German II, 3 cr, 3 cl hrs
Prerequisite: GERM 211 or equivalent
Continuation of GERM 211.

Spanish Courses:

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.

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.

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 Regional 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 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)
Social Science

Minor in History

Minimum credit hours required—18

The following courses are required:

- One of the following course sequences (6)
  - HIST 141 and 142
  - HIST 151 and 152
- Twelve (12) additional credit hours in history courses. Of these 12 credit hours, six (6) credit hours may be taken in theatre history, 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.

Restriction:

- If a student takes more than one minor in the Humanities Department, only six (6) credit hours of one minor may be applied towards another minor.

History Courses:

The following courses may be used to fulfill the Social Science portion of the General Degree Requirements (page 53).

**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.

**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.

**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 334, The American West, 3 cr, 3 cl hrs**

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

The history of the American West up to the present. Exploration and conquest, the movement of peoples, the role of the federal government, rural and urban development, resource use, issues of race and ethnicity, gender and class, as well as the “idea” of the West.

**HIST 336, History of New Mexico and the Southwest, 3 cr, 3 cl hrs**

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

Examination of New Mexico and the Southwest from the earliest human communities to the present. Consideration given to the various cultures of the Southwest, the role of New Mexico in the region and in the nation, as well as in the popular imagination.

**HIST 343, Atomic America: The Cultural History of Nuclear Technology in the United States, 3 cr, 3 cl hrs**

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

The history of nuclear technology in the United States. Explores the cultural, social, political, and economic dimensions of atomic energy, with particular emphasis given to changing images in popular culture. May include guest speakers and field trips to the Trinity Site and the National Atomic Museum.

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

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

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 in the Modern Era, 3 cr, 3 cl hrs**

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

The political, economic, social, and ideological implications of warfare in the modern era.

**HIST 376, Mass Violence and Aggression, 3 cr, 3 cl hrs**

Prerequisite: Upper-division standing or consent of the instructor

This course examines the nature and dynamics of mass violence and aggression, and their impact on politics and societies. Through lectures and readings the students explore and compare political, sociological, and psychological dimensions of genocides, state terror, and ethnic cleansing. (Same at PSY 376)

**HIST 381, History of Science and Technology to 1750, 3 cr, 3 cl hrs**

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

A survey of the historical evolution of fundamental scientific concepts and technological developments in Western and non-Western cultures from the beginning of civilization to 1750.

**HIST 382, History of Science and Technology since 1750, 3 cr, 3 cl hrs**

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

A survey of the historical evolution of fundamental scientific concepts and technological developments in Western and non-Western cultures from 1750 to the present.

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

Prerequisite: At least one 100-level history course or equivalent; ENGL 341

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 421, The Age of Radical Ideologies, 3 cr, 3 cl hrs**

Prerequisite: At least one 100-level history course or equivalent; ENGL 341

The theory and practice of nationalism, anarchism, communism, and fascism in the 19th and 20th centuries.

**HIST 442, American Indian History, 3 cr, 3 cl hrs**

Prerequisite: At least one 100-level history course or equivalent; ENGL 341

American Indian history from ancient North America to the present. Various regions and periods, with special attention given to western and southwestern tribes.

**HIST 466, Historical Fiction, 3 cr, 3 cl hrs**

Prerequisite: At least one 100-level history course or equivalent; ENGL 341

This seminar explores the genre of historical fiction, examining several historical fiction novels and shorter works.

**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

Political Science Courses:

The following courses may be used to fulfill the Social Science portion of the General Degree Requirements, page 53.

**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.

**PS 361, Issues in International Relations, 3 cr, 3 cl hrs**

Prerequisite: PS 171 or one semester of college history or consent of instructor

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.
Information Technology

**Professors:** Sueyoshi, Sung (Program Coordinator)

**Associate Professors:** Anselmo (Program Coordinator), Mazumdar, Soliman, Wedeward

**Assistant Professors:** Liebrock, Qin, Shin

**Adjunct Faculty:** Lassez, Peterson

**Visiting Faculty:** Clausen

**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 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 Degree in Information Technology**

Minimum credit hours required—130

In addition to the General Degree Requirements (page 53), the following courses are required:

- IT 111 (4), 122 (3), 221 (3), 222 (4), 263 (3), 311 (3), 328 (3), 351 (3), 373 (3), 382 (3), 491 (3), 492 (3)
- MATH 221 (3), 283 (3)
- PSY 121 (3) (can be applied as a social science course in the general degree requirements)
- Technical Electives: a sequence of 12 hours of computer science, management, or engineering courses numbered 300 or higher, approved by the student's advisor and an IT Program Coordinator. Pre-approved options include the following:
  - Distributed Computing and Security Track
    - IT 353 (3), 452 (3), 453 (3), 463 (3)
  - Security and Assurance Track
    - IT 441 (3), 453 (3), 462 (3), 463 (3)

Each of the above courses must be completed with a grade of C or better;

- Electives to complete 130 credit hours.
Sample Curriculum for the Bachelor of Science Degree in Information Technology with Security and Assurance Track

Semester 1

1. MATH 131 (calculus)
2. IT 111 (introduction to computer science)
3. CHEM 121 & 121L (general)
4. ENGL 111 (college English)
15 Total credit hours

Semester 2

1. MATH 132 (calculus)
2. PSY 121 (general psychology)
3. IT 122 (algorithms and data structures)
4. CHEM 122 & 122L (general)
3. ENGL 112 (college English)
17 Total credit hours

Semester 3

1. IT 221 (computer and network organization)
2. MATH 221 (formal logic and discrete mathematics)
3. PHYS 121 & 121L (general)
4. Biology/Geology/Engineering with lab
3. IT 263 (information protection and security)
18 Total credit hours

Semester 4

1. IT 222 (systems and Internet programming)
2. MATH 283 (introduction to applied statistics)
3. PHYS 122 & 122L (general)
3. Humans
3. Social Science
18 Total credit hours

Semester 5

1. IT 311 (human information processing and decision making)
2. IT 351 (complex system modeling and simulation)
3. IT 373 (introduction to database design and management)
3. ENGL 341 (technical writing)
3. Humans
1 Elective
16 Total credit hours

Semester 6

1. IT 328 (secure software construction)
2. IT 382 (legal and ethical information technology issues)
4. Biology/Geology/Engineering with lab
6 Electives
16 Total credit hours

Semester 7

1. IT 453* (computer networks & the internet)
2. IT 491 (senior secure system design project)
3. IT 452* (introduction to parallel processing)
3. IT 465* (information assurance)
3 Electives
15 Total credit hours

Semester 8

3. IT 492 (senior secure system design project)
3. Humanities/Social Science
3. Social Science
6 Electives
15 Total credit hours

*If a student does not follow either the Security and Assurance or Distributed Computing and Security curriculum, he or she must replace these courses with twelve hours of technical electives approved by the student’s advisor and an IT Program Coordinator.

Sample Curriculum for the Bachelor of Science Degree in Information Technology with Distributed Computing and Security Track

Semesters 1 through 4 are the same as for the Security and Assurance Track

Semester 5

1. IT 311 (human information processing and decision making)
2. IT 351 (complex system modeling and simulation)
3. IT 353* (data and computer communications)
3. IT 373 (introduction to database design and management)
3. ENGL 341 (technical writing)
1 Elective
16 Total credit hours

Semester 6

1. IT 328 (secure software construction)
2. IT 382 (legal and ethical information technology issues)
4. Biology/Geology/Engineering with lab
3. Humanities
3 Electives
16 Total credit hours

Semester 7

1. IT 453* (computer networks & the internet)
3. IT 491 (senior secure system design project)
3. IT 452* (introduction to parallel processing)
3. IT 465* (information assurance)
3 Electives
15 Total credit hours

Semester 8

3. IT 492 (senior secure system design project)
3. Humanities/Social Science
3. Social Science
6 Electives
15 Total credit hours

Information Technology Courses:

**IT 111, Introduction to Computer Science & Programming, 4 cr, 3 cl hrs, 3 lab hrs**  
Corequisite: MATH 103 or equivalent  
Introduction to the discipline of computer science: 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. The lab will focus on an introduction to programming in a structured language (e.g., C): problem solving, algorithm development, top-down design, modular programming, control structures including selection, iteration and recursion, data types including arrays, strings, and dynamic structures. Concepts implemented through extensive programming using good programming style. (Same as CS 111)

**IT 122, Algorithms and Data Structures, 3 cr, 3 cl hrs**  
Prerequisite: IT 111 or CS 111  
Programming methodology and fundamental data structures for computer programming. Algorithm design, synthesis, and analysis techniques. Basic symbolic and numerical algorithms. (Same as CS 122).

**IT 221, Computer and Network Organization, 3 cr, 3 cl hrs**  
Prerequisite: IT 122  
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 CS 221)
IT 222, Systems and Internet Programming, 4 cr, 2 cl hrs, 2 lab hrs
Prerequisite: IT 221
Programming and scripting languages for Internet applications development. Network and web programming, System level programming using operating system services. Design and techniques. Course work includes substantial programming projects.

IT 263, Information Protection and Security, 3 cr, 3 cl hrs
Prerequisite: IT 111
Corequisite: IT 221

IT 311, Human Information Processing and Decision Making, 3 cr, 3 cl hrs
Prerequisite: PSY 121 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 328, Secure Software Construction, 3 cr, 2 cl hrs, 1 lab hr
Prerequisite: IT 222 or CS 222
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 CS 328)

IT 351, Complex System Modeling and Simulation, 3 cr, 3 cl hrs
Prerequisites: IT 122; MATH 221
Characteristics and examples of complex systems. Fundamental simulation, modeling, and optimization algorithms. Advanced computational techniques for complex system modeling and analysis.
(Same as CS 351)

IT 353, Data & Computer Communications, 3 cr, 3 cl hrs
Prerequisites: IT 122, 221
(Same as CS 353)

IT 373, Introduction to Database Systems, 3 cr, 3 cl hrs
Prerequisite: IT 122
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 CS 373)

IT 382, Legal, Ethical, and Social Issues of Information Technology, 3 cr, 3 cl hrs
Prerequisite: upper division standing in the CS or IT program; or consent of instructor
A survey of current legal IT (and general business and management) issues is presented in this course. Also, social and ethical issues associated with IT and management of secure information systems are surveyed and discussed.

IT 441, Cryptography and Applications, 3 cr, 3 cl hrs
Prerequisites: IT 122; MATH 221
Basic theory of encryption and decryption. The RSA algorithm and the public/private key system. Cryptography systems in use for Internet and business applications. (Same as CS 441)

IT 452, Introduction to Parallel Processing, 3 cr, 3 cl hrs
Prerequisites: CS 222 or IT 222; IT 344
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 CS 452)

IT 453, Computer Networks & the Internet, 3 cr, 3 cl hrs
Prerequisite: IT 353
(Same as CS 453)

IT 462, Systems, Risk and Decision Analysis, 3 cr, 3 cl hrs
Prerequisites: MATH 226 or 382; 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
(Same as CS 463)

IT 491 / IT 492, Senior Secure System Design Project, each 3 cr, 3 lab hrs
Prerequisite: must have completed all junior level IT courses
A substantial system and security-related project taken over 2 regular semesters, under the supervision of a faculty member.

Staff Research Interests

Anselmo—Agent-Based Financial System Modeling and Simulation, Non-Financial Risk Modeling and Analysis
Clausen—Software Construction, Internet via Satellite, Multimedia/Internet Technologies, Embedded Systems
Lassez—Bioinformatics, Search Engines
Liebrock—Parallel Processing, High Performance Computing, Informational Assurance, Well Posedness Analysis, Graphics and Visualization
Mazumdar—Databases, Information Systems, Conceptual Modeling, Software Integrity
Peterson—Management of Organizational Information Systems
Soliman—Computer Networks, Network Security, Multimedia Image Processing
Sung—Large-Scale Simulation and Modeling, Computational Intelligence, Information Assurance
Wedeward—Adaptive Control, Robotic Systems
Management

Professor Sueyoshi
Associate Professors Anselmo (Chair of the Department), Holcomb, Ostergren
Assistant Professor Luo
Visiting Assistant Professor Ulibarri
Adjunct Faculty: Foster, Mazumdar, Peterson, Sung

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, finance, management, marketing, operations research, and statistics.

New Mexico Tech offers 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, labor relations, or general management. 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 problem solving in management. 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 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 or management. Required courses are 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)
- BA 315 (3), 317 (3)
- BCS 209 (3)
- ECON 251 (3), 252 (3)
- ENGL 111 (3), 112 (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 Elective: Three credit hours chosen from Section I of the General Degree Requirements (page 53)
- A total of eight credit hours in courses with associated laboratories from the disciplines of biology, chemistry, geology, or physics
- Electives to complete 65 credit hours

Students must achieve a minimum GPA of 2.0 in required courses in order to graduate.

Sample Curriculum for the Associate of Science in Business

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Core Requirements for the Bachelor of Science in Management

In addition to the General Degree Requirements (page 53), the following core of business and economics courses is required of all Management students:
- ACCT 201 (3), 202 (3); ACCT 350 is recommended
- BA 315 (3), 490 (3)
- BCS 209 (3), 283 (3), 305 (3)
- FIN 302 (3)
- MGT 101 (1), 330 (3), 381 (3), 472 (3), 488 (3)
- MKT 333 (3)
- ECON 251 (3), 252 (3). These courses may be used to fulfill the Social Science portion of the General Degree Requirements, page 53
- At least two semesters of a single approved foreign language are strongly suggested but not required.
- Electives to complete 130 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—130

In addition to the General Degree Requirements (page 53) and the core business requirements (above), the following courses are required:
- Business Elective Sequence: At least nine (9) credit hours selected in consultation with and approved by the student’s faculty advisor. Examples of appropriate elective sequences include FIN 410, 480, 490; ECON 361, 362, 490; MGT 462, 473, 491; and MGT 331, 451, 490.
- 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 Biology/Geology/Engineering with lab
16 Total credit hours

Semester 2
3 ENGL 112 (college English)
4 CHEM 122 & 122L (general)
4 MATH 132 (calculus)
4 Biology/Geology/Engineering with lab
15 Total credit hours

Semester 3
5 PHYS 121 & 121L (general)
3 ACCT 201 (fundamentals I)
3 BCS 209 (business computing)
3 ECON 251 (macroeconomics)
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 BCS 305 (information systems)
3 MGT 330 (organizational behavior)
3 MKT 335 (principles)
3 Elective
18 Total credit hours

Semester 6
3 FIN 302 (principles)
3 MGT 381 (market analysis)
3 ENGL 341 (technical writing)
3 Business Elective
6 Electives
18 Total credit hours

Semester 7
3 MGT 451 (leadership & motivation)
3 MGT 472 (production & operations)
3 Humanities
3 Business Elective
3 Elective
15 Total credit hours

Semester 8
3 BA 490 (business policy)
3 MGT 473 (production and operations II)
3 MGT 488 (technology entrepreneur)
3 Humanities
3 Business Elective
15 Total credit hours

Bachelor of Science in Management of Technology

Minimum credit hours required—130
In addition to the General Degree Requirements (page 53) and the core business requirements (page 97), the following courses are required:
- ES 110 (2), 111 (3), 216 (3), and nine (9) approved credit hours of engineering courses numbered 300 or above
- MATH 231 (4)
- MGT 462 (3) is recommended
- 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)
2 ES 110 (intro to engineering)
17 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 (programming for engineers)
17 Total credit hours

Semester 3
5 PHYS 121 & 121L (general)
3 ECON 251 (macroeconomics)
4 MATH 231 (calculus)
4 Biology/Geology/Engineering with lab
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/Geology/Engineering with lab
15 Total credit hours

Semester 5
3 ACCT 350 (managerial accounting)
3 BA 315 (business law I)
3 BCS 209 (business computing)
3 MGT 330 (organizational behavior)
3 MKT 335 (principles)
3 Elective
15 Total credit hours

Semester 6
3 FIN 302 (principles)
3 MGT 381 (market analysis)
3 ENGL 341 (technical writing)
3 Business Elective
6 Electives
18 Total credit hours

Semester 7
3 MGT 451 (leadership & motivation)
3 MGT 472 (production & operations)
3 Humanities
3 Business Elective
3 Elective
15 Total credit hours

Semester 8
3 BA 490 (business policy)
3 MGT 473 (production and operations II)
3 MGT 488 (technology entrepreneur)
3 Humanities
3 Business Elective
15 Total credit hours
Semester 8

3 BA 490 (business policy)
3 MGT 488 (technology entrepreneur)
3 Engineering Elective
3 Humanities/Social Science
3 Elective

15 Total credit hours

Minor in Management

Minimum credit hours required—18
The following courses are required:

- FIN 302 (3)
- MGT 330 (3), 472 (3)
- MKT 335 (3)
- Six (6) credit hours of Management Department courses numbered 300 or above.

Note: ECON 252 and BCS/MATH 283 are prerequisites for FIN 302 and MKT 335. Non-majors must obtain instructor consent in lieu of the prerequisite of ACCT 202 for FIN 302.

Accounting Courses:

ACCT 201, Fundamentals of Accounting I, 3 cr, 3 cl hrs
  Financial accounting procedures, concepts, and reports for sole proprietors.

ACCT 202, Fundamentals of Accounting II, 3 cr, 3 cl hrs
  Prerequisite: ACCT 201, BCS 209
  Financial accounting for partnerships and corporations, an introduction to managerial accounting concepts.

ACCT 350, Managerial Accounting, 3 cr, 3 cl hrs
  Prerequisite: ACCT 202 and BCS 209 or consent of instructor

ACCT 355, 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: Upper-class standing or consent of instructor
  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.

Business Administration Courses:

BA 315, Business Law I, 3 cr, 3 cl hrs
  Prerequisite: ENGL 112 or consent of instructor
  Origin and development of law, judicial procedure, torts, law of contracts, and personal property.

BA 317, Business Law II, 3 cr, 3 cl hrs
  Prerequisite: BA 315
  Sales, negotiable instruments, secured transactions, bankruptcy. Agencies, partnerships, and corporations.

BA 490, Business Policy/Corporate Strategy, 3 cr, 3 cl hrs
  Prerequisites: ACCT 202, FIN 302; ECON 251, 252; MGT 330; BCS 209, 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.

Business Computer Systems Courses:

BCS 209, Business Computing Systems, 3 cr, 3 cl hrs
  Introduction to software systems, including word processing, spreadsheet, and database applications, used to solve business problems. Current computer topics and issues.

BCS 254, Introduction to Applied Linear Algebra, 3 cr, 3 cl hrs, 1,5 lab hrs
  Prerequisite: MATH 131 passed with grade C- or better

BCS 283, Elementary Applied Statistics, 3 cr, 3 cl hrs, 1,5 lab hrs
  Prerequisite: MATH 132 passed with grade C- or better
  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. (Same as MATH 283)

BCS 305, Business Information Systems, 3 cr, 3 cl hrs
  Prerequisite: BCS 209
  A study of the implementation and use of computer-based information systems in business organizations. Emphasis will be placed on the characteristics and use of decision support systems from an organizational and individual problem-solving perspective.

BCS 415, Introduction to Operations Research: Deterministic Methods, 3 cr, 3 cl hrs
  Prerequisite: BCS 254 passed with grade C- or better
  A survey of operations research techniques including linear programming, non-linear models, and graph theoretical models. (Same as MATH 415)

BCS 486, Introduction to Stochastic Processes, 3 cr, 3 cl hrs
  Prerequisites: MATH 254 and 382, each passed with grade C- or better
BGS 488, Introduction to Operations Research: Stochastic Methods, 3 cr, 3 cl hrs
Prerequisites: BCS 283 or Math 382, passed with grade C- or better
Monte Carlo Simulation Theory. Application of simulation to problems in science, engineering, and business. Queueing systems simulation. Inventory theory. (Same as MATH 488)

BSC 490, Directed Study, 1–3 cr, 1–3 cl hrs
Prerequisite: upper-class standing or consent of instructor

Economics Courses:

These courses may be used to fulfill the Social Science portion of the General Degree Requirements, page 53.

ECON 251, Principles of Macroeconomics, 3 cr, 3 cl hrs

ECON 252, Principles of Microeconomics, 3 cr, 3 cl hrs
Microeconomic theory and public policy. Supply and demand, theory of the firm, market allocation of resources, income distribution, competition and monopoly, governmental regulation and unions.

ECON 361, Business Conditions Analysis, 3 cr, 3 cl hrs
Prerequisites: ECON 251, 252
The goals of economic policy, national income accounting, theory of income determination, economic forecasting.

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 400, 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 302, Principles of Finance, 3 cr, 3 cl hrs
Prerequisites: ACCT 202; BSC 283; ECON 252; or consent of instructor
Theory and techniques of financial management for business.

FIN 410, Theory of Financial Decisions, 3 cr, 3 cl hrs
Prerequisites: FIN 302; BSC 253; 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: BSC 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, Modern Management Issues, 1 cr, 1 cl hr
Seminar on modern management issues and the role of managerial personnel in today’s technology firms. Guest speakers and faculty presenting overview of current issues and research topics.

MGT 301, Survey of Engineering Management, 3 cr, 3 cl hrs
Prerequisites: ES 110 and 111 or equivalent
Survey designed for engineering majors. Topics include introductions to qualitative and quantitative management models and their implementation.

MGT 330, Management and Organizational Behavior, 3 cr, 3 cl hrs
Prerequisites: ENGL 112 and upper-class standing or consent of instructor
Classical and contemporary organization theories, interpersonal and organization behavior, motivation, communication, leadership, decision process in organizations.

MGT 331, Human Resource Management, 3 cr, 3 cl hrs
Planning and utilization of human resources, including recruitment, selection, equal employment opportunity, safety, compensation, appraisal, unions, training, and job evaluation.

MGT 381, Strategic Market Analysis, 3 cr, 3 cl hrs
Prerequisites: BSC 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: MGT 330
Seminar focused on current management issues in complex technology organizations. Motivating and measuring performance in ambiguous situations. Leadership and growth issues in entrepreneurial technology organizations.

MGT 463, Systems, Risk, and Decision Analysis, 3 cr, 3 cl hrs
Prerequisites: BSC 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: BSC 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, queuing 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 location, quality control, and project management.

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 490, Selected Topics, 1–3 cr, 1–3 cl hrs
Prerequisite: Upper-class standing or consent of instructor
Current topics in management.

MGT 491, Senior Seminar, Technical Management, 3 cr, 3 cl hrs
Prerequisite: upper-class standing and consent of instructor
Marketing Courses:

**MKT 335, Principles of Marketing, 3 cr, 3 cl hrs**
Prerequisite: ECON 252; BCS 283; or upper-class standing and consent of instructor
Processes, principles, and functions in current marketing systems.

**MKT 490, Selected Topics, 1–3 cr, 1–3 cl hrs**
Prerequisite: Upper-class standing or consent of instructor
Current topics in marketing.

**MKT 491, Directed Study, 1–3 cr, 1–3 cl hrs**
Prerequisite: Upper-class standing or consent of instructor

Staff Research Interests

- Sueyoshi—Management Science, Data Envelopment Analysis
- Peterson—Management, Economics, Accounting
- Ostergren—Program Management, Product Development, Total Quality Management
- Mazumdar—Database Systems, Massive Storage Systems, Computational Logic
- Luo—New Product Design and Development in Supply Chain Settings, Multiple Case Study Method, Constraint Satisfaction Problems
- Colbaugh—Complex Additive Systems Modeling, Simulation, and Analysis
- Holcomb—Telecommunication Law and Regulation, Ethical Issues in Information Assurance and Security
- Anselmo—Decision Analysis and Risk Management, Computational Finance, Electronic Commerce
- Colbaugh—Complex Additive Systems Modeling, Simulation, and Analysis
- Holcomb—Telecommunication Law and Regulation, Ethical Issues in Information Assurance and Security
- Luo—New Product Design and Development in Supply Chain Settings, Multiple Case Study Method, Constraint Satisfaction Problems
- Mazumdar—Database Systems, Massive Storage Systems, Computational Logic
- Ostergren—Program Management, Product Development, Total Quality Management
- Peterson—Management, Economics, Accounting
- Sueyoshi—Management Science, Data Envelopment Analysis, Risk and Policy Analysis
- Sung—Information Security, E-commerce
- Ulibarri—Financial Economics, Cultural Economics, Natural Resource and Environmental Economics

Mathematics

**Professors Avramidi, Borchers, Stone (Chair of the Department)**
Associate Professors: Hassain, Kerr, Schaffer
Assistant Professors: Aitbayev, Jo, Makhnin, Starrett
Instructors: Ballou, Bukowski
Emeritus Faculty: Arterburn, Ball, Dubbs, Sharples, Sherman

**Degrees Offered: B.S. in Mathematics, M.S. in Mathematics, M.S. in Mathematics with Operations Research and Statistics Option, M.S. in Mathematics with Emphasis 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 plays an important role in teaching mathematics to students in other disciplines. In addition, the department offers bachelor’s, master’s, and Ph.D. degrees in mathematics. 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 business administration, 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—130*

In addition to the General Degree Requirements (page 53), the following courses are required:

- CS 111 (4) or ES 111 (3)
- MATH 221 (3), 231 (4), 254 (3)
- MATH 335 (3), 352 (3), 372 (3), 382 (3)
- MATH 430 (3), 454 (3)
- Two courses from MATH 435 (3), 455 (3), 458 (3), 471 (3)
- Two courses from MATH 435 (3), 436 (3), 437 (3), 438 (3)
- Two courses from MATH 435 (3), 455 (3), 458 (3), 471 (3)
- MATH 403 (3) and one of MATH 484 (3), 486 (3), or 488 (3)
- MATH 415 (3), and one of either MATH 486 (3) or 488 (3)
- MATH 410 (3) and 411 (3)
- Mathematics electives to bring total credit hours in mathematics courses numbered 200 or above to a minimum of 37.
- Approved sequence of at least 18 credit hours in a single subject area other than mathematics. Courses chosen to satisfy other requirements may be used in the sequence. At least six hours must be in courses numbered 300 or above.
- Electives to complete 130 credit hours
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.

Sample Curriculum for the Bachelor of Science in Mathematics

Semester 1
- 4 MATH 131 (calculus)
- 4 CHEM 121 & 121L (general)
- 4 Biology/Geology/Engineering with lab
- 3 ENGL 111 (college English)
- **Total credit hours: 15**

Semester 2
- 4 MATH 132 (calculus)
- 4 CHEM 122 & 122L (general)
- 4 Biology/Geology/Engineering with lab
- 3 ENGL 112 (college English)
- **Total credit hours: 15**

Semester 3
- 4 MATH 231 (calculus)
- 3 MATH 254 (intro to linear algebra)
- 5 PHYS 121 & 121L (general)
- 3 Humanities
- 4 CS 111 (computer science)
- **Total credit hours: 19**

Semester 4
- 3 MATH 335 (applied analysis)
- 3 MATH 352 (basic concepts)
- 5 PHYS 122 & 122L (general)
- 3 Humanities
- 3 Social Science
- 6 Electives*
- **Total credit hours: 18**

Semester 5
- 3 MATH 372 (basic concepts of analysis)
- 3 MATH 382 (probability)
- 6 Social Science
- 6 Electives*
- **Total credit hours: 18**

Semester 6
- 3 MATH 221 (formal logic and discrete mathematics)
- 3 MATH 454 (linear algebra)
- 3 ENGL 341 (technical writing)
- 3 Humanities/Social Science
- 6 Electives*
- **Total credit hours: 18**

Semester 7
- 3 Senior Mathematics Sequence
- 3 MATH 430 (mathematical modeling)
- 6 Electives*
- **Total credit hours: 15**

Semester 8
- 3 Senior Mathematics Sequence
- 3 Mathematics Elective
- 6 Electives*
- **Total credit hours: 15**

*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.

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, MATH 471 and 472 (or equivalent) are required for all programs except the M.S. degree in Mathematics with Emphasis in Industrial Mathematics and the M.S. degree in Mathematics with Operations Research and Statistics Option. The independent study or thesis topic may be selected, subject to approval, from any area of mathematics or from any interdisciplinary area in which mathematics is prominently featured.

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 158 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 Emphasis 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 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.

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
Industrial Mathematics Committee

Avramidi—Mathematical Physics, Analysis on Manifolds, Quantum Field Theory
Borchers—Optimization, Inverse Problems
Sharples—Applied Analysis, Asymptotic Expansions
Stone—Differential Equations, Mathematical Biology, Industrial Mathematics

Master of Science in Mathematics with Operations Research and Statistics Option

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, 584, 586, 587, 589. At least one course (three credit hours) must be chosen from MATH 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.

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. Students are normally expected to take MATH 501 and 502 in their first year, and MATH 503 each semester after that.

- 48 hours of coursework approved by the student’s advisory committee, including:
  - All of the following, if not already taken: MATH 410, 411, 433, 437, 438, 471
  - 500-level MATH courses (30 credit hours) consisting of:
    - MATH 530 (3), 532 (3)
    - Six (6) credit hours of core courses: MATH 511, 535, 538, 539, 577
    - Four or more of the remaining courses are to be additional core courses (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 Ph.D. program.

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, Intermediate 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.

MATH 103, College Algebra, 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 MATH 101 passed with grade C- or better
Functions and relations, equations and inequalities, determinants and matrices, simultaneous equations, algebra of polynomials, complex numbers.

MATH 104, Trigonometry, 3 cr, 2 cl hrs, 3 lab hrs
Corequisite: MATH 103 or ACT Math score of at least 26 or SAT Math score of at least 590 or a score of 20 or higher on the algebra portion of the math placement test (page 24).
Trigonometric functions, identities, related angles, radian measure, graphs, inverse functions, trigonometric equations, logarithms, solution of plane triangles.

MATH 105, Pre-Calculus Mathematics, 5 cr, 4 cl hrs, 3 lab hrs
Prerequisites: Same as for MATH 103
Offered summers only. Class consists of five 25-minute lectures and five 55-minute labs each week of a summer session.
A condensed course covering most of the topics of MATH 103 and 104. A maximum of six credits will be allowed for any combination of MATH 103, 104, 105.

MATH 131, Calculus and Analytic Geometry I, 4 cr, 3 cl hrs, 3 lab hrs
Prerequisites: MATH 105 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 a combined score of at least 34 on the two components of the math placement tests (page 24); or MATH 104 and either ACT Math score of at least 26 or SAT Math score of at least 490.
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.

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.

MATH 221, Formal Logic and Discrete Mathematics, 3 cr, 3 cl hrs
Prerequisite: MATH 132 passed with a grade C- or better

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.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Hours</th>
<th>Corequisites/Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 254</td>
<td>Introduction to Applied Linear Algebra</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisite: MATH 131 passed with grade C- or better&lt;br&gt;Introduction to vector spaces and linear transformations. Applications. (Same as BCS 254)</td>
</tr>
<tr>
<td>MATH 283</td>
<td>Introduction to Applied Statistics</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Corequisite: MATH 132&lt;br&gt;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. (Same as BCS 283)</td>
</tr>
<tr>
<td>MATH 322</td>
<td>Vector Analysis</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisite: MATH 231 passed with grade C- or better&lt;br&gt;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.</td>
</tr>
<tr>
<td>MATH 335L</td>
<td>Applied Analysis I Computer Lab</td>
<td>1 cr</td>
<td>1 cl hr</td>
<td>Corequisite: MATH 335 or equivalent&lt;br&gt;Optional lab to accompany MATH 335. Basic introduction to the &quot;Maple&quot; syntax 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.</td>
</tr>
<tr>
<td>MATH 336</td>
<td>Applied Analysis II</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisite: MATH 24 and 335, each passed with grade C- or better&lt;br&gt;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.</td>
</tr>
<tr>
<td>MATH 352</td>
<td>Basic Concepts of Mathematics</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisite: MATH 132 passed with grade C- or better&lt;br&gt;Mathematical proofs, set theory, mathematical induction and recursion, binary relations, functions, definition and development of some common number systems, cardinal numbers, abstract algebra.</td>
</tr>
<tr>
<td>MATH 372</td>
<td>Basic Concepts of Analysis</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisite: MATH 352 or equivalent passed with grade C- or better&lt;br&gt;Dedekind cuts, sequences, limits, differentiation, integrals, infinite series.</td>
</tr>
<tr>
<td>MATH 382</td>
<td>Probability</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisite: MATH 132 passed with grade C- or better&lt;br&gt;Basic concepts of discrete and continuous probability. Common types of univariate distribution functions. Expected values. The weak law of large numbers. Uses of the central limit theorem and its applications. Introduction to stochastic processes and applications.</td>
</tr>
<tr>
<td>MATH 384</td>
<td>Applied Regression and Design of Experiments</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisite: MATH 283 or 382 passed with grade C- or better&lt;br&gt;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.</td>
</tr>
<tr>
<td>MATH 386</td>
<td>Nonparametric Statistics</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisite: MATH 283 or 382 passed with grade C- or better&lt;br&gt;Tests based on ranks for one-sample and two-sample problems, nonparametric estimates, multiple comparisons, nonparametric methods in regression. Applications in science and engineering.</td>
</tr>
<tr>
<td>MATH 391</td>
<td>Special Studies</td>
<td>hrs + cr</td>
<td>cr to be arranged</td>
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</tr>
<tr>
<td>MATH 401</td>
<td>Putnam Competition</td>
<td>1 cr</td>
<td>1 cl hr</td>
<td>Graded S/U&lt;br&gt;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.</td>
</tr>
<tr>
<td>MATH 410</td>
<td>Numerical Methods for Scientists and Engineers I</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisite: CS 111 or ES 111&lt;br&gt;Corequisite: MATH 335&lt;br&gt;Floating point arithmetic, solution of linear and nonlinear systems of equations, interpolation, numerical differentiation and integration, numerical solution of ordinary differential equations.</td>
</tr>
<tr>
<td>MATH 411</td>
<td>Numerical Linear Algebra</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisites: MATH 254, CS 111 or ES 111&lt;br&gt;Direct and iterative methods for solving linear systems, conditioning and stability, methods for computing eigenvalues and eigenvectors, linear least squares problems, applications, performance, software.</td>
</tr>
<tr>
<td>MATH 414</td>
<td>Introduction to High Performance Computing</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisite: MATH 410 passed with grade C- or better&lt;br&gt;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.</td>
</tr>
<tr>
<td>MATH 415</td>
<td>Introduction to Operations Research: Deterministic Methods</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisite: MATH 254 passed with grade C- or better&lt;br&gt;A survey of operations research techniques including linear programming, nonlinear models, and graph theoretical models. (Same as BCS 415)</td>
</tr>
<tr>
<td>MATH 430</td>
<td>Mathematical Modeling</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisites: MATH 254 and 335, MATH 283 or 382, passed with grade C- or better&lt;br&gt;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.</td>
</tr>
<tr>
<td>MATH 435</td>
<td>Complex Analysis</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisite: MATH 336 passed with grade C- or better&lt;br&gt;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.</td>
</tr>
<tr>
<td>MATH 436</td>
<td>Applications of Complex Analysis</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisite: MATH 435 passed with grade C- or better&lt;br&gt;Topics selected from linear ordinary differential equations in the complex plane, special functions, conformal mapping, Laplace transform, Fourier and Hilbert transforms.</td>
</tr>
<tr>
<td>MATH 437</td>
<td>Systems of Ordinary Differential Equations</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisites: MATH 254 and 335, each passed with grade C- or better&lt;br&gt;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, Liénard equation.</td>
</tr>
<tr>
<td>MATH 438</td>
<td>Partial Differential Equations</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisite: MATH 336 passed with grade C- or better&lt;br&gt;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.</td>
</tr>
<tr>
<td>MATH 442</td>
<td>Introduction to Differential Geometry</td>
<td>3 cr</td>
<td>3 cl hs</td>
<td>Prerequisite: MATH 254 passed with grade C- or better&lt;br&gt;Introduction to the theory of curves and surfaces, geometry on a surface. Tensor notation will be developed and used.</td>
</tr>
</tbody>
</table>
MATH 454, Linear Algebra, 3 cr, 3 cl hrs
Pre requisite: MATH 254 and 352, each passed with grade C- or better

MATH 455, 456, Introduction to Abstract Algebra, 3 cr, 3 cl hrs each semester
Pre requisite: 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
Pre requisite: 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
Pre requisite: 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 471, 472, Introduction to Analysis, 3 cr, 3 cl hrs each semester
Pre requisite: 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
Pre requisite: MATH 382 passed with grade C- or better

MATH 484, Reliability and Quality Control, 3 cr, 3 cl hrs
Pre requisite: 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
Pre requisite: MATH 254 and 382, each passed with grade C- or better

MATH 488, Introduction to Operations Research: Probabilistic Methods, 3 cr, 3 cl hrs
Pre requisite: MATH 283 or 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. (Same as BCS 488)

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
Pre requisite: Graduate standing
Attend and participate in departmental seminars. Graded on an S/U basis.

MATH 505, Neural Nets, 3 cr, 3 cl hrs
Pre requisite: 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 CS 565)

MATH 509 Graduate Internship, credit to be arranged
Pre requisite: Graduate standing

MATH 510 Computational Fluid Dynamics, 3 cr, 3 cl hrs
Pre requisite: 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, 512, Numerical Methods for Partial Differential Equations, 3 cr, 3 cl hrs each semester
Pre requisite: MATH 410 or consent of instructor

MATH 513, Advanced Topics in Numerical Analysis, 3 cr, 3 cl hrs
Pre requisite: 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
Pre requisite: 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
Pre requisite: 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
Pre requisite: MATH 415 or consent of instructor

MATH 518, Methods of Nonlinear Programming, 3 cr, 3 cl hrs
Pre requisite: 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, Inverse Problems, 3 cr, 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
Pre requisite: 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
Pre requisite: MATH 430 or equivalent
Open-ended modeling projects from actual applications.

MATH 531, Topics in Ordinary Differential Equations, 3 cr, 3 cl hrs each semester
Pre requisite: 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.

MATH 532, Perturbation Methods, 3 cr, 3 cl hrs
Pre requisite: MATH 437 or equivalent
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.

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, 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, 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 Fluid Dynamics, 3 cr, 3 cl hrs
Prerequisite: MATH 439 or equivalent
The Navier-Stokes equations, inviscid flow, irrotational fluids, viscosity, and turbulence. Other topics as time and interest permit.

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

MATH 577 Functional Analysis, 3 cr, 3 cl hrs
Prerequisite: MATH 471 or equivalent

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, Statistical Inference, 3 cr, 3 cl hrs
Prerequisite: MATH 483 or consent of instructor
Topics include limit theorems and convergence concepts, maximum likelihood estimator, sufficiency and completeness, Neyman Pearson lemma, Cramer Rao inequality, likelihood ratio test, uniformly most powerful tests, and inference for regression models.

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.

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, Spatial Variability and Geostatistics, 3 cr, 3 cl hrs
Prerequisites: MATH 382

MATH 587, 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 statistical 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 HYD 587 and GEEP 505)

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

Staff Research Interests

Avramidi—Mathematical Physics, Analysis on Manifolds, Quantum Field Theory
Borchers—Optimization, Inverse Problems
Hossain—Theory and Application of Statistics, Regression Diagnostics
Jo—Fluid Dynamics, Modeling
Kerr—Thermoelasticity, Integral Equations, Applied Mathematics
Makhnin—Stochastic Processes, Statistics
Schaffer—Applied Mathematics, Numerical Analysis
Starrett—Dynamical Systems, Physics Models
Stone—Differential Equations, Mathematical Biology, Industrial Mathematics
Optical Science and Engineering

Advisory Board Members:
Fuierer (Materials Engineering)
Teare (Electrical Engineering; Chair)
Thomas (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 362 (2), 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
Prerequisites: 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
Prerequisites: OPT 400 or consent of instructor.
An advanced course in optical testing and interferometric systems.

OPT 430, Thin Films, 3 cr, 3 cl hrs
Prerequisites: 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
Prerequisites: OPT 300
An advanced laboratory in optics and photonic systems.

OPT 490, Special Topics in Optics, cr and topics arranged
Prerequisites: 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 www.nmt.edu/~commcoll/ or call (505) 835-5511.

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.

PR 103C, Team Sports, 1 cr
PR 106C, Aerobics, 1 cr
PR 109C, Yoga, 1 cr
PR 110C, Weight Training, 1 cr
PR 115C, Golf, 1 cr
PR 116C, Intermediate Golf, 1 cr
PR 117C, Tennis/Badminton, 1 cr
PR 118C, Volleyball/Basketball, 1 cr
PR 119C, Racquetball/Squash/Handball, 1 cr
PR 125C, Martial Arts, 1 cr
PR 128C, Swim Conditioning, 1 cr
PR 130C, Pocket Billiards, 1 cr
PR 137C, Dance, 1 cr
   Has recently included classes in Irish Step Dance, Swing, Country / Western, Bellydance, Salsa, and Modern Dance.
PR 163C, Scuba Diving, 1 cr
PR 205C, Rock Climbing, 1 cr

Physics

Professors Eilek, Hankins, Kriebel, Mineschwaner, Raymond, Romero, Westphahl (Chair of the Department, Winn
Associate Professors Eack, Hofner, Sonnenfeld, Young
Assistant Professor Creech-Eakman
Adjunct Faculty: Avramidi, Balasubramanian, Blyth, Colgate, Goss, Huang, Klinglesmith, Meason, Pietras, Risun, Rupe, E. Ryan, W. Ryan, Taylor, Teare, Thomas, Ulvestad, Weatherall Emeritus Professors LeFebre, C. Moore, Schery, Wilkening

Degrees Offered: B.S. in Physics and in Physics with options in Astrophysics, Atmospheric Physics, and Computer Science; M.S. in Physics; M.S. in Physics with Specialty in Instrumentation; Ph.D. in Physics; Ph.D. in Physics with dissertation in Astrophysics, Atmospheric Physics, or Mathematical Physics

Departmental web site: http://physics.nmt.edu

Students in the Department of Physics are encouraged to pursue a broad scientific background and to master theory as well as technique. 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 three options to accompany the basic physics undergraduate degree: astrophysics, atmospheric physics, and computer science. The first two 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. The latter option is present because computers play a crucial role in any application of physics. In addition, we encourage students to consider a minor in electrical engineering (page 129). Several of the faculty have expertise in these areas.

The areas of research in atmospheric physics include thunderstorm electricity, precipitation, cloud particles, cloud dynamics, large-scale atmospheric dynamics, and the photochemistry of the middle to upper atmosphere. The Langmuir Laboratory for Atmospheric Research, located on a mountaintop an hour’s 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 in Boulder, Colorado.

Research in astrophysics includes pulsar radio emission, the dynamics and kinematics of nearby galaxies, quasars, radio galaxies, plasma astrophysics, comets, stellar evolution, and star formation. The Very Large Array and Very Long Baseline Array radio telescopes, operated by the National Radio Astronomy Observatory, are headquartered on campus and offer unique opportunities for research in radio astronomy for faculty and undergraduate and graduate students alike.
Undergraduate Program
Bachelor of Science in Physics

Minimum credit hours required—130

In addition to the General Degree Requirements (page 53), the following courses are required:
- MATH 231 (4), 254 (3), 332 (3), 335 (3), 336 (3), and three hours of approved upper-division courses
- Language—six hours
- Electives—to complete 130 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 or PHYS 131 & 131L (general)
- 4 MATH 131 (calculus)
- 4 CHEM 121 & 121L (general)
- 3 ENGL 111 (college English)
- 16 Total credit hours

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

Semester 3
- 3 PHYS 232 (modern)
- 4 MATH 231 (calculus)
- 3 Social Science
- 3 Language
- 1 Elective
- 14 Total credit hours

Semester 4
- 4 PHYS 242 (waves)
- 3 MATH 332 (vector analysis)
- 3 MATH 335 (applied analysis)
- 3 Humanities
- 3 Language
- 16 Total credit hours

Semester 5
- 3 PHYS 321 (mechanics)
- 3 PHYS 333 (electricity & magnetism)
- 3 MATH 254 (linear algebra)
- 4 Biology/Geology/Engineering with lab
- 3 ENGL 341 (technical writing)
- 16 Total credit hours

Semester 6
- 3 PHYS 324 (radiation and optics)
- 1 PHYS 336L, (electrical & magnetic measurements lab)
- 1 PHYS 340 (quantum theory)
- 1 PHYS 380 (practicum in problem solving)
- 4 Biology/Geology/Engineering with lab
- 1 Elective
- 16 Total credit hours

Semester 7
- 3 PHYS 411 (thermodynamics)
- 3 PHYS 443 (atomic and nuclear)
- 3 MATH 336 (applied analysis)
- 3 Humanities
- 3 Social Science
- 3 Electives
- 18 Total credit hours

Semester 8
- 2 PHYS 451 (senior lab)
- 3 Humanities/Social Science
- 6 Electives
- 3 MATH 382 (probability & statistics)
- 14 Total credit hours

Bachelor of Science in Physics with Astrophysics Option

Minimum credit hours required—130

In addition to the General Degree Requirements (page 53), 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 or PHYS 131 & 131L (general)
- 4 MATH 131 (calculus)
- 4 CHEM 121 & 121L (general)
- 3 ENGL 111 (college English)
- 16 Total credit hours

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

Semester 3
- 3 PHYS 232 (modern)
- 4 MATH 231 (calculus)
- 3 Social Science
- 3 Electives
- 3 Language
- 1 Elective
- 14 Total credit hours

Semester 4
- 4 PHYS 242 (waves)
- 3 MATH 332 (vector analysis)
- 3 MATH 335 (applied analysis)
- 3 Humanities
- 3 Language
- 16 Total credit hours

Semester 5
- 3 PHYS 321 (mechanics)
- 4 PHYS 325 & 327L (astrophysics)
- 3 PHYS 333 (electricity & magnetism)
- 3 MATH 254 (linear algebra)
- 4 Biology/Geology/Engineering with lab
- 17 Total credit hours

Semester 6
- 4 PHYS 326 & 328L (astrophysics)
- 1 PHYS 336L (electrical & magnetic measurements lab)
- 1 PHYS 380 (practicum in problem solving)
- 3 Humanities
- 3 Social Science
- 18 Total credit hours

Semester 7
- 3 PHYS 411 (thermodynamics)
- 3 PHYS 425 (advanced astrophysics)
- 3 PHYS 443 (atomic and nuclear)
- 3 MATH 336 (applied analysis)
- 4 Biology/Geology/Engineering with lab
- 16 Total credit hours
Semester 8
3 PHYS 426 (advanced astrophysics)
2 PHYS 451 (senior lab)
3 MATH 382 (probability & statistics)
3 ENGL 341 (technical writing)
3 Social Science
3 Humanities/Social Science
17 Total credit hours

Bachelor of Science in Physics with
Atmospheric Physics Option

Minimum credit hours required—130
In addition to the General Degree Requirements (page 53), requirements include the courses listed above for the Bachelor of Science Degree in Physics and the following courses:

- PHYS 331 (3), 332 (3), 432 (3), 434 (3)

Note: PHYS 331, 332, and 434 are offered in alternate years. Students may take either of the following two sequences:
1. Junior year: PHYS 331 (fall); PHYS 332 (spring)
   Senior year: PHYS 432 (fall); PHYS 433 (spring)
2. Junior year: PHYS 433 (spring)
   Senior year: PHYS 331, 432 (fall); PHYS 332 (spring)

Sample Curriculum for the Bachelor of Science in Physics with
Atmospheric Physics Option (Sequence 1)

Semester 1
5 PHYS 121 & 121L or PHYS 131 & 131L (general)
3 ENGL 111 (college English)
4 CHEM 121 & 121L (general)
4 MATH 131 (calculus)
16 Total credit hours

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

Semester 3
3 PHYS 232 (modern)
4 MATH 231 (calculus)
3 ENGL 341 (technical writing)
3 Social Science
3 Language
16 Total credit hours

Semester 4
4 PHYS 242 (waves)
3 MATH 332 (vectors)
3 MATH 335 (applied analysis)
3 Humanities
3 Language
16 Total credit hours

Semester 5
3 PHYS 321 (mechanics)
3 PHYS 331 (weather and climate)
3 PHYS 333 (electricity and magnetism)
3 MATH 254 (linear algebra)
4 Biology/Geoscience/Engineering with lab
16 Total credit hours

Semester 6
3 PHYS 332 (weather and climate)
3 PHYS 334 (radiation/ optics)
1 PHYS 336L (electricity and magnetism lab)
3 PHYS 340 (quantum)
1 PHYS 380 (practicum in problem solving)
3 Humanities
3 Social Science
17 Total credit hours

Sample Curriculum for the Bachelor of Science in Physics with
Atmospheric Physics Option (Sequence 2)

Semester 1 through 4 are the same as for Sequence 1

Semester 5
3 PHYS 321 (mechanics)
3 PHYS 333 (electricity and magnetism)
3 MATH 254 (linear algebra)
3 PHYS 432 (atmospheric remote sensing)
4 Biology/Geoscience/Engineering with lab
16 Total credit hours

Semester 6
3 PHYS 334 (radiation/ optics)
1 PHYS 336L (electricity and magnetism lab)
3 PHYS 340 (quantum)
1 PHYS 380 (practicum in problem solving)
3 Humanities
3 Social Science
3 Electives
17 Total credit hours

Semester 7
3 PHYS 411 (thermodynamics)
3 PHYS 432 (atmospheric remote sensing)
3 PHYS 443 (atomic and nuclear)
3 MATH 336 (applied analysis)
4 Biology/Geoscience/Engineering with lab
16 Total credit hours

Semester 8
3 PHYS 433 (special atmospheric problems)
2 PHYS 451L (senior lab)
3 MATH 438 (partial differential equations)
3 Humanities/Social Science
3 Social Science
3 Electives
17 Total credit hours
Bachelor of Science in Physics with Computer Science Option

Minimum credit hours required—131

In addition to the General Degree Requirements (page 53), requirements include the courses listed above for the Bachelor of Science Degree in Physics and the following courses:

- CS 111 (4), 122 (3), 221 (3)
- An additional six (6) hours of CS courses numbered 300 or higher

Two particularly interesting sequences are:

1. CS 344 and 451
2. CS 410 and 411

Sample Curriculum for the Bachelor of Science in Physics with Computer Science Option

Semester 1
5 PHYS 121 & 121L or PHYS 131 & 131L (general)
4 MATH 131 (calculus)
4 CS 111 (computer science)
3 ENGL 111 (college English)

Total credit hours: 16

Semester 2
5 PHYS 122 & 122L or PHYS 132 & 132L (general)
4 MATH 132 (calculus)
3 CS 122 (algorithms and data structures)
4 CHEM 121 & 121L (general)

Total credit hours: 16

Semester 3
3 PHYS 232 (modern)
4 MATH 231 (calculus)
3 CS 221 (system organization)
4 CHEM 122 & 122L (general)
3 Social Science

Total credit hours: 17

Semester 4
4 PHYS 242 (waves)
3 MATH 332 (vector analysis)
3 MATH 335 (applied analysis)
3 MATH 352 (basic concepts)
3 ENGL 112 (college English)

Total credit hours: 16

Semester 5
3 PHYS 321 (mechanics)
3 PHYS 333 (electricity & magnetism)
3 MATH 254 (linear algebra)
3 CS 344 (design and analysis of algorithms)
3 ENGL 341 (technical writing)

Total credit hours: 15

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/Geoscience/Engineering with lab
3 Humanities

Total credit hours: 15

Semester 7
3 PHYS 411 (thermodynamics)
3 PHYS 443 (atomic and nuclear)
3 MATH 336 (applied analysis)
3 CS 451 (parallel processing)
3 Humanities/Social Science
3 Language

Total credit hours: 18

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—19

- PHYS 232 (3), 242 (4)
- Three of the following courses: PHYS 321 (3), 333 (3), 334 (3), 340 (3)
- Three (3) additional hours of upper-division physics

Graduate Program

Master of Science in Physics

The Master of Science degree in Physics may be earned under either of the following plans:

With Thesis:

The student’s course of study must be approved by the student’s advisory committee and must fulfill the general requirements for the master’s degree with thesis and must include a minimum of nine credit hours selected from: PHYS 505, 508, 513, 514, 515, 516, 526.

PHYS 579, Graduate-Faculty Seminar, must be taken for the first four semesters.

Students presenting theoretical work for the thesis must, in addition, complete PHYS 501, 502.

The preliminary examination will cover courses in physics and mathematics normally included in the undergraduate physics curriculum. Thesis topics will be chosen in consultation with an advisory committee.

Without Thesis:

Courses approved by the student’s advisor must fulfill the general requirements for the master’s degree without thesis and must include the following:

- PHYS 501 (1), 502 (1), PHYS 590 (3)
- a minimum of nine credit hours selected from: PHYS 505, 508, 513, 514, 515, 516, 526.

PHYS 579 (1), Graduate-Faculty Seminar, must be taken for the first four semesters.

The preliminary examination will cover courses in physics and mathematics normally included in the undergraduate physics curriculum.
Master of Science in Physics with Specialty in Instrumentation

Students entering this M.S. program should have a bachelor’s degree in engineering, one of the sciences, mathematics, or computer science. Students will also be expected to complete at Tech basic undergraduate physics and electronics courses they have not had.

Given the varied backgrounds and interests of students in this specialty, the program of study is tailored to each student’s needs. The flexibility needed to do this is evident in the following requirements:

Credits

- 9 Graduate physics courses approved by the student’s advisory committee
- 3 EE 322, 322L (Advanced Electronics)
- 4 EE 451, 451L (Digital Signal Processing)
- 3 MATH 587 (Time Series)
- 6 At least two of the following:
  - EE 341, 342 (Linear Systems)
  - EE 443 (Control Theory)
  - EE 446 (Communications Theory)
  - CS 331, 432 (Computer Architecture, VLSI)
  - PHYS 565 (Astronomical Techniques)
- 3 Graduate course approved by the advisory committee
- 3 PHYS 590 (Independent Study)

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<th>Credits</th>
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PHYS 579 (1), Graduate-Faculty Seminar, must be taken for the first four semesters. In addition to the above requirements, students must satisfy the general requirements for the M.S. degree and pass a preliminary examination on undergraduate physics and electronics.

Doctoral Programs

Students of exceptional ability as demonstrated in previous courses in physics and mathematics, or in the preliminary examination, may pursue a program leading to the doctoral degree. All applicants to the physics doctoral degree program must submit GRE general and physics subject test scores.

The major doctoral programs of the Physics Department are in astrophysics and atmospheric physics. A degree in mathematical physics is offered in cooperation with the mathematics department. Students may also work in other areas of physics in which the department has expertise.

The following general requirements apply to all curricula: A minimum of 50 credit hours of graduate and upper-division courses approved by the student’s committee should be taken, of which 12 credit hours must be mathematics beyond that required of an undergraduate physics major. PHYS 501 and 502 (where required below) may be waived for those students who have completed the equivalent through an experimental master’s thesis. PHYS 579, Graduate-Faculty Seminar, must be taken for the first four semesters.

Doctor of Philosophy in Physics with Dissertation in Astrophysics

Current areas of research in astrophysics include quasars, pulsars, and radio galaxies, X-ray astronomy, solar and stellar activity, plasma astrophysics, and comets. The astrophysics program operates several optical telescopes at Langmuir Laboratory and also takes advantage of the proximity of the facilities of the National Radio Astronomy Observatory (NRAO). Students may pursue dissertation work not only with regular faculty but also with a number of NRAO staff who have adjunct appointments at Tech.

The following courses must be completed: PHYS 501 (1), 502 (1), 505 or 526 (3), 513 (3), 514 (3), 515 (3), 516 (3), 562 (3), 563 (3), 564 (3), 565 or 566 (3), and 579. In addition, PHYS 426 (3) must be completed unless the student has had equivalent material in previous courses.

Doctor of Philosophy in Physics with Dissertation in Atmospheric Physics

Current areas of research in atmospheric physics are the dynamics and microphysics of clouds and mesoscale weather systems, geophysical fluid dynamics, thunderstorm electrification and lightning, atmospheric radioactivity, physics of the middle and upper atmosphere, precipitation mechanisms, and radar meteorology. Research facilities include an instrumented aircraft for thunderstorm penetrations, several meteorological radars, and Langmuir Laboratory, a mountaintop observing site. Also available are the observational and computer facilities of the National Center for Atmospheric Research in Boulder, Colorado.

The following core courses must be completed:
- PHYS 331 (3), 332 (3), 501 (1), 502 (1), 505 or 526 (3), 508 (3), 513 (3), 514 (3), 515 (3), 516 (3), and 579.
- An additional six (6) credit hours must be taken in areas pertinent to the student’s program. This can be achieved by taking PHYS 533 and/or other courses approved by the student’s advisory committee.

Doctor of Philosophy in Physics

The following courses must be completed: PHYS 501 (1), 502 (1), 505 (3), 508 (3), 513 (3), 514 (3), 515 (3), 516 (3), and 579. In addition, nine credit hours of graduate physics should be completed in the student’s field of specialization.

Doctor of Philosophy in Physics with Dissertation in Mathematical Physics

The mathematical physics program is operated in cooperation with the mathematics department. Dissertation supervision may be obtained in either department. Students normally pursue research based on faculty interest in one or both departments.

The following courses must be completed:
- PHYS 505 (3), 513 (3), 514 (3), 515 (3), 516 (3), 579 (1)
- MATH 435 (3), 438 (3), 442 (3), 471 (3), 533 (3)
- Additional approved graduate and upper-division courses, including at least six credit hours from mathematics and six credit hours from physics, should be elected to bring the total to a minimum of 51 credit hours beyond the bachelor’s degree. The following courses have been approved:
  - MATH 410 (3), 411 (3), 511 (3), 531 (3), 532 (3), 533 (3), 536 (3), 538 (3)
  - PHYS 508 (3), 526 (3), 533 (3), 562 (3), 563 (3), 564 (3)
- Additional courses may be approved at the discretion of the candidate’s committee.
Physics Courses:

PHYS 121, General Physics I, 4 cr, 3 cl hrs, 2 recitation hrs
Corequisites: PHYS 121L; MATH 131
Introduction to physics concepts. Mechanics, including Newton’s Laws of force, linear and angular momentum, energy, gravitation, heat and thermodynamics, and applications.

PHYS 121L, General Physics Laboratory I, 1 cr, 3 lab hrs
Corequisite: PHYS 121
Experiments from the subject matter of PHYS 121.

PHYS 122, General Physics II, 4 cr, 3 cl hrs, 2 recitation hrs
Corequisites: PHYS 121L; MATH 131
Continuation of PHYS 121 including electricity and magnetism, optics, and atomic and nuclear phenomena.

PHYS 122L, General Physics Laboratory II, 1 cr, 3 lab hrs
Corequisite: PHYS 122
Experiments from the subject matter of PHYS 122.

PHYS 131, General Physics I, 4 cr, 3 cl hrs, 2 recitation hrs
Prerequisites: High school physics and some exposure to calculus are highly recommended.
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.

PHYS 131L, General Physics Laboratory I, 1 cr, 2 lab hrs
Corequisite: PHYS 131
Laboratory experiments from the subject matter of PHYS 131.

PHYS 132, General Physics II, 4 cr, 3 cl hrs, 2 recitation hrs
Prerequisites: PHYS 131; MATH 131
Corequisites: PHYS 132L; MATH 132
Continuation of PHYS 131. 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.

PHYS 132L, General Physics Laboratory II, 1 cr, 2 lab hrs
Corequisite: PHYS 132
Laboratory experiments from the subject matter of PHYS 132.

PHYS 222, General Physics III, 3 cr, 3 cl hrs
Prerequisite: PHYS 122 or PHYS 132 or consent of instructor
Corequisite: MATH 231
Introduction to modern physics including special relativity, basic ideas of quantum mechanics, atomic and nuclear physics, elementary particles.

PHYS 242, Vibrations and Waves, 4 cr, 3 cl hrs, 3 lab hrs
Prerequisites: PHYS 122 or PHYS 132; MATH 231
Vibrations and waves are examined from both theoretical and experimental standpoints. Theory describing simple vibrating systems, including coupled oscillators. Laboratory measurements on electrical analogs of vibrating systems. Wave theory for transverse and longitudinal waves. Experiments using electromagnetic radiation in the visible, microwave, and X-ray regions are used to illustrate the nature of waves.

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 321, Intermediate Mechanics, 3 cr, 3 cl hrs
Prerequisites: PHYS 122 or 132; MATH 231; junior standing
Corequisite: MATH 235
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 232 and 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 each semester
Prerequisites: PHYS 122, 122L or PHYS 132, 132L; PHYS 232; or consent of instructor
A self-paced introduction to astronomical observing and data reduction. Emphasis on techniques such as the operation of telescopes and their auxiliary equipment, astronomical photography, photometry, spectroscopy, and data handling. Exercises chosen from topics in solar system, stellar, galactic, and extragalactic astronomy.

PHYS 331, Physics of Weather and Climate I, 3 cr, 3 cl hrs
Prerequisite: PHYS 122 or 132
Offered Fall 2005 and alternate years
The flows of energy and water in the atmosphere, ocean, and land surface work together to form the environment in which we live. Short-term variations in these flows give rise to weather, while longer term averages are related to the Earth’s climate. This course explores the physical and chemical processes which are important for understanding weather and climate—atmospheric and oceanic thermodynamics, cloud formation and precipitation, solar and thermal radiation, and the photo-chemistry of the atmosphere.

PHYS 332, Physics of Weather and Climate II, 3 cr, 3 cl hrs
Prerequisites: PHYS 331; MATH 332 and 335
Offered Spring 2006 and alternate years
This course, a continuation of PHYS 331, introduces the principles of geophysical fluid dynamics and investigates the factors controlling winds and ocean currents, floods, drought, and temperature change, as well as climate phenomena such as El Niño, the Greenhouse Effect, and the ice ages.

PHYS 333, Electricity and Magnetism, 3 cr, 3 cl hrs
Prerequisites: PHYS 122 or PHYS 132; MATH 332
Corequisite: MATH 335
This subject is one of the cornerstones for understanding a huge variety of phenomena—electronic and optical devices, communication by telephone, radio waves, optical fibers, and the behavior of atoms and molecules. (Almost all we know about the universe beyond the Earth comes from observing electromagnetic waves.) It is remarkable that so much understanding comes from so few fundamentals—Maxwell’s four equations and the Lorentz force law. This course develops these equations and applies them. Each equation can be related to a simple and attractive picture, which helps visualization and thinking.

PHYS 334, Radiation and Optics, 3 cr, 3 cl hrs
Prerequisites: PHYS 242, 333
This course explores the behavior of electromagnetic waves, including optical waves, using Maxwell’s equations and the Lorentz force law. Elegant mathematics merges with visually pleasing and interesting effects, such as polarization, diffraction, interference, and scattering, which will be demonstrated in class using simple equipment.

PHYS 336L, Electrical and Magnetic Measurements Lab, 1 cr, 3 lab hrs
Prerequisite: PHYS 333
Experiments in electricity and magnetism, emphasizing applications to measurements in physics and geophysics.

PHYS 340, Introduction to Quantum Theory, 3 cr, 3 cl hrs
Prerequisites: PHYS 232, 231; MATH 254, 335, or consent of instructor
Electrons, atoms, and radiations. Wave-particle experiments, introductory quantum mechanics, atomic structure and spectra, the hydrogen atom, exclusion principle, electronic structure of atoms, and diatomic molecules.
PHYS 362, Image Processing, 2 cr, 2 cl hrs
Prerequisite: PHYS 122 or 132
An introduction to image processing and computational physics designed for scientists and engineers. Topics will include properties of imaging devices and systems, image construction, analysis, and display. Data will come from satellites and terrestrial sources. Examples will come from current research whenever possible.

PHYS 380, Practicum in Problem Solving, 1 cr, 2 cl hrs
Prerequisite: PHYS 232 and 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 132
Corequisite: MATH 335
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 421, Continuum Mechanics, 3 cr, 3 cl hrs
Prerequisites: PHYS 121 or PHYS 132; MATH 332, 335
Offered on demand
Statics and dynamics of fluids and elastic bodies.

PHYS 425, Astrophysics III: Plasma Astrophysics, 3 cr, 3 cl hrs
Prerequisites: PHYS 325, 326, 333
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 333 and 425; or consent of instructor
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 432, Atmospheric Remote Sensing, 3 cr, 3 cl hrs
Prerequisite: PHYS 122 or 132
Remote sensing from space and ground-based instruments is an essential part of observing the physics and chemistry of the atmosphere. The current generation of sensors and techniques are capable of measuring a wide variety of atmospheric quantities such as temperature, humidity; cloud macro- and microphysical properties, stratospheric ozone and other trace gases, electron density in the ionosphere, and upper atmospheric winds. In all cases the remote sensing is done by quantifying electromagnetic radiation emitted, absorbed, or scattered by the atmosphere. This course will examine the physics of remote sensing using radio, microwave, infrared, visible, and ultraviolet instruments. Topics will include active (e.g., radar, lidar) and passive systems (e.g. radiometers, differential absorption spectrometers).

PHYS 433, Special Problems in Atmospheric Physics, 3 cr, 3 cl hrs
Prerequisite: PHYS 331
Offered spring semesters
A 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. Quantum statistics with applications to degenerate Fermi and Bose Fluids. Radioactivity, elements of nuclear structure, nuclear energy sources. Mesons, hyperons, and resonances.

PHYS 444, Solid-State Physics, 3 cr, 3 cl hrs
Prerequisite: PHYS 340 or consent of instructor
Offered on demand
Theory and application of solid-state devices; binding in molecules and crystals; energy bands; electrons in metals; imperfections in solids; electrical, thermal, and magnetic properties of solids; and semiconductor theory.

PHYS 451, Senior Laboratory, 1 or 2 cr, 3 or 6 lab hrs
Prerequisites: PHYS 232 and senior status, or consent of instructor
Experiments in atomic, nuclear, and solid-state physics.

PHYS 489, 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, Graduate Laboratory, 1 cr, 3 lab hrs each semester
Emphasis is placed on independent effort in the design and assembly of equipment, in experimental technique and procedures, and in the analysis of data.

PHYS 505, Advanced Dynamics, 3 cr, 3 cl hrs
Offered Fall 2005 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
Offered Spring 2006 and alternate years

PHYS 513, 514, Electromagnetics I & II, 3 cr, 3 cl hrs each semester
Offered 2005-2006 and alternate years
The electromagnetic field equations; boundary value problems in electrostatics and magnetostatics; plane, cylindrical, and spherical waves, wave guides; the Hertz Vectors, retarded potentials and simple radiating systems; relativistic electrodynamics; radiation from moving charges.

PHYS 515, 516, Quantum Mechanics I and II, 3 cr, 3 cl hrs each semester
Offered 2004-05 and alternate years
Review of experiments leading to quantum theory: Schroedinger’s Equation, operators and eigenvalues, perturbation theory, and applications to simple physical systems. The second semester includes introduction to scattering theory, the theory of angular momentum, and Dirac Theory.

PHYS 526, Fluid Dynamics, 3 cr, 3 cl hrs
Offered Spring 2005 and alternate years
**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](http://www.physics.nmt.edu). This course may be repeated for credit if the material covered in each instance is different.

**PHYS 562, Stellar Astrophysics, 3 cr, 3 cl hrs**
Prerequisites: PHYS 425, 426 or equivalent or consent of instructor
Offered Spring 2005 and alternate years

**PHYS 563, Extragalactic Astrophysics, 3 cr, 3 cl hrs**
Prerequisites: PHYS 425, 426 or equivalent or consent of instructor
Offered Fall 2005 and alternate years

**PHYS 564, Relativity and Cosmology, 3 cr, 3 cl hrs**
Prerequisites: PHYS 425, 426 or equivalent or consent of instructor
Offered Spring 2006 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 Fall 2004 and alternate years
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 Spring 2006 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 Tech.

**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**

### Staff Research Interests

- **Avramidi**—Theoretical and Mathematical Physics
- **Balasubramaniam**—Spectroscopy and Polarized Radiative Transfer Dynamics of Solar Active Regions, Vector Magnetometry
- **Blyth**—Cloud and Precipitation Physics, Particle Measuring Instrumentation
- **Colgate**—Astrophysics, Plasma Physics, Atmospheric Physics
- **Creech-Eakman**—Stellar Astrophysics, Optical/IR Interferometry, IR Instrumentation
- **Eack**—Instrumentation, Atmospheric Physics, Atmospheric Electricity
- **Eilek**—Plasma Astrophysics, Quasars, Radio Galaxies, Pulsars
- **Goss**—Radio Astronomy, Interstellar Medium
- **Hanks**—Radio Astronomy of Pulsars, Instrumentation, Signal Processing
- **Hofner**—Star Formation, Interstellar Medium, X-ray Astronomy
- **Huang**—Atmospheric Radioactivity, Atmospheric Chemistry
- **Klinglesmith**—Asteroids, Photometry, Image Processing
- **Krebbel**—Lightning Studies, Radar Meteorology, Thunderstorm Electrification
- **Meason**—Nuclear Physics, Nuclear & Space Radiation Effects, Electromagnetic Radiation Effects & Directed Energy
- **Minschwaner**—Radiative Transfer and Climate, Physics of the Upper Atmosphere
- **C. Moore**—Atmospheric Physics, Weather Radar, Precipitation Mechanisms
- **Pietrač**—Inorganic Chemistry, Physical Chemistry, Nuclear Magnetic Resonance Spectroscopy
- **Raymond**—Geophysical Fluid Dynamics, Cloud Physics, Clouds and Climate
- **Rison**—Atmospheric Electricity, Radar Meteorology, Instrumentation
- **Rupen**—Gas and Dust in Galaxies, Radio Transients
- **E. Ryan**—Asteroid Collisional Physics, Observational and Theoretical Studies
- **W. Ryan**—Asteroid Astronomy, High Energy Physics
- **Schery**—Environmental Radioactivity, Atmospheric Physics
- **Sonnenfeld**—Lightning Charge Transport, Data Storage Instrumentation
- **Taylor**—Very Long Baseline Radio Astronomy, Active Galactic Nuclei
- **Teare**—Experimental Adaptive Optics, Radiation Effects and Directed Energy
- **Thomas**—Lightning Studies, Physics of the Upper Atmosphere
- **Ulvestad**—Compact Radio Sources, Seyfert Galaxies, AGNs, Space VLBI Techniques and Future Missions
- **Weatherall**—High-Energy Astrophysics, Plasma Physics
- **Westpfahl**—Dynamics of Spiral and Dwarf Galaxies
- **Wilkening**—Natural Atmospheric Radioactivity, Atmospheric Electricity
- **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).

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.

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

Accredited medical schools require a minimum of three years of college work, with a minimum grade-point average of 3.0. However, more than three-fourths of all students now applying to medical school have completed requirements for the baccalaureate degree. In addition to the courses listed above for the freshman and sophomore years, students are advised to take the following courses: BIOL 311, 341, 351, 352, 355, and 437; CHEM 311, 331, 332, 441, and 442. Two years of Spanish, French, or German are recommended. Most premedical students major in biology, chemistry, or basic sciences. The premedical student should be aware that the Medical College Admissions Test is required for admission to medical school.

Premedical Technology Program

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, students are strongly advised to undertake at least a three-year preprofessional program. Courses to be included in a two-year program should be those described above. A three-year program should add as many additional courses, except for foreign languages, as possible from those described 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.
Psychology

Professor: Cormack
Associate Professors: Holson (Chair of the Department), Samuels

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 to prepare students for further work in all specializations within the field. Students acquire the fundamentals of learning and memory, intelligence, perception, feelings and emotions, attention, thought, language and communication, the development of all these processes and their pathology, the application of psychology to other fields, as well as 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—130

In addition to the general degree Requirements (page 53), the following courses are required:
- PSY 121 (3); 205 (4); 471 or 472 (1)
- Two courses (with associated labs) chosen from among PSY 301 (4), 305 (4), 309 (4)
- 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)
- CS 111 (4)
- Electives to complete 130 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)

14 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 325 (developmental)
- 5 PHYS 121 & 121L (general)
- 4 BIOL 111 (general)
- 3 MUS 101 (survey)

18 Total credit hours

Semester 4
- 3 PSY 209 (social)
- 3 MATH 283 (statistics)
- 5 PHYS 122 & 122L (general)
- 4 BIOL 112 (general)
- 3 Elective

18 Total credit hours

Semester 5
- 4 PSY 301 (perception)
- 3 HIST 151 (comparative civilization)
- 3 BIOL 331 (cell biology)
- 3 PHIL 231 (introduction)
- 4 CS 111 (introduction)

17 Total credit hours

Semester 6
- 4 PSY 305 (learning, memory, and cognition)
- 3 HIST 152 (comparative civilization)
- 4 BIOL 351 (physiology)
- 3 ENGL 341 (technical writing)
- 3 Elective

17 Total credit hours

Semester 7
- 4 PSY 309 (physiological)
- 3 PSY 330 (abnormal)
- 9 Electives

16 Total credit hours

Semester 8
- 1 PSY 472 (seminar)
- 3 PSY 400 (history)
- 11 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

Psychology Courses:

The following courses may be used to fulfill the Social Science portion of the General Degree Requirements, page 53.

PSY 121, General Psychology, 3 cr, 3 cl hrs

The study of behavior. Includes perception, motivation, learning, personality, social processes, and physiological processes.

PSY 205, Experimental Psychology, 4 cr, 3 cl hrs, 2 lab hrs

Prerequisite: PSY 121; a lab usage fee is charged

Basic concepts and research methodology in the study of behavior; emphasis on experimental design, control, and laboratory methods.

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 the design and interpretation of psychopharmacological research; emphasis on self-administered drugs as well as addictions and treatment.

PSY 301, Perception, 4 cr, 3 cl hrs, 2 lab hrs

Prerequisites: PSY 205; a lab usage fee is charged

Experimental and theoretical study of sensory mechanisms and perceptual processes.

PSY 305, Cognitive Psychology, 4 cr, 3 cl hrs, 2 lab hrs

Prerequisites: Psychology 205 with a C- or better; a lab usage fee is charged

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. The laboratory is designed to give students the opportunity to explore the experimental bases of cognitive processes.
PSY 309, Behavioral Neuroscience, 4 cr, 3 cl hrs, 2 lab hrs
Prerequisites: Psychology 205 passed with a C- or better; Biology 111, 112; a lab usage fee is charged

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 312, Psychopharmacology, 3 cr, 3 cl hrs
Prerequisites: PSY 212; BIOL 111, 112
Behavioral and pharmacological techniques for the study of drugs acting on the nervous system. Topics include sites of drug action, CNS toxicity, psychotherapeutics, and experimental designs employed in psychopharmacological research.

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 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
An introduction to psychopathology. Includes the etiology, diagnosis, treatment, and prognosis of behavioral disorders.

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
General overview of ethological and physiological approaches to the study of animal behavior. (Same as BIOL 362)

PSY 376, Mass Violence and Aggression, 3 cr, 3 cl hrs
Prerequisite: Upper-division standing or consent of the instructor
This course examines the nature and dynamics of mass violence and aggression, and their impact on politics and societies. Through lectures and readings the students explore and compare political, sociological and psychological dimensions of genocides, state terror, and ethnic cleansing. (Same at HIST 376)

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
Study of central questions and concepts of psychology from their origins in classical philosophy and medicine to modern times.

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.

Staff Research Interests
Cormack—Psychophysics, Visual Perception, Sensory Mechanisms
Holson—Developmental Neurobiology, Neurotoxicology, Behavioral Teratology
Samuels—Cognitive Development, Reasoning and Problem Solving, Memory, Brain Injury and Rehabilitation
Science Teaching

Interdepartmental Program

Administrative Committee for Master of Science Teaching:
- Chávez (mineral engineering)
- Deming (humanities)
- Johnson (graduate dean, ex officio)
- Smoake (biology)
- Stone (mathematics)
- Wedeward (electrical engineering)
- Werbelow (chemistry)
- Westpfahl (physics)
- Coordinator: Wolfe

Degree Offered: Master of Science Teaching

Program Description

The Master of Science Teaching (MST) program is designed to provide graduate-level classroom and laboratory instruction for secondary 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 effectuate these as directed study or independent study projects in their own classrooms during the academic year. Courses for the participants are offered by a variety of departments on campus 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.

Admission to the Program

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.

Transfer Credit Policy

Credits used for another degree are not available for use in the MST degree program. Up to 12 credit hours of approved upper-division undergraduate or graduate (300–500 level) science, mathematics, engineering, and/or technology courses taken at New Mexico Tech may be applied to the total required for the MST degree.

A maximum of 12 credit hours of course work with grade B or better, earned at New Mexico Tech or 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 transfer credit in science, mathematics, engineering, and/or technology. Transferred credits may include up to six credit hours of graduate 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 Teaching Program
Graduate Office
801 Leroy Place
New Mexico Tech
Socorro, NM 87801

For information on Tech’s Education Department and alternate licensure, see page 86.

MST Fellowships

The MST Office maintains a list of available fellowships.

Policies

Endorsement Policy

Although the MST program is not primarily intended to provide courses which may be used to add endorsements to New Mexico State Department of Education certification, undergraduate courses taken at New Mexico Tech and Science Teaching courses, such as ST 501, 502, 511, 512, and in some cases 581 that are based on New Mexico Tech undergraduate courses may be used to add such endorsements. Further information regarding certification endorsements may be obtained from the New Mexico Department of Education, 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 will 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., the library, computer center, advisor, or graduate committee), the student must be registered for at least one Tech upper-division or graduate course.

Master of Science Teaching

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 (ST 591), which may be experimental, theoretical, or applied, under the supervision of a faculty member. Six credit hours will be allowed for the thesis. The non-thesis program involves the preparation of a paper (ST 590—Independent Study) under the supervision of a faculty member. The paper may be experimental, theoretical, or applied in terms of science teaching. Three credit hours will be allowed for the preparation of this paper. A list of individuals willing to supervise independent study can be obtained from the MST Coordinator.
Graduate Advisory Committee

Each MST student will be assigned a temporary advisor at the time of first registration. The student will select a thesis, or independent-study advisor and an advisory committee by the end of the student’s second semester of residency. 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 faculty members. The MST Coordinator is the fourth member of all MST committees. The academic advisor serves as chair of the advisory committee. The MST Coordinator and the Graduate Dean must approve the advisor and members of the advisory committee. The student should meet with his or her advisory committee at least once a year.

Program Requirements

All incoming MST students must demonstrate competence in science and mathematics by
1. completing the introductory courses:
   • ST 523, Survey of Biology
   • ST 524, Survey of Chemistry
   • ST 525, Survey of Geology
   • ST 526, Survey of Physics: Newton’s Laws
   • ST 550, Mathematics for Teachers
2. passing the appropriate placement exams (see above)
These courses or the appropriate placement exams are prerequisites for most other ST courses.

Master of Science Teaching students must take the following core of 16 credit hours that will give breadth and depth to the program:
1. All incoming students must take a technical communication course and a computer literacy course.
   • ST 530, Technical Communication for Teachers (2)
   • ST 556, Computers and Science Teaching (2)
2. For comprehensiveness, MST students must take one course in each of the following distribution areas, for a total of eight credit hours:
   • Math/Computer/Economics/Business (2)
   • Physics/Chemistry (2)
   • Geology/Biology (2)
   • Engineering (2)
3. For depth, MST students must take an additional two courses (four 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)
• ST 592, Seminar (1)
• Additional courses to complete 30 credit hours. These courses may be chosen from MST courses or other Tech courses numbered 300 or above. Up to 12 transfer credit hours are allowed.

Science Teaching Courses:

Prerequisites for all courses: at least one year of teaching experience and competence in basic courses in subject matter area, or consent of instructor.
Science Teaching 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.
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.

ST 501, 502, Biology for Teachers I, II, 3 cr each
Prerequisites: ST 523 and 550, or consent of instructor

Review of modern biology. Students register concurrently in BIOL 111 for 501 or 112 for 502. Extra work involving a research paper or curriculum development is required.

ST 511, 512, Chemistry for Teachers I, II, 3 cr each
Prerequisites: ST 524 and 550, or consent of instructor

Review of basic chemical principles. Students register concurrently in CHEM 121 for 511 or 122 for 512. Extra work involving a research paper or curriculum development is required.

ST 513, Molecular Biology Laboratory for Teachers, 2 cr
Prerequisites: ST 523 and 550, or consent of instructor

An introduction to the techniques used in molecular biology, including spectrophotometry, electrophoresis, gel filtration, chromatography, hydrolysis, and the analysis of biological polymers.

ST 515, Human Biology for Teachers I, 2 cr
Prerequisites: ST 523 and 550, or consent of instructor

Discussion of health-related issues for humans, and the principles of and biological bases for these issues. Topics include AIDS, autoimmune diseases, organ transplants, artificial organs, cardiovascular diseases, regeneration processes, and birth control.

ST 517, Environmental Studies, 2 cr
Prerequisites: ST 523 and 550, or consent of instructor

A study of the interrelationships of organisms with their physical and chemical environment. Biological interactions among populations, communities, ecosystems, and pollutants.

ST 519, Modern Genetics, 2 cr
Prerequisites: ST 523 and 550, or consent of instructor

A study of recent developments in genetics including genetic engineering, gene splicing, and recombinant DNA; also new concepts of the structure of DNA.

ST 523, Survey of Biology, 1 cr

A survey of life functions at the cellular level. Includes 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 524, Survey of Chemistry, 1 cr

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. 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

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: Newton’s Laws, 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 530, Technical Communication for Teachers, 2 cr
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. For English and science teachers.

ST 531, Research and Documentation, 2 cr
Various kinds of research (both primary and secondary) and documentation, particularly in the fields of science. Gathering data, writing (literature reviews, reports, articles, bibliographies), and documenting correctly.

ST 540, Rockin Around New Mexico, 1 cr
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 550; or consent of instructor
A study of the principles and technology of mineral occurrence, extraction, and refining. Field trips complement lectures and laboratory experiments. Emphasis on New Mexico base metal deposits.

ST 544, Geological and Environmental Engineering for Teachers, 2 cr
Prerequisites: ST 525 and 550; or consent of instructor
An introduction to waste disposal, soil properties, civil engineering and the environment, and the uses and misuses of natural resources. Classroom and laboratory work with one-day field trips.

ST 547, Field Techniques in Geology for Teachers, 2 cr
Prerequisites: ST 525 and 550; or consent of instructor
Rock and mineral identification, geochronology, stratigraphic succession, and practical field mapping in the San Juan Basin. Rigorous activity and primitive camping. Enrollment limited.

ST 548, Geology of the Southwest—National Parks and Natural Resources, 2 cr
Prerequisites: ST 525 and 550; or consent of instructor
A field geology course focusing on regional geologic settings of the arid Southwest, including identification of rocks and minerals, geologic environments, and interpretation of geologic field data.

ST 549, Fundamentals of Mining Engineering, 2 cr
Prerequisites: ST 525 and 550; or consent of instructor
An overview of general concepts of mining engineering, emphasizing social, economic, and environmental impacts of mining; stages of development of a mine; general descriptions of mining methods; equipment selection; ground stability issues; mine waste disposal.

ST 550, Mathematics for Teachers, 2 cr
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 551, Concepts in Mathematics for Teachers, 2 cr
Prerequisites: ST 550; or consent of instructor
Examples are taken from number theory, algebra, geometry, and analysis. A menu of class projects will be provided, some of which are amenable to study and solution by computer.

ST 552, Calculus on a Computer, 2 cr
Prerequisites: ST 550; or consent of instructor
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 554, Mathematical Modeling, 2 cr
Prerequisites: ST 550; or consent of instructor
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, Computers and Science Teaching, 2 cr
General techniques of computer maintenance and upgrading, including hardware and software. Basic use of the World Wide Web, including sites and techniques of special interest to teachers.

ST 557, Fractals and Chaos, 2 cr
Prerequisites: ST 550; or consent of instructor
The development of the basic geometry of fractals, using both deterministic and random methods, the mathematical ideas behind chaos, and connections between the ideas of chaos and fractals, and applications.

ST 558, Probability and Statistics, 2 cr
Prerequisites: ST 550; or consent of instructor
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 562, Astronomy for Teachers, 2 cr
Prerequisites: ST 526 and 550; or consent of instructor
General principles of astronomy and astrophysics; radio and x-ray phenomena; stellar properties and evolution; origin of the solar system. Optical and Radio Astronomy are explored alternate summers.

ST 564, Great Concepts in Physics, 2 cr
Prerequisites: ST 526 and 550; or consent of instructor
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 566, Atoms and Molecules, 2 cr
Prerequisites: ST 526 and 550; or consent of instructor

ST 571, Advanced Topics in Science Teaching, 2 or 3 cr
Prerequisites: ST 525 and 550; or consent of instructor
Study of special topics in science and mathematics adapted to precollege education.

ST 576, Environmental Chemistry, 2 cr
Prerequisites: ST 524 and 550; or consent of instructor
Evaluation of environmental problems from a chemical point of view, including topics in air pollution, photochemistry, solution chemistry, and heavy metal chemistry.

ST 581, Directed Study, cr to be arranged
Study under the guidance of a member of the graduate faculty. In general, subject matter will supplement that available in other graduate course offerings.

ST 590, Independent Study, 3 cr

ST 591, Thesis (master's program), 6 cr

ST 592, Seminar, 1 cr
Presentation of the final MST project, ST 590 or 591. The presentation can be either oral, in the form of a seminar at New Mexico Tech, or an electronic publication.
The bachelor’s programs in chemical engineering, electrical engineering, engineering mechanics, environmental engineering, materials engineering, mineral engineering and petroleum engineering are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET).

Professional Examinations
All engineering majors are required to take the Fundamentals in Engineering (FE) examination as a requirement for graduation. This examination is the entry-level requirement for those individuals who intend to attain a professional engineer status. The FE examination is given in the fall and spring each year at New Mexico Tech. The FE examination is a national examination; therefore, the results are transferable to any state or territory of the United States.

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Chemical Engineering

(www.nmt.edu/~cheme)

Associate Professors Bretz, Dong, Jeon, Weinkauf (Program Chair)
Adjunct Faculty: Bickel, Cal, Dunston, Lee, McCoy
Laboratory Associate: Marshall

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, medicine, fuels, semiconductors, plastics, and paper have all been driven by the ingenuity of chemical engineers. Current frontiers being explored by chemical engineers include the design and implementation of new medical devices, fuel cells, micro-machines, nanocomposites, new batteries, bio/chemical sensors, explosives, and improved fuel systems. Chemical engineers are concerned with reducing energy consumption, producing new molecules which enrich our lives, and minimizing the contamination of our environment at the source. 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 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, 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 complete engineers who can: solve problems, experiment, innovate, be resourceful, and champion ideas through effective communication.
2. Our graduates will possess an understanding of the broad reach of a modern Chemical Engineering education and the array of knowledge required to implement solutions which will benefit our society.
3. Our graduates will be engaged in successful careers covering the spectrum of fields which require a command of the principles of Chemical Engineering.
4. Our graduates will benefit from a lifelong love of learning, opening doors to graduate study and enabling graduates to adapt to changes and opportunities in the profession.

Undergraduate Program

Bachelor of Science in Chemical Engineering

Minimum credit hours required—136

In addition to the General Degree Requirements (page 53), the following courses are required:

- CHEM 311 & 311L (4), 331 & 331L (4), 333 & 333L (4)
- EE 211 (3) or ES 332 (3)
- MATH 231 (4), 335 (3)
- MATE 202 & 202L or 235 & 235L (4)
- Chemistry/Biology Elective (3) Any upper-division chemistry or biology course approved by the advisor
- Engineering/Technical Electives (6) Upper-division engineering or other approved courses. These electives should generally be Chemical Engineering or other engineering program courses at the 300-, 400- or 500-level. Advanced courses in chemistry, biology, mathematics, and computer science are encouraged. Chemical Engineering technical elective courses include ChE 463, 464, 470, 472, 473, 474, 475, and 489. Consult the semester schedule and your advisor for the availability of other technical electives of interest.

Chemical engineering majors must maintain a minimum GPA of 2.0 in required courses in order to graduate.

All 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 ES 110 (intro to 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 ES 111 (computer programming)
- 4 MATH 132 (calculus II)
- 4 CHEM 122 & 122L (general)
- 5 PHYS 121 & 121L (general)

16 Total credit hours

Semester 3

- 3 ChE 326 (intro to chemical engineering)
- 4 MATH 231 (calculus III)
- 3 ES 201 (statics)
- 4 CHEM 311 & 311L (analytical)
- 3 ENGL 112 (college English II)

17 Total credit hours

Semester 4

- 3 ES 216 (fluid mechanics)
- 3 ES 347 (engineering thermodynamics)
- 3 MATH 335 (applied analysis I)
- 5 PHYS 122 & 122L (general)
- 3 Humanities

17 Total credit hours

Semester 5

- 3 ChE 349 (ChE thermodynamics)
- 3 EE 211 (circuits) or ES 332 (electrical engineering)
- 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 ES 316 (engineering economics)
- 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 ES 302 (strength of materials)
- 4 CHEM 333 & 333L (organic)
- 3 Engineering/Technical Elective
- 3 Humanities/Social Science

18 Total credit hours

Semester 8

- 2 ChE 443 (process control)
- 1 ChE 443L (process control lab)
- 3 ChE 462 (plant design II)
- 3 Chemistry/Biology Elective
- 3 Engineering/Technical Elective
- 3 Humanities
- 3 Social Science

18 Total credit hours

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), 474 (3)
- ChE 473 (3)

Chemical Engineering Courses:

ChE 326, Principles of Chemical Engineering, 3 cr, 3 cl hrs
Prerequisite: ES 111; MATH 132
Offered: spring and fall semesters
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 345L, Chemical Engineering Design Lab, 1 cr, 3 lab hrs
Prerequisites: ES 216, 347, and 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; 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
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)
Elective Courses

**ChE 352, Separation Processes, 3 cr, 3 cl hrs**
Prerequisites: ChE 349; ES 330
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 443, Process Dynamics and Control, 2 cr, 2 cl hrs**
Prerequisites: MATH 335 and (ES 330 or ES 334)
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 352
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: ES 316 or consent of instructor
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, 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 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, Advanced Transport Phenomena, 3 cr, 3 cl hrs**
Prerequisites: ES 316 and 330 or consent of instructor
Highly recommended for students considering graduate school
Advanced principles of momentum, heat and mass transfer. Topics will include laminar Newtonian and non-Newtonian flow, elementary turbulent flow, heat conduction in composites, boundary layer theory, radiation, and binary diffusion with adsorption reaction.

**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: MATE 202 or consent of instructor
A practical and “hands-on” course covering the essentials of polymer processing and polymer materials characterization. A survey of polymer processing techniques with emphasis on the fundamentals of extrusion. Lab topics include: extruder operation, compounding, scanning calorimetry, rheometry, and mechanical testing. Field trips to manufacturing facilities. (Same as MATE 474)

**ChE 475, 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.

**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.

Chemical Engineering Staff

**Research Interests**

Bretz—Transport Phenomena, Phase Behavior, Natural Gas Processing

Dong—Membrane Separations, Catalytic Membranes, Solid Oxide Fuel Cells

Jeon—Polymer Science and Engineering, Neutron and Light Scattering, Polymer Nanocomposites and Thin Films, Dynamic Light Scattering, High-Vacuum Anionic Polymerization

Weinkauf—Polymer Engineering, Membrane Separations, Plasma Polymer Thin Films, Microsensors, Plasma Surface Modification
Civil Engineering

Professor Aimone-Martin
Associate Professors Cal (Chair of Department), Huang, Richardson
Adjunct Faculty: Ghosh, Hendrickx, Kuhn

Degree Offered: B.S. in Civil Engineering; Areas of Specialization: Geotechnical, Water Resources, and Structural

Program Educational Objectives
1. To develop undergraduate student competence in the fundamentals of civil engineering and across a specialty area of structural, geotechnical or water resources engineering.
2. To prepare students in the general areas of logical analysis, critical thinking, rational design, and ethical engineering practice.
3. To prepare students for advanced education in civil engineering and related fields, and to prepare students for professional licensure.

The primary objective of this program is to produce a well-balanced civil engineer capable of entering the civil engineering profession or continuing studies at the graduate level. Graduates will be well-prepared to solve current civil engineering problems, and 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 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. Our 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 two-semester design project.

Undergraduate Program

Bachelor of Science in Civil Engineering

Minimum credit hours required—133
In addition to the General Degree Requirements (page 53), the following courses are required:

- CE 101 (1), 201 (3), 301 (3), 302 (3), 402 (3), 411 (3), 413 (3), 418 (2), 482 (2)
- CE 404 (3) or ES 316 (3)
- ES 110 (2), 201 (3), 216 (3), 302 (3), 303 (3)
- ES 332 or EE 211 (3)
- MATH 231 (4), 283 (3), 335 (3)
- ME 220 (3), 420 (4)
- MENG 300 (2), 421 (3)
- Technical Electives (12 or 13): Four courses in a civil engineering specialty. Civil engineering track options include:
  - Geotechnical (13): CE 420 (3), CE 422 (3), ME 434 (3), ME 442 (4)
  - Water Resources (12): CE 423 (3), ENVE 201 (3), HYD 403 (3), HYD 412 (3)
  - Structural (12): CE 412 (3), CE 414 (3), MENG 304 (3), MENG 441 (3)

Students pursuing a B.S. in Civil Engineering must take all engineering and hydrology courses for a letter grade.

Civil engineering majors must maintain a minimum GPA of 2.0 in required courses in order to graduate. All 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)
2. CHEM 121 (intro to chemistry)
3. ENGL 111 (Introduction to English)
4. ES 110 (Intro to Engineering)
5. MATH 131 (Calculus)
6. Social Science
7. Total credit hours

Semester 2
3. ENGL 112 (English Composition)
4. ES 111 (Intro to Engineering)
5. MATH 132 (Calculus)
6. Social Science
7. Total credit hours

Semester 3
4. CHEM 122 & 122L (Chemistry)
5. ES 201 (Statics)
6. MATH 231 (Calculus)
7. PHY 121 & 121L (Physics)
8. Total credit hours

Semester 4
3. CE 201 (Materials, Properties, and Testing)
4. ES 201 (Statics)
5. MATH 231 (Calculus)
6. ME 220 (Surveying and Map Preparation)
7. Total credit hours

Semester 5
3. CE 301 (Construction Engineering)
4. ES 303 (Dynamics)
5. ENGL 341 (Technical Writing)
6. MATH 283 (Statistics)
7. Humanities
8. Social Science
9. Total credit hours

Semester 6
3. CE 302 (Structural Engineering)
4. ES 332 (Electrical Engineering or EE 211 (Circuits)
5. MENG 300 (Mechanics Lab)
6. MENG 421 (Finite Element Analysis and Design)
7. ME 420 (Soil and Rock Mechanics)
8. Social Science
9. Total credit hours

Semester 7
3. CE 402 (Transportation Engineering)
4. CE 411 (Design of Steel and Concrete Structures)
5. CE 413 (Foundation Design & Analysis)
6. CE 481 (Senior Design)
7. CE Electives
8. Humanities
9. Total credit hours

10. Total credit hours

Semester 8
3. CE 404 or ES 316 (Engineering Practice and Economics)
4. CE 482 (Senior Design)
5. CE Electives
6. Humanities/Social Science
7. Total credit hours

17–18 Total credit hours
Civil Engineering Track Options

Water Resources Engineering Track
3 CE 423 (open channel hydraulics)
3 ENVE 201 (environmental engineering)
3 HYD 403 (groundwater hydrology)
3 HYD 412 (surface water hydrology)

Geotechnical Engineering Track
3 CE 420 (pavement design)
3 CE 422 (geotechnical waste containment design)
3 ME 434 (drilling & blasting)
4 ME 442 (applied geomechanics)

Structural Engineering Track
3 CE 412 (advanced design of metal structures)
3 CE 414 (advanced design of concrete structures)
3 MENG 304 (advanced strength of materials)
3 MENG 441 (dynamics and vibrations in structural design)

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, Introduction to Construction Engineering, 3 cr, 3 cl hrs
Prerequisite: Junior standing
Introduction to the construction processes: contracting and bonding, planning and scheduling, estimating and project control, productivity models, and construction economics.

CE 302, Introduction to Structural Engineering, 3 cr, 3 cl hrs
Prerequisite: ES 201, 302
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 402, Introduction to Transportation Engineering, 3 cr, 3 cl hrs
Prerequisite: CE 301
Introduction to the design, planning, operation, management, and maintenance of transportation systems. Principles for planning integrated multi-modal transportation systems (highways, air, rail, etc.). Introduction to the layout of highways, airports, and railroads with traffic flow models, capacity analysis, and safety. Functional design concepts for both the facilities and systems areas of study with life cycle costing procedures and criteria for optimization.

CE 404, Engineering Practice and Economics, 3 cr, 3 cl hrs
Prerequisites: CE 301 and senior standing
Lectures designed to provide an appreciation of the role of science, technology, and the needs of society in conceiving projects, balancing the interplay of conflicting demands, and utilizing a variety of disciplines to produce unified and efficient systems. Topics covered include: engineering economics, project management and scheduling, and professional ethics.

CE 411, Design of Steel and Concrete Structures, 3 cr, 3 cl hrs
Prerequisites: ES 302, CE 302
Introduction to the design of metal structures; behavior of members and their connections; theoretical, experimental, and practical bases for proportioning members and their connections. Study of the strength, behavior, and design of reinforced concrete members subjected to moments, shear, and axial forces.
Staff Research Interests

Aimone-Martin—Drilling and Blasting, Geotechnical Engineering,
Mineral Evaluation, Geostatistics
Cal—Air Quality Engineering and Science, Fate and Transport of
Pollutants, Chemical Engineering, Water Treatment
Ghosh—Macro Behavior of Composites, Structural Health
Monitoring and Restoration, Finite Element Analysis,
Construction Materials and Project Management,
Experimental Mechanics and Instrumentation
Hendrickx—Vadose Zone Hydrology, Water and Salt Balance of
Natural and Irrigated Systems, Evapotranspiration, Remote
Sensing, Soil Physics, Electromagnetic Induction
Huang—Hazardous Waste Management, Biological and
Chemical Waste Treatment, Environmental Systems Modeling,
Risk Assessment
Kuhn—Geotechnical Engineering
Richardson—Biological Wastewater Treatment, Groundwater
Contamination, Site Remediation

Electrical Engineering

Professors Rison, Thomas
Associate Professors R. Bond, Teare (Chair of the Department),
Wedeward
Assistant Professors El-Osery, Erives, Xiao
Adjunct Faculty: Calloni, Dong, El-Kady, Krehbiel, Mansfield, Meason,
Reicher, Restaino, Robinett, Sarkodie-Gyan, Wick

Degrees Offered: B.S. in Electrical Engineering; M.S. in Electrical
Engineering

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

1. Graduates will be technically competent within the degree of Electrical
   Engineering. They will have the ability to synthesize and apply
   engineering knowledge and fundamentals to solving complex,
   real-world electrical engineering problems. They will demonstrate
   the ability to pursue lifelong learning in engineering, thus
   reinforcing and expanding on their engineering fundamentals and
   their depth and strength in mathematics and science.

2. Graduates will be prepared for professional practice in electrical
   engineering. They will have the ability to understand ethical and
   social choices inherent in the engineering profession and apply
   them in their daily practice of engineering. They will have the
   ability to work effectively in teams, through having the ability to
   communicate effectively, both orally and in writing; and they will
   appreciate the importance of encouraging the best in others.

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
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. Personal computer-based instruments and software
packages provide students with up-to-date engineering and design
techniques.

Design is integrated into all aspects of the curriculum. Students take an “Introduction to Design” course in the second semester of their junior year. This and their other course work prepare students for two Senior Design Project courses, in which students apply material learned in the classroom to real-world problems. Projects are available from the greater Tech community, including Tech research labs, Langmuir Laboratory for Atmospheric Research, the Energetic Materials Research and Testing Center, and the VLA and VLBA facilities of the National Radio Astronomy Observatory.

Five-year programs are available in which students obtain dual
degrees in electrical engineering and in related fields such as
computer science, physics, or mathematics.
Graduates of Tech’s 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—130

In addition to the General Degree Requirements (page 53), the following courses are required:
- Introduction to problem-solving and computer skills: CS 111 (4)
- Mathematics core: MATH 231 (4), 254 (3), 332 (3), 382 (3)
- Electrical Engineering electives: a minimum of seven credit hours, including at least one lab credit hour, from Electrical Engineering 300- and 400-level courses, excluding the Electrical Engineering core classes listed above.
- Engineering/Computer Science electives. Six hours from the following:
  - Electrical Engineering courses numbered 200 and above (excluding EE core and elective classes)
  - Computer Science courses except CS 111 and 122
  - Other engineering dept. courses numbered 200 and above
  - Engineering Science courses numbered 200 and above, except ES 316 and 332
- At least three credit hours must be from outside the Electrical Engineering Department.
  
- Electives to complete 130 credit hours. Without prior departmental approval, the following cannot be used for these electives: ENGL 103; MATH 101, 103, 104, 105; PR courses; or New Mexico Tech Community College courses.

To enroll in an Electrical Engineering Department class, a student must pass the prerequisites of the course with a grade of C- or better. 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.

All engineering majors are required to take the Fundamentals in Engineering (FE) exam as a requirement for graduation.

While fulfilling the General Degree Requirements (page 53), Electrical Engineering students must also satisfy a depth requirement in the humanities or social sciences. Each Electrical Engineering student is required to take at least nine credit hours in a single area chosen from the following. Three of the credit hours must be 300-level or above.

1. Literature (including SPAN 352)
2. Philosophy
3. History
4. Economics (ES 316 is excluded)
5. Psychology
6. A single foreign language that is not the student’s native language. Note: Lower-division language courses do not fulfill the humanities requirement

Students may substitute sequences in Art History or Music after obtaining the consent of the Electrical Engineering Department.

**Sample Curriculum for the Bachelor of Science in Electrical Engineering**

**Semester 1**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 131 (calculus)</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 121 &amp; 121L or 131 &amp; 131L (general)</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 121 &amp; 121L (general)</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 111 (college English)</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total credit hours</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

**Semester 2**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 132 (calculus)</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 122 &amp; 122L or 132 &amp; 132L (general)</td>
<td>5</td>
</tr>
<tr>
<td>CHEM 122 &amp; 122L (general)</td>
<td>4</td>
</tr>
<tr>
<td>EE 101 &amp; 101L (introduction to electrical engineering)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total credit hours</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

**Semester 3**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 231 (calculus)</td>
<td>4</td>
</tr>
<tr>
<td>EE 211 (circuits)</td>
<td>3</td>
</tr>
<tr>
<td>EE 231 &amp; 231L (digital electronics)</td>
<td>4</td>
</tr>
<tr>
<td>CS 111 (programming)</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 112 (college English)</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total credit hours</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

**Semester 4**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 254 (linear algebra)</td>
<td>3</td>
</tr>
<tr>
<td>MATH 332 (vector analysis)</td>
<td>3</td>
</tr>
<tr>
<td>EE 212 &amp; 212L (circuits)</td>
<td>4</td>
</tr>
<tr>
<td>EE 308 &amp; 308L (microcontrollers)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total credit hours</strong></td>
<td><strong>17</strong></td>
</tr>
</tbody>
</table>

**Semester 5**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 321 &amp; 321L (analog electronics)</td>
<td>4</td>
</tr>
<tr>
<td>EE 333 (electricity and magnetism)</td>
<td>3</td>
</tr>
<tr>
<td>EE 341 (continuous time signals)</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 341 (technical writing)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total credit hours</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

**Semester 6**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 382 (introduction to design)</td>
<td>3</td>
</tr>
<tr>
<td>MATH 382 (probability)</td>
<td>3</td>
</tr>
<tr>
<td>Electrical Engineering Elective with lab</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total credit hours</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

**Semester 7**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 481 (senior design project)</td>
<td>3</td>
</tr>
<tr>
<td>EE 451 &amp; 451L (digital signal processing)</td>
<td>3</td>
</tr>
<tr>
<td>Electrical Engineering Elective</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total credit hours</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

**Semester 8**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 434 (electromagnetic wave transmission and radiation)</td>
<td>3</td>
</tr>
<tr>
<td>EE 482 (senior design project)</td>
<td>3</td>
</tr>
<tr>
<td>Engineering/Computer Science Elective</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total credit hours</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

Additional sample curricula can be found on the Electrical Engineering Department homepage at [http://www.ee.nmt.edu](http://www.ee.nmt.edu)
Minor in Electrical Engineering

Minimum credit hours required—19

The following courses are required:

- EE 101 & 101L (2), 211 (3), 212 & 212L (4), 231 & 231L (4)
- Six (6) additional credit hours of Electrical Engineering courses selected from: 308 & 308L (4), 321 & 321L (4), 322 & 322L (4), 324 (3), 333 (3), 341 (3).

Graduate Program

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 53), 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 separate requirements of both an undergraduate degree and a graduate degree in Electrical Engineering in a five-year period. A combined minimum of 158 credit hours with at least 19 credit hours of 500-level courses and Engineering in a five-year period. A combined minimum of 158 undergraduate degree and a graduate degree in Electrical Engineering with Thesis may be contingent upon adherence to the approved program of studies. Graduate admission will be contingent upon adherence to the approved program of studies. Graduate status will be granted on fulfillment of the requirements for the B.S. degree.

Sample Curriculum for the Master of Science in Electrical Engineering with Thesis

**Semester 1**

1. EE 521 (measurement and instrumentation) 4 credits
2. EE 451 (digital signal processing) 4 credits
3. Non-EE Graduate Course 3 credits
4. EE 592 (graduate seminar) 3 credits

12 Total credit hours

**Semester 2**

1. EE 570 (advanced topics) 4 credits
2. EE 434 (electromagnetic wave transmission and radiation) 3 credits
3. EE 435 (rf and microwave lab) 1 credit
4. Non-EE Graduate Course 3 credits
5. EE 592 (graduate seminar) 3 credits

12 Total credit hours

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, 101L, Introduction to Electrical Engineering 2 cr, 1 cl hr, 3 lab hrs**

Corequisites: MATH 103; EE 101 and 101L are corequisites of each other

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**

Prerequisite: MATH 132; EE 101 or junior standing

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, 212L, Circuits and Signals II, 4 cr, 3 cl hrs, 3 lab hrs**

Prerequisite: EE 211; EE 101 or junior standing

Corequisites: EE 212 and 212L are corequisites of each other.

Normally offered spring semester

Continuation of EE 211, Laplace transform techniques, transient response, steady-state sinusoidal response, and frequency response of RLC circuits.

**EE 231, 231L, Digital Electronics, 4 cr, 3 cl hrs, 3 lab hrs**

Corequisites: EE 101 or ES 111 or CS 111. EE 231 and 231L are corequisites of each other.

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 308, 308L, Microcontrollers, 4 cr, 3 cl hrs, 3 lab hrs**

Prerequisites: CS 111; EE 231 and 231L

Corequisites: EE 308 and 308L are corequisites of each other.

Normally offered spring semester

Introduction to microcontrollers. Elementary assembly- and C-language programming, bus structures, parallel and serial interfaces, support devices. Using logic analyzers and disassemblers in circuit testing. Using microcontrollers in measurement and control applications.

**EE 321, 321L, Analog Electronics, 4 cr, 3 cl hrs, 3 lab hrs**

Prerequisites: EE 212 and 212L; PHYS 122 or 132

Corequisites: EE 321 and 321L are corequisites of each other.

Normally offered fall semester

Basic principles and use of operational amplifiers, diodes, field-effect transistors, and bipolar junction transistors in electronic circuits.

**EE 322, 322L, Advanced Electronics, 4 cr, 3 cl hrs, 3 lab hrs**

Prerequisites: EE 231 and 231L, 321 and 321L, and 341

Corequisites: EE 322 and 322L are corequisites of each other

Applications in analog electronics. Topics include timing and switching circuits, power supply techniques, active filters, switched capacitor circuits, oscillators, and phase-locked loops.

**EE 324, Semiconductor Theory and Devices, 3 cr, 3 cl hrs**

Prerequisite: PHYS 122 or 132

Corequisite: EE 321

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
Prerequisites: MATH 332 and PHYS 122 or 123
Electric and magnetic fields in free space and in matter. Energy storage as a function of field quantities and the relation of this to capacitance and inductance. Maxwell’s equations applied to simple electrostatic and magnetostatic problems, plane waves, and transmission lines. Transient and sinusoidal steady state solutions of uniform transmission line problems modeled in terms of circuit parameters.

EE 341, Continuous Time Signals and Systems, 3 cr, 3 cl hrs
Prerequisites: EE 212 and MATH 254
Principles of linear time-invariant systems. Dynamic systems, Laplace transforms, system functions, poles and zeros, frequency domain, Fourier transforms, feedback systems, continuous-time convolution.

EE 342, Discrete Time Signals and Systems, 3 cr, 3 cl hrs
Prerequisite: EE 341
Normally offered: spring semester
Discrete time systems, z-transform, discrete-time convolution. Impulse response, sampling in time and frequency domains, modulation, discrete Fourier transform.

EE 352, Microcomputer Interfacing, 2 cr
Prerequisite: EE 308 and 308L
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 308, 308L, 321, 321L, 333, 341, 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 434, Electromagnetic Wave Transmission and Radiation, 3 cr, 3 cl hrs
Prerequisite: EE 333
Normally offered: spring semester
Reflection and interaction of plane waves at planar interfaces. The propagation characteristics of metallic and dielectric waveguides with particular emphasis on fiber optics. Radiation from linear current elements and planar apertures and arrays of these elements. 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
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, Introduction to Communications Theory, 3 cr, 3 cl hrs
Prerequisite: MATH 382
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, 451L, Digital Signal Processing, 3 cr, 3 cl hrs, 3 lab hrs
Prerequisites: EE 308 and 341
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, communication systems, sound processing, and other applications.

EE 481, 481L, Senior Design Project I, 3 cr
Prerequisites: EE 341, 382, and have declared electrical engineering as a major
Normally offered: spring 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 includes the use of computers, applications of physics, numerical computation, signal processing and other electrical engineering techniques to real-world engineering problems.

EE 482, 482L, Senior Design Project II, 3 cr
Prerequisite: EE 481, and have declared electrical engineering as a major
Normally offered: spring semester
A continuation of the capstone design projects begun in EE 481. The student teams bring their design projects to successful conclusion. Status reports, final presentations 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
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 a EE faculty member.

EE 521, Measurement and Instrumentation, 4 cr, 3 cl hrs, 3 lab hrs
Prerequisites: EE 308, 322, and 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 the VHDL programming language in a CAD environment.

EE 533, Optical/RF Engineering, 3 cr, 3 cl hrs
Prerequisites: EE 324 and 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 PC 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, QOQSK. Statistical analysis of various modulation schemes.

EE 546, Digital Communication II, 3 cr, 3 cl hrs  
Prerequisite: EE 546 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. (Same as EM 548)

EE 551, Discrete-Time Signal Processing, Filtering, and Estimation, 3 cr, 3 cl hrs  
Prerequisites: EE 451; MATH 254 and 382  
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 implement 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 and 382  
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 and 443 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, PICs, 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 EM 554)

EE 562, Microwave Engineering & Radar, 3 cr, 3 cl hrs  
Prerequisite: EE 434 or equivalent or consent of instructor  

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, 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  
Prerequisites: Graduate standing  
Offered both Spring and Fall semester. Credits cannot be applied towards the 30 credit hours required for graduation.

Staff Research Interests

R. Bond—Design for Test/Manufacturability, Teaching Effectiveness  
Calloni—Gravitational Wave Interferometry  
Dong—Chemical Sensors  
El-Kady—Optics and Photonics Systems  
El-Osery—Wireless Communications, Control Systems, Soft Computing  
Erives—Hyperspectral Imaging  
Krehbiel—Lighting, Thunderstorms, Radar  
Mansfield—Radar Systems  
Meason—Nuclear, Electromagnetic and Space Radiation Effects and Directed Energy  
Reicher—Physics and Simulation of Thin Films  
Restaino—Adaptive Optics, Novel Optical Systems  
Rison—Atmospheric Electricity, Instrumentation, Lightning Protection  
Robinett—Controls, Optimization, Sensors, Computer Vision  
Sarkodie-Gyan—Machine Vision, Biomedical Engineering, Mechatronic Systems  
Teare—Experimental Adaptive Optics, Radiation Effects and Directed Energy  
Thomas—Lightning, Thunderstorms and Instrumentation  
Weddward—Adaptive Control, Robotic Systems, Complex Systems  
Wick—Experimental Adaptive and Active Optics  
Xiao—Photonic/Fiber Sensors, Intelligent Sensor Networks, Optical Communications, Computer Vision
Engineering Management

Professors Colbaugh, Sueyoshi
Associate Professors Arselmo (Chair of the Department), Holcomb
Visiting Assistant Professors Ulibarri
Adjunct Faculty: Foster, Hirschfeld, 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 29.

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); MATH 585 (3)
- Electives (6): Example sequences are EMGT 511 (3) and 512 (3) or EMGT 521 (3) and 522 (3)
- 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, 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, 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, Information Systems in Technology Organizations, 3 cr, 3 cl hrs

Databases and the interaction between database information systems and organizational decision processes. Data mining and other topics relevant to data- and technology-intensive organizations. Discussion of the optimal information system design and implementation.

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.

EMGT 505, 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, Managing Technology Resources, 3 cr, 3 cl hrs

The study of human and other resources within technology and engineering organizations. Negotiation, leadership, resource allocation and other critical management topics will be discussed in this seminar. Research on organizational behavior issues unique to an engineering/technical environment will be studied.
Environmental Engineering

Professor Airmone-Martin
Associate Professors Cal (Chair of the Department), Huang, Richardson
Adjunct Faculty: Brady, Hendricks

Degrees Offered: B.S. in Environmental Engineering; M.S. in Environmental Engineering

Department Mission Statement

The main objective of this program is to produce well-balanced environmental engineers capable of entering the environmental engineering market as professionals, prepared to deal with current problems, and also having an ability to adapt to future environmental issues. The curricular content embodies the basic sciences, mathematics, humanities and social sciences, and engineering sciences common to most engineering disciplines. In addition, it draws heavily upon advanced physical, chemical, biological and engineering science concepts. An assortment of environmental engineering courses provides a strong background in the fundamentals of physical, chemical and biological processes and unit operations specific to the discipline. This approach, coupled with a program philosophy of logical analysis, critical thinking, rational design, and ethical practice, enables the environmental engineering graduate to address varied multi-media problems and develop integrated air-water-land approaches to problem solving. The program offers the graduate the environmental breadth and technological depth needed to interface with multi-disciplinary teams solving complex environmental problems. A common thread throughout the program is that environmental engineers must exercise ecological wisdom as they engineer for society with the appreciation and understanding that humans are an integral part of nature and must live harmoniously within the ecological and resource limits of the earth.

A secondary program objective is to prepare students for advanced education. A broad environmental engineering baccalaureate program has intrinsic value as a foundation for specialization in graduate school. Ancillary to this is the concept that a Bachelor of Science degree at New Mexico Tech in Environmental Engineering should not, in itself, be the final step in the educational staircase. In other words, our objective is also to provide the graduate with a foundation for continued professional growth and development and lifelong learning.

The design experience is cultivated early on in the study of environmental engineering at New Mexico Tech. Appropriate elements of design are integrated throughout the curriculum beginning with Introduction to Engineering I (ES 110) and culminating in a major comprehensive design experience offered by Senior Design Thesis (ENVE 490). The grouping or linking of coursework in engineering topics and basic and applied sciences provide a base of knowledge consistent with achieving program objectives. This coursework has been carefully selected by faculty consensus to give the student an introductory-level exposure to the fundamentals in the following major focus areas of environmental engineering: water and wastewater, solid and hazardous waste, air quality and air pollution control. Environmental engineering coursework should, therefore, include such subjects as organic chemistry, microbiology, groundwater hydrology, fluid mechanics, heat and mass transfer, and, perhaps, process instrumentation and control. The rationale for selection of specific classes is simple. The curriculum reflects an effort by the faculty to complement the major focus areas with appropriate engineering topics and relevant specialized sciences. A proficiency in these three areas of environmental engineering, augmented by professional experience, will produce those skills necessary to conceive, plan, design and implement actions required for the protection of human health and welfare and for the preservation and enhancement of our environment.
Program Educational Objectives

The Environmental Engineering Program has established a set of educational objectives to maintain and improve the quality of its undergraduate program:

1. To produce well-balanced environmental engineers capable of entering the environmental engineering market as professionals that are prepared to manage current problems, and are able to adapt to changing technologies and regulations. Target employers include environmental regulatory agencies, industrial companies, and government research laboratories.

2. To prepare students in the general areas of logical analysis, critical thinking, rational design, and ethical engineering practice to enable environmental engineering students to address a wide variety of environmental engineering problems.

3. To prepare students for advanced education in fields such as environmental engineering, environmental health, chemical engineering, and hydrology, and to prepare students for professional licensure.

Undergraduate Program

Bachelor of Science in Environmental Engineering

Minimum Hours Required—134

In addition to the General Degree Requirements (page 53), the following courses are required:

- MATH 231 (4), 283 (3), 335 (3)
- CHEM 311 (3), 333 (3)
- BIOL 111 (3), 111L (1), 343 (3)
- HYD 403 (3)
- ES 332 or EE 211 (3)
- ES 316 or CE 404 (3)
- Technical Electives (3): Approved technical electives include ENVE 421, 491; CE 422, 423; HYD 412; ChE 351, 352, 443; CHEM 422; or other elective approved by the department chair

Students pursuing a B.S. in Environmental Engineering must take all engineering and hydrology courses for a letter grade.

All 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)
2. ENGL 111 (college English)
3. BIOL 111 (general)
4. CHEM 121 (general)
5. MATH 131 (calculus)
6. ES 110 (intro)

18 Total credit hours

Semester 2

1. ENVE 201 (intro)
2. MATH 335 (applied analysis)
3. PHYS 122 & 122L (general)
4. ES 201 (statics)
5. BIOL 343 (microbiology)

17 Total credit hours

Semester 3

1. MATH 231 (calculus)
2. PHYS 121 & 121L (general)
3. CHEM 311 (quantitative analysis)
4. Social Science
5. Humanities

18 Total credit hours

Semester 4

1. ENVE 201 (intro)
2. MATH 335 (applied analysis)
3. PHYS 122 & 122L (general)
4. ES 201 (statics)
5. BIOL 343 (microbiology)

17 Total credit hours

Semester 5

1. ENVE 303 (water)
2. ES 216 (fluid mechanics)
3. ES 302 (materials)
4. ES 347 (thermodynamics)
5. MATH 283 (statistics)
6. CHEM 333 (organic)

17 Total credit hours

Semester 6

1. ENVE 302 (environmental law)
2. ENVE 304 (wastewater)
3. ENVE 306 (water lab)
4. ENVE 407 & 407L (soil mechanics)
5. ES 316 or CE 404 (engineering practice and economics)
6. ES 350 (heat and mass transfer)
7. ENGL 341 (technical writing)

16 Total credit hours

Semester 7

1. ENVE 411 (solid and hazardous waste)
2. ENVE 413 (air pollution engineering)
3. HYD 403 (groundwater hydrology)
4. Social Science
5. Humanities

16 Total credit hours

Semester 8

1. ENVE 416 (air pollution design)
2. ENVE 490 (senior thesis)
3. ES 332 (electrical) or EE 211 (circuits)
4. Approved Technical Elective
5. Social Science
6. Humanities

15 Total credit hours
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. Depending upon resource availability, students may choose an area of specialization or they may pursue a broad environmental engineering education. 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 accredited 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 ENVE coursework, and 6 credit hours of ENVE 591 (thesis). All students, regardless of specialization, must take ENVE 501 (3) and ENVE 503 (3). In addition to the required courses, students may specialize in one of several areas (listed below).

Courses for the broad ENVE track will be offered at least once within a two-year period. Courses for the other areas of specialization will be offered upon sufficient demand.

Recommended Course Sequences for Areas of Specialization:
- **Broad**—ENVE 413 (3), 501 (3), 503 (3), 512 (3), 520 (3), 521 (3), 591 (6), technical electives (6)
- **Water Quality Engineering and Science**—ENVE 501 (3), 503 (3), 510 (3), 511 (3), 512 (3), 591 (6), technical electives (9)
- **Hazardous Waste Engineering**—ENVE 501 (3), 503 (3), 520 (3), 521 (3), 522 (3), 591 (6), technical electives (9)
- **Air Quality Engineering and Science**—ENVE 413 (3), 501 (3), 503 (3), 530 (3), 535 (3), 591 (6), technical electives (9)

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), and a minimum of 18 credit hours must be 400- or 500-level Environmental Engineering lecture or laboratory courses. The student’s course of study must be approved by the student’s advisory committee, and it must fulfill the other requirement of the M.S. in Environmental Engineering degree program with the exception of 6 credit hours of thesis (ENVE 591).

Environmental Engineering Courses:

**ENVE 101, Environmental Engineering Seminar, 1 cr, 1 hr**
Seminar 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 cr hrs**
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 302, Environmental Law and Regulations, 2 cr, 2 cr hrs**
Prerequisites: 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, 2 cr, 2 cr hrs**
Prerequisites: ENVE 201; CHEM 311; or consent of instructor
Corequisites: ES 216, 350
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, gas transfer, etc. A design project will be developed by teams as partial fulfillment of course requirements.

**ENVE 304, Wastewater Treatment Process Design, 2 cr, 2 cr hrs**
Prerequisites: BIOL 343; ES 216, 350; or consent of instructor
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, etc. A design project will be developed by teams as partial fulfillment of course requirements.

**ENVE 306, Water and Wastewater Laboratory, 1 cr, 3 lab hrs**
Corequisites: ENVE 303 or 304 or consent of instructor
Bench-scale analysis of unit operations and processes in water and wastewater treatment. Potential laboratory topics include tracer analysis, coagulation, water softening, sedimentation, carbon absorption, ion exchange, chemical oxidation, biological oxidation, etc. Monitoring and performance evaluation using various analytical techniques common to the field. Investigations by teams; results presented in engineering reports. Emphasis on planning of experiments, evaluation of data, and report writing.

**ENVE 407, 407L, Soil Mechanics, 2 cr, 3 cr hrs, 3 lab hrs**
(First semester only)
Prerequisites: ES 302
Stress-strain properties and engineering classification of soils. Compaction, consolidation, and seepage analysis and design. Meets with ME 420 and 420L first half of semester only.
ENVE 411, Solid and Hazardous Waste Engineering, 4 cr, 4 cl hrs
Prerequisites: ES 350 and 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, 3 cr, 3 cl 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. Basic atmospheric chemistry of the troposphere and stratosphere. Design of air pollution control equipment for removal of gases and particles from air streams. Units operations examined include cyclones, electrostatic precipitators, fabric filters, wet scrubbers, adsorbers, and absorbers.

ENVE 416, Design of Air Pollution Engineering Systems, 3 cr, 2 cl hr, 3 lab hrs
Prerequisites: ENVE 413 or consent of instructor
Students learn how to use dispersion modeling and process design software, air pollution monitoring equipment, and design unit operations for air pollution engineering systems. Design projects will cover air permitting, atmospheric dispersion modeling, and integrated air pollution control systems. Laboratories will cover measurement of gaseous and particulate air pollutants, air quality data analysis, and unit operations of air quality systems.

ENVE 421, Green Engineering, 3 cr, 3 cl hrs
Prerequisite: Consent of instructor
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.

ENVE 490, Senior Design Thesis, 3 cr
Prerequisite: Senior standing or 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.

ENVE 491, Special Topics in Environmental Engineering, 3 cr, 3 cl hrs
Prerequisite: Senior standing or consent of instructor
ENVE 411, Solid and Hazardous Waste Engineering, 4 cr, 4 cl hrs
Prerequisites: ES 350 and consent of instructor
Advanced study of treatment unit operations and processes within industry-specific waste 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 510, Advanced Water Chemistry, 3 cr, 3 cl hrs
Prerequisite: ENVE 501 or consent of instructor
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 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
Prerequisite: Consent of instructor
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.

ENVE 522, Geotechnical Waste Containment Design, 3 cr, 3 cl hrs
Prerequisite: ENVE 407 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 530, Advanced Air Pollution Engineering, 3 cr, 3 cl hrs
Prerequisites: ENVE 413, 501, or consent of instructor
Application of basic pollution control techniques to a variety of source categories, including industrial and mobile sources. State-of-the-art and developing technologies such as catalytic combustion, advanced oxidation, and bioremediation. Classroom presentations and a semester-long design project.

ENVE 535, Transport and Fate of Air Pollutants, 3 cr, 3 cl hrs
Prerequisites: ES 216; MATH 335; or consent of instructor
Development and application of theories and techniques to predict the movement and dilution of air pollutants after emission from a pollutant source. Basics of meteorology in relation to descriptions of atmospheric motion and stability. Examination of the different types of atmospheric dispersion models (Gaussian, Eulerian, and Lagrangian). Aerosol formation mechanisms and formation of gaseous pollutants in the troposphere.
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

Staff Research Interests

Aimone-Martin—Drilling and Blasting, Geotechnical Engineering, Mineral Evaluation, Geostatistics
Brady—Aquatic Chemistry, Global Change, Groundwater Remediation
Cal—Air Quality Engineering and Science, Chemical Engineering, Fate and Transport of Pollutants, Water Treatment
Hendrickx—Vadose Zone Hydrology, Water and Salt Balance of Natural and Irrigated Systems, Evapotranspiration, Remote Sensing, Soil Physics, Electromagnetic Induction
Huang—Hazardous Waste Management, Biological and Chemical Waste Treatment, Environmental Systems Modeling, Risk Assessment
Richardson—Biological Wastewater Treatment, Groundwater Contamination

Materials and Metallurgical Engineering

Professors G. Bond, Inal, McCoy
Associate Professors Burleigh, Fuierer, Hirschfeld (Chair of the Department), Lu, Majumdar
Adjunct Faculty: Adolph, Curro, Doughty, Hockersmith, Lowe, Ravi, Romig, Sickafus, M. Smith
Emeritus Professor Purcell

Degrees Offered: B.S. in Materials Engineering, Materials Engineering with Metallurgical Engineering option; M.S. and Ph.D. in Materials Engineering

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 Objectives

1. To develop undergraduate student competence in the fundamentals of materials science and engineering, across the subdisciplines of metals, ceramics, polymers, and composites.
2. To develop graduate student expertise in a specialized area of materials engineering.
3. To develop the theoretical understanding, hands-on experimental skills, and intellectual agility necessary for a productive professional life in today’s highly technical and rapidly changing society.
4. To develop the students’ abilities in both the acquisition and the generation of information.
5. To develop the students’ abilities in the creative application of information and knowledge for the common good of society.
6. To develop the students’ abilities in communicating technical information and knowledge in both written and oral form.

The undergraduate program aims to produce well rounded materials engineers who are ready to play a productive and responsible role in their chosen field. The students graduate with a combination of strengths, versatility, and hands-on experience that enables them to perform well whether they enter employment directly or choose to pursue graduate studies first. One of the fundamental aspects of an engineering education is the ability to combine theory with practice. The program provides students with a very solid foundation in theory, but there is also a strong emphasis on a “hands-on” approach. This is achieved through the wide range of courses offered in the department (both required and elective) that have a laboratory component—in each, the laboratory and classroom elements are carefully integrated, as well as the capstone design sequence and senior thesis. Additional hands-on 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 the Energetic Materials Research and Testing Center, New Mexico Bureau of Geology and Mineral Resources, and Petroleum Recovery Research Center.

The curriculum in materials engineering has broad applications. It encompasses several disciplines involving metals, ceramics, polymers, and composites. Synthesis, processing, and microstructural characterization of novel materials (metallic,
ceramic, electronic, and composite) as well as investigation of defect-controlled properties (strength, fracture toughness, etc.) form the core of the materials program. In research methodology, the full range of analysis is applied, from macroscopic and real-world examples such as plant design and industrial fabrication, to microscopic analysis of materials. Applications derived from characteristics and qualities of metals and other materials provide an open-ended program in the engineering field. In addition to sophisticated equipment on the Tech campus, extensive laboratory and research facilities are available at Kirtland Air Force Base and Sandia National Laboratories in Albuquerque, and at Los Alamos National Laboratory. Scientists at these labs maintain close relationships with Tech personnel.

Tech’s Electron Optics Facilities are available for research and instruction in all fields. The facilities include a JEOL 6100 Scanning Electron Microscope, fitted with a Noran Energy Dispersive X-ray Analyzer; an Amray 1200B Scanning Electron Microscope; a JEOL 100C Scanning Transmission Electron Microscope (STEM); and a Philips EM 430 transmission electron microscope. The facilities also include a substantial complement of equipment for specimen preparation.

Undergraduate Program

The Materials Engineering Program is accredited by the Engineering Accreditation Commission of ABET.

Bachelor of Science in Materials Engineering

Minimum credit hours required—134

In addition to the General Degree Requirements (page 53), the following courses are required:

- MATH 231 (4), 335 (3)
- ES 110 (2), 111 (3), 201 (3), 302 (3), 332 (3)
- METE 327 & 327L (4)

Advanced basic science: A minimum of three credit hours (CHEM 331 or 333 is recommended).

- Technical electives (6): Technical and advanced basic science electives must be chosen with the approval of the advisor. (See note on electives following the sample curriculum, below.)
- Electives to complete 134 credit hours

The chosen curriculum must provide a minimum of 16 engineering design credits. Engineering design credits are included in various engineering courses, and students who complete all coursework at Tech fulfill this requirement. Transfer students must consult their advisors about engineering design credits.

Credit for trigonometry or college algebra is not allowed for engineering students.

All 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 Materials Engineering

<table>
<thead>
<tr>
<th>Semester</th>
<th>Courses</th>
</tr>
</thead>
</table>
| 1        | MATE 101L (introduction) | 3
|          | ENGL 111 (college English) | 3
|          | MATH 131 (calculus) | 4
|          | CHEM 121 (general) | 4
|          | Social Science | 3
|          | ES 110 (intro) | 2
|          | Total credit hours | 17 |
| 2        | ENGL 112 (college English) | 3
|          | MATH 132 (calculus) | 4
|          | CHEM 122 & 122L (general) | 4
|          | ES 111 (intro) | 3
|          | Social Science | 3
|          | Total credit hours | 17 |
| 3        | MATH 231 (calculus) | 5
|          | PHYS 121 & 121L (general) | 5
|          | Humanities | 3
|          | Total credit hours | 16 |
| 4        | MATE 202 & 202L (introduction) | 4
|          | MATH 231 (calculus) | 4
|          | PHYS 121 & 121L (general) | 5
|          | Humanities | 3
|          | Total credit hours | 16 |
| 5        | MATH 335 (applied analysis) | 3
|          | PHYS 122 & 122L (general) | 5
|          | MATE 235 & 235L (materials) | 4
|          | ES 201 (statics) | 3
|          | Social Science | 3
|          | Total credit hours | 18 |
| 6        | MATE 301 & 301L (ceramics) | 3
|          | MATE 314 (transport processes) | 3
|          | MATE 350 (materials thermodynamics) | 3
|          | ES 302 (mechanics of materials) | 3
|          | ENGL 341 (technical writing) | 3
|          | Total credit hours | 16 |
| 7        | MATE 351 (polymers) | 3
|          | MATE 382 (design) | 2
|          | METE 327 & 327L (physical) | 4
|          | ES 332 (electrical) | 3
|          | Humanities | 3
|          | Technical Elective* | 3
|          | Total credit hours | 18 |
| 8        | MATE 431 (manufacturing processes of materials) | 3
|          | MATE 441 (X-ray) | 3
|          | MATE 445 (composites) | 3
|          | MATE 467 (seminar) | 2
|          | MATE 481 (design) | 3
|          | Advanced Basic Science Elective* | 3
|          | Total credit hours | 17 |
| 9        | MATE 442 (diffusion) | 3
|          | MATE 452 (physics of metals & ceramics) | 3
|          | MATE 482 (design) | 3
|          | Humanities/Social Science | 3
|          | Technical Elective* | 3
|          | Total credit hours | 15 |

*Electives must be approved by the student’s advisor. Engineering design credits are in brackets: METE 434; MATE 402, 402L [1], 410 [3], 430, 431, 435 [1], 443, 444, 446, 447, 450 [1]; 470, 474, 479, 483; ES 316, 421 [2]; MATH 283, 382, 384, 410, 454; CHEM 311 & 311L, 331, 333, 443; GEOL 101, 211; PHYS 340, 444; EE 211, 212, 321; ED 462 [1].
Bachelor of Science Degree in Materials Engineering with Metallurgical Engineering Option

Minimum credit hours required—134

In addition to the General Degree Requirements (page 53), the following courses are required:

- MATH 231 (4), 335 (3)
- ES 110 (2), 111 (3), 201 (3), 302 (3), 332 (3)
- METE 326 (3), 327 & 327L (4), 382 (2), 481 (3), 482 (3)
- Advanced basic science: A minimum of three credit hours (CHEM 331 or 333 is recommended).
- Technical electives (13): Technical and advanced basic science electives must be chosen with the approval of the advisor. See note on electives following the sample curriculum, below.
- Electives to complete 134 credit hours

The chosen curriculum must provide a minimum of 16 engineering design credits. Engineering design credits are included in various engineering courses, and students who complete all coursework at Tech fulfill this requirement. Transfer students must consult their advisors about engineering design credits.

Credit for trigonometry or college algebra is not allowed for engineering students.

All 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 Materials Engineering with Metallurgical Engineering Option

<table>
<thead>
<tr>
<th>Semester</th>
<th>Courses</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semester 1</td>
<td>1 MATE 101L (introduction)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3 ENGL 111 (college English)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4 MATH 131 (calculus)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>4 CHEM 121 &amp; 121L (general)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2 ES 110 (intro)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3 Social Science</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Total credit hours</strong></td>
<td><strong>17</strong></td>
</tr>
<tr>
<td>Semester 2</td>
<td>3 ENGL 112 (college English)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4 MATH 132 (calculus)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>4 CHEM 122 &amp; 122L (general)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3 ES 111 (intro)</td>
<td>3</td>
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<tr>
<td></td>
<td>3 Social Science</td>
<td>3</td>
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<td></td>
<td><strong>Total credit hours</strong></td>
<td><strong>17</strong></td>
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<tr>
<td>Semester 3</td>
<td>4 MATH 231 (calculus)</td>
<td>4</td>
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<tr>
<td></td>
<td>5 PHYS 121 &amp; 121L (general)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>4 MATE 202 &amp; 202L (introduction)</td>
<td>4</td>
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<tr>
<td></td>
<td>3 Humanities</td>
<td>3</td>
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<tr>
<td></td>
<td><strong>Total credit hours</strong></td>
<td><strong>16</strong></td>
</tr>
<tr>
<td>Semester 4</td>
<td>3 MATH 335 (applied analysis)</td>
<td>3</td>
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<tr>
<td></td>
<td>5 PHYS 122 &amp; 122L (general)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>4 MATE 235 &amp; 235L (materials)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3 ES 201 (statics)</td>
<td>3</td>
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<tr>
<td></td>
<td>3 Social Science</td>
<td>3</td>
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<tr>
<td></td>
<td><strong>Total credit hours</strong></td>
<td><strong>18</strong></td>
</tr>
<tr>
<td>Semester 5</td>
<td>3 ES 302 (mechanics of materials)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3 MATE 314 (transport processes)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3 MATE 350 (materials thermodynamics)</td>
<td>3</td>
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<tr>
<td></td>
<td>5 ENGL 341 (technical writing)</td>
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<td></td>
<td>3 Technical Elective*</td>
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<tr>
<td></td>
<td><strong>Total credit hours</strong></td>
<td><strong>15</strong></td>
</tr>
<tr>
<td>Semester 6</td>
<td>3 ES 332 (electrical)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3 METE 326 (process)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4 METE 327 &amp; 327L (physical)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2 METE 382 (design)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3 Humanities</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3 Technical Elective*</td>
<td>3</td>
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<td></td>
<td><strong>Total credit hours</strong></td>
<td><strong>18</strong></td>
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<tr>
<td>Semester 7</td>
<td>3 METE 481 (design)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3 MATE 431 (manufacturing processes of materials)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3 MATE 441 (X-ray)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2 MATE 467 (seminar)</td>
<td>2</td>
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<tr>
<td></td>
<td>7 Technical Electives*</td>
<td>7</td>
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<tr>
<td></td>
<td><strong>Total credit hours</strong></td>
<td><strong>18</strong></td>
</tr>
<tr>
<td>Semester 8</td>
<td>3 MATE 435 (mechanical)</td>
<td>3</td>
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<tr>
<td></td>
<td>3 MATE 452 (physics of metals &amp; ceramics)</td>
<td>3</td>
</tr>
<tr>
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<td>3 MATE 482 (design)</td>
<td>3</td>
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<tr>
<td></td>
<td>3 Humanities/Social Science</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3 Advanced Basic Science Elective*</td>
<td>3</td>
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<tr>
<td></td>
<td><strong>Total credit hours</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

*Electives must be approved by the student's advisor. Engineering design credits are in brackets: METE 425 [1], 428 [1], 434, MATE 402 & 402L [1], 410 [3], 430, 431, 442 [1], 443, 444, 445 [1], 447, 450 [1], 470, 479, 483; ES 316, 421 [2]; MATH 283, 392, 394, 410, 454; CHEM 311 & 311L, 331, 332 & 332L, 333, 411 & 411L; GEOC 443; GEOL 101, 211, 312; PHYS 346; EE 211, 212, 231, 321; ED 462 [1].

Minor in Materials Engineering

Minimum credit hours required—22

The following courses are required:

- MATE 202 & 202L (4), 235 & 235L (4), 301 & 301L (4), 351 (3), 445 (3)
- METE 327 & 327L (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
- MATE 351 (3), 474 (3)
- ChE 473 (3)

Graduate Programs

Master of Science in Materials Engineering

The student's course of study must be approved by the student's advisory committee and must fulfill the general requirements for the master's degree and must include MATE/ METE 591 (thesis). No more than three credit hours of directed study can be used to satisfy the course work requirements.

Students must take MATE 592 each semester offered if the student is in residence. Distance-education students will be required to document conference participation in lieu of this requirement. Only one credit of MATE 592 may be used to fulfill degree requirements.
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. Additional information can be found under the Graduate Program (page 34).

In addition to the requirements specified for the M.S. degree, students seeking the Ph.D. degree in materials are required to take a minimum of 24 credit hours of approved course work, of which at least 12 credit hours must be in 500-level courses; no more than three of these hours should be directed study. Students must take MATE 592 each semester offered if the student is in residence. Distance-education students will be required to document conference participation in lieu of this requirement. Only one credit of MATE 592 may be used to fulfill degree requirements.

Dissertation research must also be completed. In order to pursue dissertation research, the student must pass a candidacy examination and a qualifying examination. An oral defense of the completed written dissertation is also required.

Suitable topics for doctoral candidates can be selected from a broad range of materials issues (relating to ceramics, composites, metals, or polymers) that are of current interest to the department's faculty.

Special Programs

Students pursuing an advanced degree in materials may elect to emphasize and develop a background in the general area of materials with research centered around an area of structure-property-processing performance of metals, ceramics, polymers, and composites. This could involve modern microstructural characterization techniques (X-rays and electron microscopy); mechanical and physical property measurements; explosive forming, hardening, and consolidation; performance under conditions of fatigue, high temperatures, and aggressive environments.

Interdisciplinary programs in the areas of materials are encouraged. Joint dissertation supervision is provided by the appropriate departments or divisions. Research facilities not available on the campus may be available through cooperative agreements with the Air Force Weapons Laboratory at Kirtland Air Force Base and Sandia National Laboratories in Albuquerque, and Los Alamos National Laboratory.

The Joint Center for Materials Science was organized to fulfill these three objectives:

1) to promote cooperation between New Mexico Tech, the University of New Mexico, and New Mexico State University in providing continuing education in materials science for graduate students and technical people employed in New Mexico by conducting graduate courses, seminars, thesis research, etc.;

2) to develop cooperative efforts in research among these three universities and Sandia National Laboratories, the Air Force Weapons Laboratory at Kirtland Air Force Base, and Los Alamos National Laboratory, to bring maximum resources to bear on materials problems pertinent to the establishment of technical programs in the state; and

3) to help coordinate and provide guidance to the three universities on graduate education in materials science.

Many pertinent course offerings are to be found within the department, and others can be selected from other departments at New Mexico Tech or at participating institutions.

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, 202L, Introduction to Materials Engineering, 4 cr, 3 cl hrs, 3 lab hrs
Corequisite: CHEM 112
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 235, 235L, Materials Engineering, 4 cr, 3 cl hrs, 3 lab hrs
Prerequisite: MATE 202 or consent of instructor
Offered spring semester
A survey of solid materials of technological importance including ceramics, glasses, semiconductors, polymers, and composites.

MATE 301, 301L, Introduction to Ceramic Engineering, 4 cr, 3 cl hrs, 3 lab hrs
Prerequisite: MATE 202, 235; or consent of instructor
Ceramic processing and beneficiation techniques, from raw materials to finished products. Chemistry and structure of ceramic raw materials. Microstructures of traditional (porcelain and glass) and advanced (modern structural and electrical) ceramics. Properties of ceramics, and their dependence on processing and microstructure.

MATE 314, Transport Processes, 3 cr, 3 cl hrs
Prerequisites: MATH 131; PHYS 121
Introduction to the concepts of fluid dynamics and mass and heat transfer.

MATE 350, Materials Thermodynamics, 3 cr, 3 cl hrs
Prerequisite: MATE 202
Review of basic laws from a transport-process-based perspective. Thermodynamics of multicomponent mixtures. Phase equilibria in mixtures. (Same as CHE 349)

MATE 351, Introduction to Polymeric Materials, 3 cr, 3 cl hrs
Prerequisite: MATE 202; MATH 231; MATE 350 or CHE 349
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 382, Introduction to Engineering Design, 2 cr, 1 cl hr, 3 lab hrs
Prerequisites: ES 110, 301; MATE 235
A study of materials-oriented design methodology with emphasis on materials selection, interaction of materials, processing and design, cost evaluations, problem solving, decision making, ethics and non-technical considerations in design, and engineering statistics. Development of project-oriented skills through team design projects. (Same as METE 382)

MATE 402, Physical Ceramics, 3 cr, 3 cl hrs
Prerequisite: MATE 301
Offered spring semester, alternate years
Review of ceramic microstructures. Atomatic, microstructural, and thermodynamic origins of ceramic properties, with emphasis on the effects of atomic and structural defects and interpretation of phase diagrams.

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. 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, Fundamentals in Manufacturing Processes of Materials, 3 cr, 3 cl hrs
Prerequisite: 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 434, Introduction to Solidification and Phase Transformations, 3 cr, 3 cl hrs
Prerequisites: MATE 350; METE 327
Corequisite: MATE 442
Thermodynamic considerations and phase diagrams (review); influence of interfaces on equilibrium; influence of interfaces and of strain energy on microstructure and kinetics; solidification of single-component and multicomponent systems; ingots, castings, and welds; sol-gel processing; diffusional transformations in solids: precipitation, eutectoid transformations, massive transformations, and ordering; diffusionless transformations in solids: martensitic transformations.

MATE 435, Mechanical Behavior of Materials, 3 cr, 3 cl hrs
Prerequisites: MATE 202 or consent of instructor

MATE 441, X-ray Diffraction, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: PHYS 122

MATE 442, Solid State Diffusion, 3 cr, 3 cl hrs
Prerequisite: MATE 314

MATE 443, Magnetic Materials, 3 cr, 3 cl hrs
Prerequisite: MATE 235 or consent of instructor

MATE 445, Introduction to Composite Materials, 3 cr, 3 cl hrs
Prerequisites: ES 302 or consent of instructor

MATE 446, Modeling in Materials Science and Engineering, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: MATH 335; MATE 301; METE 327
The objective of this course is to familiarize students with different modeling methods in materials science and engineering. Emphasis will be on introduction of fundamentals followed by hands-on simulation with available computer software. Students will be encouraged to develop program-writing skills.

MATE 447, Optical Materials, 3 cr, 3 cl hrs
Prerequisite: MATE 235 or consent of instructor

MATE 452, Physics of Metals and Ceramics, 3 cr, 3 cl hrs
Prerequisite: Senior standing or consent of instructor

MATE 453L, Electronic Materials Laboratory, 1 cr, 3 lab hrs
Prerequisite: 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, 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, 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 467, Materials Seminar, 2 cr, 2 cl hrs
Prerequisite: Senior standing
Students, faculty, and distinguished visitors discuss subjects of current and/or long-range interest in various fields of materials.

MATE 470, Corrosion Phenomena, 3 cr, 3 cl hrs
Prerequisite: CHEM 122
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 474, Polymer Processing and Characterization, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: MATE 202 or consent of instructor
A practical and "hands-on" course covering the essentials of polymer processing and polymer materials characterization. A survey of polymer processing techniques with emphasis on the fundamentals of extrusion. Lab topics include: extruder operation, compounding, scanning calorimetry, rheometry, and mechanical testing. Field trips to manufacturing facilities. (Same as ChE 474)

MATE 479, Transmission Electron Microscopy, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: MATE 441 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: MATE 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, Engineering Design I, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: MATE 382
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, application of engineering statistics. (Same as MTE 481)

MATE 482, Engineering Design II, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: MATE 481
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, preparation and presentation of final project report. (Same as MTE 482)

MATE 483, Scanning Electron Microscopy, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: PHYS 122 or consent of instructor

MATE 491, Directed Study/Senior Thesis, 3 cr
Prerequisite: Senior standing or consent of instructor
This course may not be used to fulfill graduate degree requirements.

MATE 502, Physical Ceramics, 3 cr, 3 cl hrs
Prerequisite: MATE 301
Offered spring semester, alternate years
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, 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. New capacitor formulations (high permittivity) and "relaxor" ferroelectrics. Ferroelectric phase transitions and phenomenology. Piezoelectricity, pyroelectricity, and applications.

MATE 505, 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, Statistical Mechanics of Simple Materials, 3 cr, 3 cl hrs
Prerequisite: MATE 350 or consent of instructor
Materials that can be "fooled" into looking like ideal gases are used to introduce the concepts and methods of statistical mechanics. Topics covered include: gas adsorption, blackbody radiation, superfluidity and superconductivity, black hole formation, electrical conductivity, the Curie temperature, and the calculation of pi.

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, 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 mechanisms. Stress and interdiffusion in thin films. Electrical and optical properties of thin films, heterostructures, quantum wells, and superlattices.

MATE 514, Liquid State Theory, 3 cr, 3 cl hrs
Prerequisite: MATE 350 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 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 530, Design and Analysis of Experiments, 3 cr, 3 cl hrs
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). Shares lectures with MATE 430, but is graded separately, and additional work is required at the graduate level.

MATE 531, 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, Introduction to Solidification and Phase Transformations, 3 cr, 3 cl hrs
Prerequisites: MATE 350; MATE 327
Corequisite: MATE 442
Thermodynamic considerations and phase diagrams (review); influence of interfaces on equilibrium; influence of interfaces and strain energy on microstructure and kinetics; solidification of single-component and multicomponent systems; ingots, castings, and welds; sol-gel processing; diffusional transformations in solids: precipitation, eutectoid transformations, massive transformations, and ordering; diffusionless transformations in solids: martensitic transformations. Shares lectures with MATE 434 (formerly 444), but is graded separately, and additional work is required at the graduate level.

MATE 541, Advanced Physical Metallurgy, 3 cr, 3 cl hrs
Prerequisites: MATH 335 or equivalent; MATE 327 or equivalent; MATE 235 or equivalent; consent of the instructor
MATE 543, Advanced Mechanical Metallurgy, 3 cr, 3 cl hrs
Prerequisites: MATH 335 or equivalent, METE 327 or equivalent, MATE 235 or equivalent, consent of instructor
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: METE 434 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 541 or 543 or equivalent or consent of instructor
Application 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 546, Interfacial Phenomena, 3 cr, 3 cl hrs
Prerequisite: MATE 530 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.

MATE 547, Dynamic Deformation of Solids, 3 cr, 3 cl hrs
Prerequisite: Graduate standing

MATE 548, Advanced Composite Materials, 3 cr, 3 cl hrs
Prerequisite: MATE 541 or MATE 543 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, Advanced Dislocation Theory, 3 cr, 3 cl hrs
Prerequisite: MATE 351 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 graduate-level work is required.

MATE 550, 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. Shares lecture with MATE 460, but is graded separately, and additional graduate-level work is required.

MATE 551, 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 552, Materials Engineering Graduate Seminar, 2 cr, 2 cl hrs
Prerequisite: Graduate standing or consent of instructor
Seminar presentations by students, faculty and outside speakers. Discussion of topics of technical interest, and of global, societal, and ethical issues related to materials engineering.

MATE 553, Radiation Effects in Materials, 3 cr, 3 cl hrs
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 554, Scattering Techniques, 3 cr, 3 cl hrs
Prerequisite: MATE 351 or consent of instructor

MATE 556, Interfacial Phenomena, 3 cr, 3 cl hrs
Prerequisite: MATE 530 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.
Metallurgical Engineering Courses:

**METE 326, Introduction to Process Metallurgy, 3 cr, 3 cl hrs**
Prerequisite: ES 111; 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, Physical Metallurgy, 4 cr, 3 cl hrs, 3 lab hrs**
Prerequisite: MATE 202

**METE 382, Introduction to Engineering Design, 2 cr, 1 cl hr, 3 lab hrs**
Prerequisites: ES 110, 301; MATE 235
Corequisite: ES 302
A study of materials-oriented design methodology with emphasis on materials selection, interaction of materials, processing and design, cost evaluations, problem solving, decision making, ethics and non-technical considerations in design, and engineering statistics. Development of project-oriented skills through team design projects. (Same as MATE 382)

**METE 434, Introduction to Dislocation Theory, 3 cr, 3 cl hrs**
Prerequisite: METE 327 or consent of instructor

**METE 481, Engineering Design I, 3 cr, 2 cl hrs, 3 lab hrs**
Prerequisite: METE 382
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, application of engineering statistics. (Same as MATE 481)

**METE 482, Engineering Design II, 3 cr, 2 cl hrs, 3 lab hrs**
Prerequisite: METE 481
Continuation of the design projects initiated in METE 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, preparation and presentation of final project report. (Same as MATE 482)

**METE 491, Directed Study/Senior Thesis, 3 cr**
Prerequisite: Senior standing or consent of instructor

Staff Research Interests

G. Bond—Electron Microscopy, Hydrogen Effects, Metal Hydrides, Radiation Damage, Biomimetic Materials and Processing, Carbon Dioxide Sequestration, Controlled Crystallization

Burleigh—Corrosion Mechanisms, Alloy Design, Coatings for Corrosion Prevention

Doughty—Chemical Routes to Ceramic Materials, Chemical Sensors, Catalysis, Mechanisms of Chemical Reactions

Fuierer—Electronic Ceramics, Chemical Routes to Ceramic Materials and Thin Films, Atomic Force Microscopy

Hirschfeld—Properties and Processing of Structural Ceramics, Glass Ceramics, and Advanced Composites; Porous Ceramics; Ceramic Coatings for Corrosion Resistance, Thermal Spray


Lu—Thin-Film Processing and Microstructure; Interfaces: Structure and Properties

Majumdar—Mechanics of Materials and Interfaces, Composites, Fracture

McCoy—Statistical Theory and Simulation of Polymers and Other Systems of Materials Interest

Purcell—Mineral Dressing, Flotation, Coal Cleaning

Ravi—Processing of Composites, Coatings

Romig—Electron Optics, Phase Transformations, Solid-State Diffusion

M. Smith—Plasma Spraying
Mechanical Engineering

Professors Colbaugh, Cerity, Inal (Chair of the Department), Lyons
Associate Professors Bakhtiyarov, Duffey, Ostergren, Walling
Assistant Professor Ghosh
Adjunct Faculty: Abernathy, Anderson, Baty, Cooper, Marcy, Meason, Melof, Willan
Emeritus Faculty: Miller, Oravec

Degrees Offered: B.S. in Mechanical Engineering; B.S. in Engineering Mechanics; M.S. in Engineering Mechanics

The Department of Mechanical Engineering at New Mexico Tech administers the following programs:

- Bachelor of Science in Mechanical Engineering
- Bachelor of Science in Engineering Mechanics
- Master of Science in Engineering Mechanics
- Specialization in Explosives Engineering
- Specialization in Advanced Mechanics
- Specialization in Mechatronics Systems Engineering

Program Educational Objectives

The specific student learning objectives of the Mechanical Engineering Department are listed as follows:

1. Students will learn engineering sciences and demonstrate the application of this knowledge to mechanical engineering problems through course sequences focused on specific, relevant mechanical engineering topics.
2. The program will prepare students for successful engineering careers.
3. The program will provide students with practical design experience through partnerships with industry.
4. Specialized programs will provide opportunities for qualified students to develop teaching and research skills.
5. The program will challenge students and faculty to improve the learning process.
6. The program will continue to raise the expectations of all constituencies, to attract a wide variety of excellent students, and to be a nationally recognized engineering program.

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 mechanics, solid mechanics, vibrations and mechatronics. Junior and senior mechanical engineering students work on year-long design projects that range from the SAE Mini Baja® competition vehicles to biomedical instruments.

Minimum credit hours required—134

In addition to the General Degree Requirements (page 53), the following courses are required:

- MENG 300 (2), 304 (3), 305 (3), 381 (1), 382 (1), 405 (2), 405L (1), 421 (3), 431 (3), 441 (3), 451 (3), 481 (2), 482 (2), 483 (2) & 483L (1)
- MATE 202 & 202L (4)
- MATH 231 (4), 332 (3), 335 (3)
- Technical Electives: Six hours from upper-division courses outside the department chosen by the student with the faculty advisor’s approval. The courses must provide an understanding of the process of mathematical modeling coupled with computer usage.

Students may pursue either a B.S. in Mechanical Engineering or a B.S. in Engineering Mechanics. Students may not receive both degrees. Prior to graduation, students must declare to the Registrar on the Intent to Graduate form which degree title will be imprinted on their diploma and transcript.

Courses used for the degree, including the general degree requirements (page 53), may not be taken on an S/U basis. Credit for MATH 103, college algebra, and MATH 104, trigonometry, is not allowed for mechanical engineering students.

All engineering majors must take the Fundamentals in Engineering (FE) exam as a requirement for graduation. Passing this exam is a major step in the process of attaining professional registration. It is strongly recommended that the exam be taken in semester 7, before the graduation semester (semester 8).

It is strongly recommended that all Mechanical Engineering students follow the sample curriculum and, in particular, complete ES 216 (fluid mechanics) prior to enrolling in ES 347 (thermodynamics).

Sample Curriculum for the Bachelor of Science in Mechanical Engineering

| Semester 1 | 3 ENGL 111 (college English) |
| Semester 1 | 4 MATH 131 (calculus) |
| Semester 1 | 4 CHEM 121 & 121L (general) |
| Semester 1 | 2 ES 110 (intro.) |
| Semester 1 | 3 Social Science |
| Semester 1 | 16 Total credit hours |

| Semester 2 | 4 ENGL 112 (college English) |
| Semester 2 | 4 MATH 132 (calculus) |
| Semester 2 | 5 PHYS 121 & 121L (general) |
| Semester 2 | 3 ES 111 (computer engr.) |
| Semester 2 | 15 Total credit hours |
New Mexico Tech engineering students take many of the engineering science and design courses offered by this department. The topics include mechanics, thermodynamics, unit operations, economics, engineering drawing, fluid mechanics, basic computer skills, and basic electrical engineering. The courses are taught by faculty members drawn from all Tech engineering departments and the business administration department.

Minimum credit hours required—134

In addition to the General Degree Requirements (page 53), the following courses are required:

- MENG 300 (2), 304 (3), 305 (3), 381 (1), 382 (1), 405 (2), 405L (1), 421 (3), 431 (3), 441 (3), 451 (3), 461 (2), 482 (2), 483 (2) & 483L (1)
- MATE 202 & 202L (4)
- MATH 231 (4), 332 (3), 335 (3)
- Technical Electives: Six hours from upper-division courses outside the department chosen by the student with the faculty advisor’s approval. The courses must provide an understanding of the process of mathematical modeling coupled with computer usage.

Students may pursue either a B.S. in Mechanical Engineering or a B.S. in Engineering Mechanics. Students may not receive both degrees. Prior to graduation, students must declare to the Registrar on the Intent to Graduate form which degree title will be imprinted on their diploma and transcript.

Courses used for the degree, including the general degree requirements (page 53), may not be taken on an S/U basis. Credit for MATH 103, college algebra, and MATH 104, trigonometry, is not allowed for engineering mechanics students.

All engineering majors must take the Fundamentals in Engineering (FE) exam as a requirement for graduation. Passing this exam is a major step in the process of attaining professional registration. It is strongly recommended that the exam be taken in semester 7, before the graduation semester (semester 8).

It is strongly recommended that all Engineering Mechanics students follow the sample curriculum and, in particular, complete ES 216 (fluid mechanics) prior to enrolling in ES 347 (thermodynamics).

**Sample Curriculum for the Bachelor of Science in Engineering Mechanics**

**Semester 1**

<table>
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<td>ENGL 111 (college English)</td>
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<td>MATH 131 (calculus)</td>
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<td>2</td>
<td>ES 110 (intro.)</td>
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<td>3</td>
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**Semester 2**

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<td>ENGL 112 (college English)</td>
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<td>MATH 132 (calculus)</td>
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<tr>
<td>3</td>
<td>ES 111 (computer engr.)</td>
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**Semester 3**

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<td>ENGL 341 (technical writing)</td>
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<td>4</td>
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<td>3</td>
<td>ES 201 (Statics)</td>
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<td><strong>Total credit hours</strong></td>
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</table>

**Bachelor of Science in Engineering Mechanics**

The Bachelor of Science in Engineering Mechanics prepares students for a successful career in many engineering fields such as aerospace, petroleum, mining, environmental, manufacturing, and electrical. Students study specific topics such as solid mechanics, materials engineering, dynamics, thermodynamics, electrical engineering, and fluid mechanics along with more general courses in engineering science, engineering design, and engineering economics to obtain a broad engineering education. These courses include the humanities and social sciences and of course, a study of chemistry, physics, and mathematics. With this broad education, the Engineering Mechanics graduate is prepared to enter industry and attack the engineering problems faced by society. An alternative approach is to enter graduate school for further study in engineering, business, or law.
Semester 4
3 MATH 335 (applied analysis)
5 PHYS 122 & 122L (general)
4 MATE 202 & 202L (intro to materials)
3 ES 216 (fluid mechanics)
3 ES 302 (strength of materials)
18 Total credit hours

Semester 5
3 MATH 332 (vector analysis)
3 ES 303 (dynamics)
3 ES 316 (engineering economics)
3 ES 347 (thermodynamics)
1 MENG 381 (junior design)
3 Social Science
16 Total credit hours

Semester 6
2 MENG 300 (mechanics lab)
3 MENG 304 (advanced strength of materials)
3 MENG 305 (engineering analysis)
1 MENG 382 (junior design)
3 ES 332 (electrical circuits)
3 ES 350 (heat & mass transfer)
3 Humanities
18 Total credit hours

Semester 7 (Take FE exam)
2 MENG 405 (system dynamics & controls)
3 MENG 451 (machine design)
2 MENG 481 (senior design)
3 MENG 483 & 483L (mechatronics)
3 Technical Elective
3 Social Science
17 Total credit hours

Semester 8
3 MENG 421 (finite element analysis & design)
3 MENG 431 (fluid/thermal systems)
3 MENG 441 (dynamics & vibration)
2 MENG 482 (senior design)
3 Technical Elective
3 Humanities/Social Science
17 Total credit hours

Specialization in Explosives Engineering

The Master of Science in Engineering Mechanics with Specialization in Explosives Engineering is available to students with an engineering degree in any field. However, students must demonstrate a competence in mathematics and the basic undergraduate mechanics offered in a typical engineering mechanics or mechanical engineering curriculum, such as differential equations, mechanics of materials, and engineering dynamics. The degree may be earned with or without a thesis.

Thesis Option

The student, with the approval of the student’s advisory committee, must complete nine (9) hours of 500-level engineering mechanics courses and nine (9) hours of 500-level explosives engineering courses to earn this specialization. In addition, the student must take an additional six (6) hours of senior- or graduate-level courses outside of the department that are approved by the student’s advisory committee. The student must also take a minimum of six credit hours in EM 591, Thesis. The student must also prepare and submit a thesis to his/her advisory committee for approval in accordance with the general requirements of the graduate school. The minimum credit hour requirement for the Specialization in Explosives Engineering with thesis is 30 credit hours.

Independent Study Option

The student, with the approval of the student’s advisory committee, must complete nine (9) hours of 500-level engineering mechanics courses and twelve (12) hours of 500-level explosives engineering courses to earn this specialization. In addition, the student must take an additional six (6) hours of senior- or graduate-level courses outside of the department that are approved by the student’s advisory committee. The student is also required to submit a research report to his/her advisory committee on a topic pertinent to the field of explosives engineering. The student must take three credit hours of EM 590, Independent Study. The minimum credit hour requirement for the Specialization in Explosives Engineering with independent study option is 30 credit hours.

Specialization in Advanced Mechanics

The Master of Science in Engineering Mechanics with Specialization in Advanced Mechanics is available to students with an engineering degree in any field. However, students must demonstrate a competence in mathematics and the basic undergraduate mechanics offered in a typical engineering mechanics or mechanical engineering curriculum, such as differential equations, mechanics of materials, and engineering dynamics. The Master of Science in Engineering Mechanics with Specialization in Advanced Mechanics may only be earned with a thesis in accordance with the general requirements of the graduate school.

The student, with the approval of the student’s advisory committee, is required to take a minimum of 18 credit hours of 500-level courses of which nine (9) credit hours must be the core advanced mechanics courses: EM 521 (3), Elastic Stability; EM 531 (3), Mechanics of Viscous Fluids; EM 541 (3), Vibrations of an Elastic Continuum.

In addition, the student must take an additional six (6) credit hours of senior- or graduate-level courses outside of the department that are approved by the student’s advisory committee. The student must take a minimum of six credit hours of EM 591, Thesis. The student must also prepare and submit an acceptable thesis to his/her advisory committee for approval in accordance with the general requirements of the Graduate School. The minimum credit hour requirement for the Specialization in Advanced Mechanics is 30 credit hours.
Specialization in Mechatronic Systems Engineering

The Master of Science in Engineering Mechanics with Specialization in Mechatronics Systems Engineering may be earned with or without thesis. The student must have a B.S. degree in an engineering or science discipline as a prerequisite for this program. The synergy of this program suggests the accommodation of a wide variety of students (from computer science, mechanical engineering, electrical engineering, etc.) to this specialization; hence, the study program may be designed to accommodate each student’s academic background.

Requirements
A minimum of 30 credit hours is required for the Master of Science in Engineering Mechanics with Specialization in Mechatronics Systems Engineering.

- Core Classes—at least 12 credit hours from the following: EM 548/EE 548, Manipulator Based Robotics; EM 554/EE 554, Embedded Control Systems; EM 567/CS 567, Smart Engineering Systems I; EM 568/CS 568, Smart Engineering Systems II; EM 570, Advanced Mechatronics; EM 572, Sensor Technology; EM 574, Electrical Measurements of Non-Electrical Quantities; EM 576, Biomedical Mechatronics
- Graduate Seminar—2 credit hours, EM 585/CS 585, Research Methods in Mechatronics Systems Engineering
- Elective Courses—Suitable courses for a graduate program in Mechatronics Systems Engineering, which may include, but are not limited to, advanced engineering or advanced computer science courses.
- Thesis (6 credit hours) or 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.

Engineering Science Courses:
The major content of these courses is directed toward the fundamental core subjects of engineering.

ES 101, 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: EM 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 111 or CS 111; 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 111 or CS 111; 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. Computational techniques using MATLAB. (Same as MENG 305)

ES 316, Engineering Economics, 3 cr, 3 cl hrs
Prerequisite: ES 111
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; ES 111
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 347
Corequisite: MATH 335

ES 405L, Instrumentation, Measurement, and Process Control Laboratory, 1 cr, 3 lab hrs
Prerequisite: ES 111; MATH 335
Laboratory exercises involving instrumentation and design of basic control systems. (Same as MENG 405L)

ES 489, Special Topics in Engineering Science, 3 cr, 3 cl hrs
ES 491, Directed Study, cr to be arranged

Mechanical Engineering Courses:
The major content of these courses is directed toward the core subjects of engineering.

MENG 300, Mechanics Laboratory, 2 cr, 6 lab hrs
Prerequisites: ES 216, 302; ENG 341
Experiments in solid and fluid mechanics, testing methods, and measurement techniques. Tension, compression, buckling, and bending of various common structural materials. Basic fluid properties, buoyancy, major and minor friction losses in pressure conduits, positive displacement and centrifugal pumps.
MENG 304, Advanced Strength of Materials, 3 cr, 3 cl hrs  
Prerequisite: 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, Engineering Analysis, 3 cr, 3 cl hrs  
Prerequisite: 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. Computational techniques using MATLAB. (Same as ES 305)

MENG 405, Dynamic Systems and Controls, 2 cr, 2 cl hrs  
Prerequisites: ES 332, MENG 305, MATH 335 or consent of the instructor  
Corequisite: MENG 405L, or ES 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, Instrumentation, Measurement, and Process Control Laboratory, 1 cr, 3 lab hrs  
Prerequisite: ES 111, MATH 335  
Laboratory exercises involving instrumentation and design of basic control systems. (Same as ES 405L)

MENG 421, Finite Element Analysis and Design, 3 cr, 2 cl hrs, 3 lab hrs  
Prerequisites: MENG 304 passed with grade C or better; MENG 305 or ES 305  
Introduction to finite element analysis for structural, heat transfer, and fluid-flow systems. Use of computer-aided design (CAD) to address engineering design problems. Laboratory devoted to CAD operations and its use in complex design problems.

MENG 483, Mechatronics, 2 cr hr, 2 cl hr  
Prerequisite: ES 111; MATH 335; MENG 305  
Corequisite: MENG 405, 451; EE 341 for EE majors or consent of instructor  
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 489, Special Topics in Mechanical Engineering, 3 cr, 3 cl hrs

MENG 491, Directed Study, cr to be arranged

Mechanical Engineering Design Courses:

The major content of these courses is directed toward the practice of engineering design and the ethical, economic, and societal issues that are part of the profession of engineering.

MENG 381, Junior Engineering Design Clinic I, 1 cr, 3 lab hrs  
Prerequisites: ES 216, 302; MATH 335; PHYS 122 & 122L; ENGL 341; junior standing  
Corequisite: MATH 332  
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, 1 cr, 3 lab hrs  
Prerequisite: MENG 381  
A continuation of MENG 381 academic-year-long engineering design project.

MENG 431, Fluid and Thermal Systems Design I, 3 cr, 3 cl hrs  
Prerequisites: MENG 305; ES 350; MATH 335  
Advanced dimensional analysis. Design and synthesis of systems based on application of incompressible fluid flow, heat transfer, design optimization theories, and economics. Design problems to include complex pressure conduit and pipe networks, heat exchangers, dynamic and positive displacement pumps, and hydraulic motors.

MENG 441, Dynamics and Vibrations in Structural Design, 3 cr, 3 cl hrs  
Prerequisites: MENG 305; ES 303; MATH 332; 335  
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, Design of Machine Elements, 3 cr, 3 cl hrs  
Prerequisites: ES 303, MENG 304, 305, 381, 382; 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 481, Senior Engineering Design Clinic I, 2 cr, 6 lab hrs  
Prerequisite: MENG 382  
Corequisite: MENG 451  
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, 2 cr, 6 lab hrs  
Prerequisite: MENG 481  
A continuation of MENG 481 academic-year-long engineering design project.
Engineering Mechanics Courses:

The major content of these courses is directed toward a Master of Science degree in Engineering Mechanics.

Distance education students are required to have the consent of the instructor before enrolling in any EM course.

EM 504, Advanced Mechanics of Materials, 3 cr, 3 cl hrs
Prerequisite: MENG 304 or equivalent 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.

EM 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 ME 515)

EM 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)

EM 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 ME 520)

EM 521, Elastic Stability, 3 cr, 3 cl hrs
Prerequisite: MENG 304 or consent of the instructor

EM 531, Mechanics of Viscous Fluids, 3cr, 3 cl hrs
Prerequisite: MENG 431 or consent of the instructor

EM 541, 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.

EM 545, Introduction to Explosive Engineering, 3 cr, 3 cl hrs
Prerequisites: CHEM 122 and 122L; PHYS 122 and 122L; ES 111 or CS 111; 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.

EM 546, Detonation Theory, 3 cr, 3 cl hrs
Prerequisites: EM 545; MATH 335; 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. The concept of deflagration to detonation transition. (Same as ME 546)

EM 548, Manipulator Based Robotics, 4 cr, 3 cl hrs, 3 lab hrs
Prerequisite: MENG 405 or equivalent 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)

EM 549, Wave Propagation, 3 cr, 3 cl hrs
Prerequisites: MATH 335 or consent of instructor
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. (Same as ME 549)

EM 550, Advanced Explosives Engineering, 3 cr, 3cl hrs
Prerequisites: EM 545; MATH 335; or consent of instructor
The detonation of non-ideal explosives, equation of state for porous media, charged particle 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)

EM 553, Computer Modeling of Detonations, 3 cr, 3 cl hrs
Prerequisites: EM 545 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 hydrodynamics methods, equation of state and strength models, and numerical fracture and fragmentation. (Same as ME 553)

EM 554, Embedded Control Systems, 4 cr, 3 cl hrs, 3 lab hrs
Prerequisites: EE 308 or EE 443 or MENG 405 or equivalent consent of instructor
Micro-controller or microcomputer based embedded control systems. A comparative survey of currently available embedded computers/controllers including SVC’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)

EM 567, Smart Engineering Systems, 3 cr, 3 cl hrs
Prerequisites: MATH 254, 382; CS 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. (Same as CS 567)

EM 568, Smart Engineering Systems II, 3 cr, 3 cl hrs
Prerequisites: MATH 254, 382; CS 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. (Same as CS 568)
Staff Teaching & Research Interests

Abernathy—Numerical Hydrodynamics
Anderson—Structural Mechanics including Blast and Seismic Effect, Energy Systems; Nuclear Reactors, Heat Pipes and Fuel Cells
Baty—Computer Modeling and Simulation
Marcy—General Aviation, Conceptual Design
Gerity—Robotics, System Integration, Technology Turnkey and Licensing

Ghosh—Macro Behavior of Composites, Biomechanics, Finite Element Analysis, Experimental Mechanics and Instrumentation, Structural Health Monitoring and Restoration, Construction Materials and Project Management


Lyons—Drilling Mechanics, Structural Mechanics, Structural Vibrations

Meason—Electromagnetic Directed Energy, Nuclear Engineering, EW/EO/EM Effects, Environmental Monitoring of Natural and Man-made Radionuclides

Melof—Energetic Materials, Synthesis of Explosives, Explosives Chemistry

Miller—Finite Element Analysis, Explosive Synthesis of Materials, High-temperature Systems

Oravecz—Rock Mechanics, Instrumentation, High Precision Displacement Measurements


Walling—Air Blast Loading of Structures, Seismic Response of Structures, High Velocity Impact of Hardened Structures, Mitigation of Effects of Explosive Detonations


EM 570, 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.

EM 572, 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.

EM 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.

EM 576, 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.

EM 581, Directed Study, cr to be arranged

EM 585, Graduate Seminar—Mechatronics, 2 cr

EM 586, Advanced Topics in Engineering Science, 2 - 3 cr each semester

EM 590, Independent Study, cr to be arranged

EM 591, Thesis (master’s degree), cr to be arranged
Mineral Engineering

Professor Aimone-Martín, Chávez
Associate Professors Fakhimi, N. Mojtabai (Chair of the Department)
Adjunct Faculty: Barker, Gundiler, Kozushko, Kuhn, McLemore, C. Mojtahid, Walder
Emeritus Professors Oravecz, Wolski

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

• To provide the students 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.
• To maintain a team of faculty who are committed to providing high quality of teaching and research.
• To prepare the students for the challenges of establishing a successful diversified career in the rapidly changing professional environment.

Program Educational Objectives

1) To inspire, as a primary goal, creativity in thinking and skills in problem solving to assist industry in meeting daily challenges
2) To develop a responsible professional with a sense of social awareness
3) To promote excellence in independent and open-ended engineering problem solving, oral and written presentation skills
4) To provide proficiency in basic science and engineering skills
5) To provide real-world experiences through summer jobs and field trips to operations in New Mexico as well as other states and countries for immediate entry into industry
6) Program graduates will achieve a measurable advancement in professional duties and salaries and be capable of demonstrating continued professional growth within the first seven years after graduating

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—132

In addition to the General Degree Requirements (page 53), the following courses are required:

• MATH 231 (4), 335 (3)
• ES 110 (2), 111 (3), 201 (3), 216 (3), 302 (3), 332 (3)
• ES 303 or 347 (3)
• GEOL 101 & 101L (4), 211 (4), 353 (3)
• ME 101 (1), 220 (3), 320 (2), 340 (3), 360 (3), 380 (6), 410 (3), 419 (2), 420 (4), 435 (2), 440 (2), 442 (4), 462 (3), 470 (1), 471 (2)

All 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 Mineral Engineering

Semester 1
1 ME 101 (intro)
4 GEOL 101 & 101L (principles)
4 MATH 131 (calculus)
3 ENG 112 (college English)
2 ES 110 (intro)
18 Total credit hours

Semester 2
3 ES 111 (intro)
4 MATH 132 (calculus)
4 CHEM 122 & 122L (general)
3 ENG 112 (college English)
3 Social Science
17 Total credit hours

Semester 3
5 PHYS 121 & 121L or 131 & 131L (general)
4 MATH 231 (calculus)
4 GEOL 211 (mineralogy)
3 Humanities
16 Total credit hours

Semester 4
3 ME 220 (surveying and map preparation)
2 ME 320 (economic analysis)
5 PHYS 122 & 122L or 132 & 132L (general)
3 MATH 335 (applied analysis)
3 ES 201 (statics)
16 Total credit hours
Semester 5
3 ME 340 (geostatistics and mineral evaluation)
3 ME 360 (exploration and field mapping)
3 ES 302 (strength of materials)
3 ES 216 (fluids)
3 ENGL 341 (technical writing)
3 Social Science
18 Total credit hours

Semester 6
6 ME 380 (mine systems)
4 ME 420 (soil and rock mechanics)
3 ME 462 (mineral deposits)
3 GEOL 333 (structural)
16 Total credit hours

Semester 7
3 ME 410 (environmental issues)
2 ME 440 (mine ventilation)
4 ME 442 (applied geomechanics)
1 ME 470 (senior design I)
3 ES 347 (thermodynamics) or ES 303 (dynamics)
3 Humanities/Social Science
16 Total credit hours

Semester 8
2 ME 419 (mineral and natural resource law)
2 ME 435 (mineral processing)
2 ME 471 (senior design II)
3 ES 332 (electrical engineering)
3 Humanities
3 Social Science
15 Total credit hours

Bachelor of Science in Mineral Engineering with Emphasis in Explosives Engineering

Minimum credit hours required—140
In addition to the General Degree Requirements (page 53), the following courses are required:
- MATH 231 (4), 335 (3)
- ES 110 (2), 111 (3), 216 (3), 301 (3), 302 (3), 303 (3), 332 (3)
- GEOL 101 & 101L (4), 211 (4), 353 (3)
- CHE 475 (3) or ED 441 (3) or ME 545 (3)

Students are strongly encouraged to do their senior design projects in the area of Explosives Engineering or related projects.

Minor in Mineral Engineering

Minimum credit hours required—19
Chosen from the following courses:
- ME 220 (2), ME 320 (2) or ES 316 (3), ME 340 (3), ME 360 (3), ME 380 (6), ME 410 (3), 419 (2), ME 420 (4), ME 434 (3), ME 435 (2), ME 440 (2), ME 442 (4), ME 462 (3)

Students may substitute other courses with the approval of the department. Students are also responsible for prerequisites.

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 ES 201, ES 302, and ME 420. Any other deficiencies may have to be covered as required by 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.

- **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.

- **Geotechnical Engineering**—At least 12 credits selected from ME 512, ME 515 or EM 515, ME 517 or EM 517, ME 520, ME 525, ME 531, ME 532, ME 533, ME 537, ME 540, ME 561. Other courses can be substituted with the approval of the research advisor and committee.

- **Explosives Engineering**—At least 12 credits selected from ME 512, ME 515 or EM 515, ME 517 or EM 517, ME 520, ME 534, ME 545, ME 548, ME 549 or EM 549, ME 550, ME 552, ME 553 or EM 553, ME 556, ME 570, CHEM 540. Other courses can be substituted with the approval of the research advisor and committee.

**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 131, ES 111
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 315, Mining Lab, 2 cr, 1 cl hr, 2 lab hrs**
Prerequisite: Consent of instructor
Offered on demand
An introduction and hands-on experience in underground mine work: health and safety, support placement, mucking, dewatering, mapping and surveying. All classes are held at the department’s experimental mine (Waldo mine).

**ME 320, Economic Analysis, 2 cr, 2 cl hrs**
Prerequisite: ES 111
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: ES 111; ME 320
Introduction to statistics. Obtaining, evaluating, and presenting mineral resource information. Ore reserves estimation using geometric weighting techniques and geostatistical methods. The use of computers is emphasized.
ME 360, Exploration and Field Mapping, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisites: GEOL 211; 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 409, Design of Structures, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: ES 302
Offered on demand
Reinforced concrete; concrete design, beams, slabs, retaining walls, columns, and footings. Grouting and shotcreting. Structural steel design: tension members, beams, columns, bolted and welded connections, frames, and trusses. Rock bolting. Rigging. PC applications. Student presentations on selected topics. A design project is required.

ME 410, Environmental Issues, 3 cr, 3 cl hrs
Prerequisites: ME 380; ES 216
Corequisite: ME 442

ME 419, Legal Aspects of Mineral Engineering, 2 cr, 2 cl hr
Prerequisite: Senior standing or consent of instructor
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 and Rock Mechanics, 4 cr, 3 cl hrs, 3 lab hrs
Prerequisite: ES 302

ME 421, Applied Economic Geology, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: GEOL 353
Offered on demand
Lithologic and lithochemical characterization of metallferous 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 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 soil 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
Prerequisites: 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, Mineral Processing, 2 cr, 1 cl hr, 2 lab hrs
Prerequisite: ME 380; ES 216 and 347
Theory and practice of concentration of ores and industrial minerals. Crushing, grinding, sizing, gravity separation, flotation, leaching, solid-liquid separations.

ME 440, Mine Ventilation, 2 cr, 2 cl hrs
Prerequisite: ME 380
Control of underground environmental problems; dusts, gases, temperature, and humidity. Analysis of natural and mechanical ventilation systems and equipment. Measurement techniques

ME 442, Applied Geomechanics, 4 cr, 3 cl hrs, 3 lab hrs
Prerequisite: ME 420
Analysis and design of structures and excavations in geological media on surface and underground. Support and reinforcement design. Geological hazards and remedial measures. Design projects.

ME 462, Mineral Deposite, 3 cr, 2 cl hrs, 2 lab hrs
Prerequisites: GEOL 211
Ore formation processes and ore mineralogy; geologic and geochemical characterization of ore deposits using hand specimen, petrographic, and field mapping techniques. Visits to prospects and operating mines to observe variations in ore deposit characteristics to document geologic and geochemical parameters used to describe ore-forming systems. (Same as GEOL 462)

ME 470, Senior Design I, 1 cr, 1 cl hr
Prerequisite: Senior standing and consent of instructor
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 report project 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 505, Graduate Seminar, 1 cr

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 512, Advanced Rock Mechanics, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite: ME 420 or consent of instructor
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 EM 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, Lagrange and Hermite interpolation functions, isoparametric elements, numerical integration, two-dimensional problems, solution of Poisson and Laplace equations, triangular and quadrilateral elements, elasticity problems, theory of minimum potential energy, stiffness matrix, examples. (Same as EM 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 for determination of stress intensity factor, fracture toughness, J-integral. Elasto-plastic fracture. (Same as EM 520)

ME 521, Advanced Minerals Exploration, 3 cr, 3 cl hrs
Prerequisites:ME 360 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
Prerequisites:ME 360 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:GEOL 211 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 Mises and Mohr-Coulomb failure criteria, flow rule, hardening, softening and perfect plasticity, method of characteristics in solving plasticity problems, kinematics and velocity discontinuity, plastic limit analysis, upper- and lower-bound theorems, examples in soil and rock mechanics.

ME 531, Advanced Foundation Design and Analysis, 3 cr, 3 cl hrs
Prerequisite:ME 420 or consent of instructor

ME 532, Advanced Soil Mechanics, 3 cr, 2 cl hrs, 3 lab hrs
Prerequisite:ME 420 or consent of instructor
Advanced laboratory testing of soils and their behavior with special attention to problem soils. Lab testing will include but not be limited to direct shear, compaction, swell consolidation, and seepage analysis. Special projects may be selected.

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:ME 420 or consent of instructor

ME 537, Design and Construction of Underground Openings, 3 cr, 3 cl hrs
Prerequisite:ME 420 or consent of instructor

ME 540, Numerical Methods in Geotechnical Engineering, 3 cr, 3 cl hrs
Introduction to matrix, finite difference, and finite element methods with application to various problems in geomechanics, including the design of foundations, steady state seepage, slope stability, and underground excavations.

ME 545, Vibration Analysis and Control, 3 cr, 3 cl hrs
Prerequisite:ME 434 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
Prerequisites:ES 545 or consent of instructor. Distance education students are required to have the consent of the instructor.
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 EM 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
Prerequisites:MATH 335 or consent of instructor. Distance education students are required to have the consent of the 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. (Same as EM 549)

ME 550, Advanced Explosives Engineering, 3 cr, 3 cl hrs
Prerequisites:EM 545; MATH 335; or consent of instructor. Distance education students are required to have the consent of the 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 EM 550)
ME 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 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
Prerequisites: EM 545 or consent of instructor. Distance education students are required to have the consent of the 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 EM 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: GEOL 211; GEOL 318 or 319 or equivalent; ME 360 or GEOL 480
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 565, Mine Waste Characterization, 3 cr, 3 cl hrs
Prerequisite: Consent of instructor

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

Staff Research Interests

Aimone-Martin—Drilling and Blasting, Geotechnical Engineering, Mineral Evaluation, Geostatistics
Barker—Industrial Minerals
Chávez—Applied Mineral Exploration, Ore Deposits, Natural Resource Utilization
Fakhimi—Geomechanics, Numerical Modeling
Gundiler—Hydrometallurgy and Mineral Processing
Kozushko—Mine Design, Support and Reinforcement Design, Underground Safety
C. Mojtabai—Natural Resources Law
N. Mojtabai—Site Investigation, Rock Fragmentation, Mine Design, Geomechanics
Oravecz—Rock Mechanics
Waldier—Geochemistry, Mine Reclamation, Mine Waste Characterization
Wolski—Mine Design, Ventilation
Petroleum Engineering

The Department of Petroleum and Chemical Engineering administers the disciplines of both Petroleum Engineering and Chemical Engineering. The members of the faculty are involved in both programs at the undergraduate and graduate levels.

Distinguished Professor Anderson
Langdon Taylor Endowed Chair, Professor Teufel
Professors Lee, Lyons
Associate Professors Bretz, Chen, Engler (Chair of the Department), Weinkauf
Research Associate Williams
Adjunct Faculty: Arguello, Bickel, Buckley, Grigg, Huang, Kelly, Martin, Lorenz, Parkinson, Plisga, Seright, Szychansk, Taber, Traeger, Warpinski

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:

1. To educate an individual to be a petroleum engineer who is competent in drilling and completions, production, and reservoir evaluation.
2. To develop the graduate's ability to analyze open-ended problems and design solutions for petroleum engineering and related disciplines, understand the associated uncertainties, and to evaluate the societal impact.
3. To prepare a graduate to meet the challenges of the future petroleum engineering profession.
4. To promote effective oral and written technical communication skills.
5. To prepare graduates with engineering fundamentals to work effectively in industry.

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.

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. Those prospective students are encouraged to contact the Petroleum and Chemical Engineering Department for a detailed description of the preparatory course program requirements.

Undergraduate Program

Bachelor of Science in Petroleum and Natural Gas Engineering

Minimum credit hours required—134

In addition to the General Degree Requirements (page 53), the following courses are required:

• ES 110 (2), 111 (3), 201 (3), 216 (3), 302 (3), 303 (3), 316 (3), 332 (3), 347 (3)
• MATH 231 (4), 335 (3)
• GEOL 101 & 101L (4), 317 (3), 460 (3)
• 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 achieve a minimum GPA of 2.0 in required courses in order to graduate.

All engineering majors are required to take the Fundamentals in Engineering (FE) exam and receive a non-zero score as a requirement for graduation.

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  GEOL 101 & 101L (principles)
2  ES 110 (intro)

18 Total credit hours

Semester 2

4  MATH 132 (calculus)
3  ES 111 (intro)
5  PHYS 121 & 121L (general)
3  ENGL 112 (college English)
3  Social Science

18 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

3  PETR 245 (petroleum fluids)
3  MATH 335 (applied analysis)
3  ES 216 (fluid mechanics)
3  ES 302 (mechanics)
3  ES 347 (thermodynamics)
3  GEOL 317 (sedimentology)

18 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  Humanities

17 Total credit hours
Doctor of Philosophy in Petroleum Engineering

Students of exceptional ability as demonstrated in a master’s degree program may pursue a program leading to the doctoral degree. Students who obtain an M.S. degree without thesis will not be eligible for the doctorate program. The emphasis at the doctoral level is the development of a student’s abilities to apply analytical methods, critical thinking and creativity towards research. Course work is meant to complement and enhance this primary objective.

The course of study for students seeking a Ph.D. must be approved by the student’s advisory committee and the department chair. In addition to satisfying all requirements for the M.S. degree with thesis, the program will include a minimum of 30 credit hours of course work and 24 credit hours of dissertation research beyond the M.S. degree. In addition to the departmentally 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.

Dissertation subjects may be chosen from among the fields listed under staff research interests.

Petroleum Engineering Courses

PETR 101, Introduction to Petroleum Engineering, 1 cr, 1 cl hr
Introduction to reservoir, drilling and production aspects of petroleum engineering. Included will be guest lectures from industry, government and research and field trips to drilling/production sites.

PETR 245, Petroleum Fluids, 3 cr, 3 cl hrs
Prerequisites: CHEM 122; MATH 132; ES 111
Corequisite: ES 347
Characteristics and properties of reservoir fluids. Representation of fluid property data for computer uses with models and regression.

PETR 311L, Drilling Mud Laboratory, 1 cr, 3 lab hrs
Corequisite: PETR 311
The composition, measurement, and design of the properties of drilling fluids.

PETR 345L, Reservoir Engineering Laboratory, 1 cr, 3 lab hrs
Corequisite: PETR 345
Laboratory measurement of reservoir fluid/rock properties, PVT, and core analysis. Computer data analyses using statistical techniques including probability concepts, regression, and optimization.

PETR 370, Reservoir Evaluation, 4 cr, 3 cl hrs, 3 lab hrs
Prerequisites: PHYS 122; PETR 345; GEOL 317
Evaluation of reservoir properties from log, core and pressure transient data. Interpretation of openhole well logs and pressure drawdown and buildup tests. Lab exercises in analyzing log and welltest examples, preparation of subsurface maps. (Same as GEOP 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 analysis and optimization of rate of penetration, abnormal pressure detection, formation fracture resistance, well control, bottom hole assembly and drillstring design, and advanced drilling hydraulics.
PETR 413, Well Design, 2 cr, 2 cl hrs
Prerequisite: PETR 311 or consent of instructor
Well planning, casing string design, well completion methods, cementing design, tubing design, perforating, control of sand, water and gas.

PETR 413L, Well Design Lab, 1 cr, 3 lab hrs
Corequisite: PETR 413
The composition, testing, and design of cement slurries and fracturing fluids.

PETR 424, Production Engineering, 2 cr, 2 cl hrs
Prerequisite: PETR 345

PETR 424L, Production Engineering Laboratory, 1 cr, 3 lab hrs
Prerequisite: ES 111, 216
Corequisite: PETR 424
Basic fluid properties, experimental determination of major and minor friction losses for flow in pressure conduits. Comparison of experimental data with published engineering fluid flow data. Application of positive displacement and centrifugal pumps in experiments. ASME and API Lien Pipe industrial pie standards. (Same as the fluid mechanics portion of MENG 300)

PETR 425, Production Engineering Design, 3 cr, 3 cl hrs
Prerequisites: PETR 424, 424L
Design of a flowing well using nodal analysis. Optimal production tubing size selection. Basic characteristics of various artificial lift techniques. Selection of artificial lift techniques. The design of artificial lift systems including sucker rod pumps, submersible pumps, and gas lift.

PETR 442, Equilibrium Stagewise Processes, 3 cr, 3 cl hrs
Prerequisite: ES 347 or consent of instructor
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.

PETR 443, Underbalanced Drilling and Completions, 3 cr, 3 cl hrs
Prerequisite: PETR 311
Air and gas, aerated, and stable foam drilling and completions operations. Development of basic calculational theory and application to operational problems. Emphasis on the planning of successful drilling and completions operations. Selection of appropriate field equipment for drilling and completions operations. Solution of drilling and completions field problems.

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 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 464, Natural Gas Engineering, 3 cr, 3 cl hrs
Prerequisite: PETR 245
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 CHE 464)

PETR 465, Corrosion Engineering, 3 cr, 3 cl hrs
Prerequisite: PETR 424 or consent of instructor
Engineering study of problems in petroleum and natural gas industry, specifically those associated with drilling, production and enhanced recovery. Principles of cathodic protection and effects of electrolysis on metals.

PETR 471, Reservoir Description, 2 cr, 2 cl hrs
Prerequisites: PETR 378, 445; ES 316; GEOL 460
Corequisite: PETR 424
Offered fall semester
Applied characterization of a field project through integration of reservoir, production and geological data. Well performance and production optimization.

PETR 472, Reservoir Management, 2 cr, 2 cl hrs
Prerequisite: PETR 471
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.

PETR 478, Petroleum Seminar, variable credit, 2 cl hrs
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 HYD 403 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 535, Advanced Drilling Mechanics, 3 cr, 3 cl hrs
Prerequisite: PETR 311 or consent of instructor

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, insitu stress measurements, wellbore stability, sand control, and reservoir compaction/subsidence.

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 554, Advanced Natural Gas Engineering, 3 cr, 3 cl hrs
Prerequisite: PETR 454 or consent of instructor
Gas flow in vertical and inclined pipes, surface facilities, gas processing, overall transportation requirements.

PETR 555, 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 555, Advanced Directional Drilling, 3 cr, 3 cl hrs
Prerequisite: PETR 511 or consent of instructor

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 570 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

Staff Research Interests
Anderson—Petroleum Management
Arguello—Mechanical Engineering, Numerical Analysis
Bickel—Thermal and Fluid Sciences, Engineering Analysis
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, Simulation/Modeling
Grigg—Gas Flooding Processes, Phase Behavior
Kelly—Reservoir Evaluation and Management
Lee—Natural Gas Storage, Applied Numerical Methods, Phase Behavior, Membrane Technology
Lorenz—Petroleum Geology
Lyons—Drilling Mechanisms, Enhanced Recovery
Martin—Reservoir Management, EOR
Parker—Expert System Design, Fuzzy Logic Control
Pilska—Production Operations
Seright—Profile Control; Polymer, Water, and Chemical Flooding
Sydansk—Gels and Conformance Improvement
Taber—Oil Recovery Processes, Mechanisms
Teufel—Rock Mechanics, Naturally Fractured Reservoir Characterization, In-Situ Stresses, Reservoir Simulation including Stress Distribution, Subsidence, Mechanisms
Traeger—Material Science, Chemical Engineering
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