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# Colorado School of Mines Bulletin

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## Mission and Goals

Colorado School of Mines is a public research university devoted to engineering and applied science related to resources. It is one of the leading institutions in the nation and the world in these areas. It has the highest admission standards of any university in Colorado and among the highest of any public university in the U.S. CSM has dedicated itself to responsible stewardship of the earth and its resources. It is one of a very few institutions in the world having broad expertise in resource exploration, extraction, production and utilization which can be brought to bear on the world's pressing resource-related environmental problems. As such, it occupies a unique position among the world's institutions of higher education.

The school's role and mission has remained constant and is written in the Colorado statutes as: *The Colorado School of Mines shall be a specialized baccalaureate and graduate research institution with high admission standards. The Colorado School of Mines shall have a unique mission in energy, mineral, and materials science and engineering and associated engineering and science fields. The school shall be the primary institution of higher education offering energy, mineral and materials science and mineral engineering degrees at both the graduate and undergraduate levels. (Colorado revised Statutes, Section 23-41-105)*

Throughout the school's history, the translation of its mission into educational programs has been influenced by the needs of society. Those needs are now focused more clearly than ever before. We believe that the world faces a crisis in balancing resource availability with environmental protection and that CSM and its programs are central to the solution to that crisis. Therefore the school's mission is elaborated upon as follows:

*Colorado School of Mines is dedicated to educating students and professionals in the applied sciences, engineering, and associated fields related to*

- *the discovery and recovery of the Earth's resources*
- *their conversion to materials and energy*
- *their utilization in advanced processes and products*
- *the economic and social systems necessary to ensure their prudent and provident use in a sustainable global society*

*This mission will be achieved by the creation, integration, and exchange of knowledge in engineering, the natural sciences, the social sciences, the humanities, business and their union to create processes and products to enhance the quality of life of the world's inhabitants.*

*The Colorado School of Mines is consequently committed to serving the people of Colorado, the nation, and the global community by promoting stewardship of the Earth upon which all life and development depend. (Colorado School of Mines Board of Trustees, 2000)*

## Undergraduate

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To Mines Students:

This Bulletin is for your use as a source of continuing reference. Please save it.

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Address correspondence to: Colorado School of Mines, Golden, CO 80401

Main Telephone: 303-273-3000 Toll Free: 800-446-9488

Inquiries to Colorado School of Mines should be directed as follows:

*Admissions:* Bruce Goetz, Director of Admissions, [admit@mines.edu](mailto:admit@mines.edu)

*Student Life:* Dan Fox, Vice President for Student Life & Dean of Students

*Financial Aid:* Jill Robertson, Director of Financial Aid

*Registrar:* Lara Medley, Registrar, [registrar@mines.edu](mailto:registrar@mines.edu)

*Academic Affairs:* Terry Parker, Provost and Executive Vice President

# Academic Calendar

## Fall Semester 2012

Description	Date(s)	Day(s) of Week
Confirmation Deadline	Aug. 20	Monday
Faculty Conference	Aug. 20	Monday
Classes Start (1)	Aug. 21	Tuesday
Graduate Student Late Fee	Aug. 24	Friday
Labor Day - Classes in Session	Sep. 3	Monday
Census Day	Sep. 5	Wednesday
Fall Break (not always Columbus Day)	Oct. 15 & 16	Monday & Tuesday
Midterm Grades Due	Oct. 15	Monday
Last Withdrawal - Continuing Students (12 wks)	Nov. 13	Tuesday
Priority Registration for Fall Term	Nov. 12-16	Monday - Friday
Non-Class Day prior to Thanksgiving Break	Nov. 21	Wednesday
Thanksgiving & day after - No Class, Campus Closed	Nov. 22 & 23	Thursday & Friday
Last Withdrawal - New Freshmen & Transfers	Nov. 30	Friday
Classes End	Dec. 6	Thursday
Dead Week - No Exams	Dec. 3-7	Monday-Friday
Dead Day - no academic activities	Dec. 7	Friday
Final Exams	Dec. 8, 10-13	Saturday, Monday-Thursday
Semester Ends	Dec. 14	Friday
Commencement	Dec. 14	Friday
Final Grades Due	Dec. 17	Monday
Winter Break	Dec. 17 - Jan. 18	

## Spring Semester 2013

Description	Date(s)	Day(s) of Week
Confirmation Deadline	Jan. 8	Tuesday
Classes Start (1)	Jan. 9	Wednesday
Graduate Student Late Fee	Jan. 11	Friday
Census Day	Jan. 24	Thursday
Non-Class Day - Presidents' Day	Feb. 18	Monday
Midterm Grades Due	Mar. 4	Monday
Spring Break - 9th full week of Spring Term	Mar. 11-15	Monday-Friday
Last Withdrawal - Continuing & Grad (13 weeks)	April 9	Tuesday
E-Days	April 4-6	Thursday-Saturday
Priority Registration Summer/Fall	April 8-12	Monday-Friday
Engineering Exam	April 13	Saturday

Last Withdrawal - New Freshmen & Transfers	April 26	Friday
Classes End	May 2	Thursday
Dead Week - no exams	April 29 - May 3	Monday-Friday
Dead Day - no academic activities	May 3	Friday
Final Exams	May 4, 6-9	Saturday, Monday-Thursday
Semester Ends	May 10	Friday
Commencement	May 10	Friday
Final Grades Due	May 13	Monday

## Summer Sessions 2013

Description	Date(s)	Day(s) of Week
Summer I Starts (6-week session) (1)	May 13	Monday
Summer I Census	May 17	Friday
Memorial Day - No Classes, Campus Closed	May 27	Monday
Summer I Last Withdrawal - All Students	June 7	Friday
Summer I Ends	June 21	Friday
Summer I Grades Due	June 24	Monday
Summer II Starts (6-week session) (1)	June 24	Monday
Summer II Census	June 28	Friday
Independence Day - No Classes, Campus Closed	July 4	Thursday
Summer II Last Withdrawal - All Students	July 19	Friday
Summer II Ends (2)	Aug. 2	Friday
Summer II Grades Due	Aug. 5	Monday

- Petition for changes in tuition classification due in the Registrar's office for this term.
- PHGN courses end two weeks later on Friday, August 16th.

# Welcome

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## The Academic Environment

We strive to fulfill this educational mission through our undergraduate curriculum and in an environment of commitment and partnership among students and faculty. The commitment is directed at learning, academic success and professional growth, it is achieved through persistent intellectual study and discourse, and it is enabled by professional courtesy, responsibility and conduct. The partnership invokes expectations for both students and faculty. Students should expect access to high quality faculty and to appropriate academic guidance and counseling; they should expect access to a high quality curriculum and instructional programs; they should expect to graduate within four years if they follow the prescribed programs successfully; and they should expect to be respected as individuals in all facets of campus activity and should expect responsive and tactful interaction in their learning endeavors. Faculty should expect participation and dedication from students, including attendance, attentiveness, punctuality and demonstrable contribution of effort in the learning process; and they should expect respectful interaction in a spirit of free inquiry and orderly discipline. We believe that these commitments and expectations establish the academic culture upon which all learning is founded.

CSM offers the bachelor of science degree in Chemical Engineering, Chemistry, Economics, Engineering, Engineering Physics, Geological Engineering, Geophysical Engineering, Mathematical and Computer Sciences, Metallurgical and Material Engineering, Mining Engineering, and Petroleum Engineering. A pervasive institutional goal for all of these programs is articulated in the *Profile of the Colorado School of Mines Graduate*:

- All CSM graduates must have depth in an area of specialization, enhanced by hands-on experiential learning, and breadth in allied fields. They must have the knowledge and skills to be able to recognize, define and solve problems by applying sound scientific and engineering principles. These attributes uniquely distinguish our graduates to better function in increasingly competitive and diverse technical professional environments.
- Graduates must have the skills to communicate information, concepts and ideas effectively orally, in writing, and graphically. They must be skilled in the retrieval, interpretation and development of technical information by various means, including the use of computer-aided techniques.
- Graduates should have the flexibility to adjust to the ever changing professional environment and appreciate diverse approaches to understanding and solving society's problems. They should have the creativity, resourcefulness, receptivity and breadth of interests to think critically about a wide range of cross-disciplinary issues. They should be prepared to assume leadership roles and possess the skills and attitudes which promote teamwork and cooperation and to continue their own growth through life-long learning.
- Graduates should be capable of working effectively in an international environment, and be able to succeed in an increasingly interdependent world where borders between cultures and economies are becoming less distinct. They should appreciate the traditions and languages of other cultures, and value diversity in their own society.

- Graduates should exhibit ethical behavior and integrity. They should also demonstrate perseverance and have pride in accomplishment. They should assume a responsibility to enhance their professions through service and leadership and should be responsible citizens who serve society, particularly through stewardship of the environment.

## History of CSM

In 1865, only six years after gold and silver were discovered in the Colorado Territory, the fledgling mining industry was in trouble. The nuggets had been picked out of streams and the rich veins had been worked, and new methods of exploration, mining, and recovery were needed.

Early pioneers like W.A.H. Loveland, E.L. Berthoud, Arthur Lakes, George West and Episcopal Bishop George M. Randall proposed a school of mines. In 1874, the Territorial Legislature appropriated \$5,000 and commissioned Loveland and a Board of Trustees to found the Territorial School of Mines in or near Golden. Governor Routt signed the Bill on February 9, 1874, and when Colorado became a state in 1876, the Colorado School of Mines was constitutionally established. The first diploma was awarded in 1883.

As CSM grew, its mission expanded from the rather narrow initial focus on nonfuel minerals to programs in petroleum production and refining as well. Recently it has added programs in materials science and engineering, energy and environmental engineering, and a broad range of other engineering and applied science disciplines. CSM sees its mission as education and research in engineering and applied science with a special focus on the earth science disciplines in the context of responsible stewardship of the earth and its resources.

CSM long has had an international reputation. Students have come from nearly every nation, and alumni can be found in every corner of the globe.

## Unique Programs

Colorado School of Mines is an institution of engineering and applied science with a special focus in Earth, Energy, Environment and Materials. As such, it has unique programs in many fields. This is the only institution in the world, for example, that offers doctoral programs in all five of the major earth science disciplines: Geology and Geological Engineering, Geophysics, Geochemistry, Mining Engineering and Petroleum Engineering. It has one of the few Metallurgical and Materials Engineering programs in the country that still focuses on the complete materials cycle from mineral processing to finished advanced materials.

In addition to these traditional programs which define the institutional focus, the school is pioneering programs in interdisciplinary areas. One of the most successful of these is the Engineering Division program, which currently claims more than one-third of the undergraduate majors. This program combines civil, electrical, environmental and mechanical engineering in a nontraditional curriculum that is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 – telephone (410) 347-7700. Another, at the graduate level, is the Master of International Political Economy of Resources. Such programs serve as models at CSM.

While many of the programs at CSM are firmly grounded in tradition, they are all experiencing continual evolution and innovation. Recent successes in integrating aspects of the curriculum have spurred similar activity in other areas such as the geosciences. There, through the medium of computer visualization, geophysicists and geologists are in the process of creating a new emerging discipline. A similar development

is occurring in geo-engineering through the integration of aspects of civil engineering, geology and mining. CSM has played a leadership role in this kind of innovation over the last decade. Many degree programs offer CSM undergraduate students the opportunity to begin work on a Graduate Certificate, Professional Master's Degree, or Master's Degree while completing the requirements for their Bachelor's Degree. These combined Bachelors-Masters programs have been created by CSM faculty in those situations where they have deemed it academically advantageous to treat BS and MS degree programs as a continuous and integrated process. These are accelerated programs that can be valuable in fields of engineering and applied science where advanced education in technology and/or management provides the opportunity to be on a fast track for advancement to leadership positions. These programs also can be valuable for students who want to get a head start on graduate education.

## Location

Golden, Colorado has been the home for CSM since its inception. Located 20 minutes west of Denver, this community of 18,000 is located in the foothills of the Rockies. Skiing is an hour away to the west. Golden is a unique community that serves as home to CSM, the Coors Brewing Company, the National Renewable Energy Laboratory, a major U.S. Geological Survey facility that also contains the National Earthquake Center, and the seat of Jefferson County. Golden once served as the territorial capital of Colorado.

## Accreditation

Mines is accredited through the doctoral degree by the Higher Learning Commission (HLC) of the North Central Association, 230 South LaSalle Street, Suite 7-500, Chicago, Illinois 60604-1413 – telephone (312) 263-0456. The Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET), 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 – telephone (410) 347-7700, accredits undergraduate degree programs in Chemical Engineering, Chemical and Biochemical Engineering, Engineering, Engineering Physics, Geological Engineering, Geophysical Engineering, Metallurgical and Materials Engineering, Mining Engineering and Petroleum Engineering. The American Chemical Society has approved the degree program in the Department of Chemistry and Geochemistry.

## Administration

General management of the School is vested by State statute in a Board of Trustees, consisting of seven members appointed by the governor. A non-voting student member is elected annually by the student body and a non-voting faculty member is elected to serve a two-year term by the academic faculty. Financial support comes from student tuition and fees and from the State through annual appropriations. These funds are augmented by government and privately sponsored research, private gift support from alumni, corporations, foundations and other friends.

## Colorado School of Mines Non-Discrimination Statement

In compliance with federal law, including the provisions of Titles VI and VII of the Civil Rights Act of 1964, Title IX of the Education Amendment of 1972, Sections 503 and 504 of the Rehabilitation Act of 1973, the Americans with Disabilities Act (ADA) of 1990, the ADA Amendments Act of 2008, Executive Order 11246, the Uniformed Services Employment and Reemployment Rights Act, as amended, the Genetic Information Nondiscrimination Act of 2008, and Board of Trustees Policy 10.6, the Colorado School of Mines does not discriminate against individuals on the basis of age, sex, sexual orientation, gender identity, gender

expression, race, religion, ethnicity, national origin, disability, military service, or genetic information in its administration of educational policies, programs, or activities; admissions policies; scholarship and loan programs; athletic or other school-administered programs; or employment.

Inquiries, concerns, or complaints should be directed by subject content as follows:

The Employment-related EEO and discrimination contact is:

Mike Dougherty, Associate Vice President for Human Resources  
Guggenheim Hall, Room 110  
Golden, Colorado 80401  
(Telephone: 303.273.3250)

The ADA Coordinator and the Section 504 Coordinator for employment is:

Ann Hix, Benefits Manager, Human Resources  
Guggenheim Hall, Room 110  
Golden, Colorado 80401  
(Telephone: 303.273.3250)

The ADA Coordinator and the Section 504 Coordinator for students and academic educational programs is:

Ron Brummett, Director of Career Planning & Placement / Student Development Services  
1600 Maple Street, Suite 8  
Golden, Colorado 80401  
(Telephone: 303.273.3297)

The Title IX Coordinator is:

Maureen Durkin, Director of Policy and Planning  
Guggenheim Hall, Room 212A  
Golden, Colorado 80401  
(Telephone: 303.384.2236)

The ADA Facilities Access Coordinator is:

Gary Bowersock, Director of Facilities Management  
1318 Maple Street  
Golden, Colorado 80401  
(Telephone: 303.273.3330)

# Student Life

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## Facilities

### Student Center

The Ben H. Parker Student Center contains the offices for the Vice President of Student Life and Dean of Students, Associate Dean of Students, Apartment Housing, Student Activities and Greek Life, Student Government (ASCSM), Admissions and Financial Aid, Cashier, International Student and Scholar Services, Career Services, Registrar, BlasterCard, Conference Services, and student organizations. The Student Center also contains the student dining hall (known as the Slate Cafe), Diggers Den food court, bookstore, student lounges, meeting rooms, and banquet facilities.

### Student Recreation Center

Completed in May 2007, the 108,000 square foot Student Recreation Center, located at the corner of 16th and Maple Streets in the heart of campus, provides a wide array of facilities and programs designed to meet student's recreational and leisure needs while providing for a healthy lifestyle. The Center contains a state-of-the-art climbing wall, an eight-lane, 25 meter swimming and diving pool, a cardiovascular and weight room, two multi-purpose rooms designed and equipped for aerobics, dance, martial arts programs and other similar activities, a competition gymnasium containing three full-size basketball courts as well as seating for 2500 people, a separate recreation gymnasium designed specifically for a wide variety of recreational programs, extensive locker room and shower facilities, and a large lounge intended for relaxing, playing games or watching television. In addition to housing the Outdoor Recreation Program as well as the Intramurals and Club Sports Programs, the Center serves as the competition venue for the Intercollegiate Men and Women's Basketball Programs, the Intercollegiate Volleyball Program and the Men and Women's Intercollegiate Swimming and Diving Program.

### W. Lloyd Wright Student Wellness Center

The W. Lloyd Wright Student Wellness Center, 1770 Elm Street, houses four health and wellness programs for Mines students: the Coulter Student Health Center, the Student Health Benefits Plan, the Counseling Center and Student Disability Services. The wellness center is open from 8:00 am to 5:00 pm, Monday through Friday, during the fall and spring semesters.

**Coulter Student Health Center:** Services are provided to all students who have paid the student health center fee. The Coulter Student Health Center (303) 273-3381, FAX (303) 273-3623 is located on the first floor of the W. Lloyd Wright Student Wellness Center at the corner of 18th and Elm Streets (1770 Elm Street). Nurse practitioners and registered nurses provide services Monday through Friday 8:00 am to 12:00 pm and 1:00 pm to 4:45 pm and family medicine physicians provide services by appointment several days a week. After hours students can call New West Physicians at (303) 278-4600 to speak to the physician on call (identify yourself as a CSM student). The Health Center offers primary health and dental care. For X-rays, specialists or hospital care, students are referred to appropriate providers in the community. More information is available at <http://healthcenter.mines.edu>.

**Dental Clinic:** The Dental Clinic is located on the second floor of the W. Lloyd Wright Wellness Center. Services include cleanings, restoratives, and x-rays. Students who have paid the student health fee are eligible for this service. The dental clinic is open Tuesdays, Wednesdays, and Fridays during the academic year with fewer hours in the summer.

Services are by appointment only and can be made by calling the Dental Clinic. Dental care is on a fee-for-service basis, and students enrolled in the CSM Student Health Benefits Plan pay lower rates for dental care. The Dental Clinic takes cash or checks, no credit/debit cards

**Fees:** *Students are charged a mandatory Health Services fee each semester, which allows them access to services at the Health Center. Spouses of enrolled CSM students can choose to pay the health center fee and are eligible for services. Dental services are not available to spouses.*

**Immunization Requirement:** *The State of Colorado requires that all students enrolled have proof of two MMR's (measles, mumps and rubella). A blood test showing immunity to all three diseases is acceptable. History of disease is not acceptable.*

**Student Health Benefits Plan:** *The SHBP office is located on the second floor of the W. Lloyd Wright Student Wellness Center.*

**Adequate Health Insurance Requirement:** *All degree seeking U.S. citizen and permanent resident students, and all international students regardless of degree status, are required to have health insurance. Students are automatically enrolled in the Student Health Benefits Plan and may waive coverage if they have comparable coverage under a personal or employer plan. International students must purchase the SHBP, unless they meet specific requirements. Information about the CSM Student Health Benefits Plan, as well as the criteria for waiving, is available online at <http://shbp.mines.edu> or by calling 303.273.3388. Coverage for spouses and dependents is also available. Enrollment confirmation or waiver of the CSM Student Health Benefits Plan is done online for U.S. Citizens and Permanent Residents. International students must complete a paper enrollment/waiver form. The deadline is Census Day.*

**Counseling Center:** *Located on the second floor of the W. Lloyd Wright Student Wellness Center, phone 303-273-3377. Services are available for students who have paid the Student Services fee. Individual personal, academic, and career counseling is offered on a short-term basis to all enrolled CSM students. In cases where a student requires longer-term counseling, referrals are made to providers in the local community. The Counseling Center also provides education and assessment on alcohol and other drug use. More information is available at <http://counseling.mines.edu/>.*

**Student Disability Services:** *Located on the second floor of the W. Lloyd Wright Student Wellness Center, phone 303-273-3377. Student Disability Services provides students with disabilities an equal opportunity to access the institution's courses, programs and activities. Services are available to students with a variety of disabilities, including but not limited to attention deficit hyperactivity disorders, learning disorders, psychological disorders, vision impairment, hearing impairment, and other disabilities. A student requesting disability accommodations at the Colorado School of Mines must comply with the Documentation Guidelines and submit required documents, along with a completed Request for Reasonable Accommodations form to Student Disability Services.*

*Documentation Guidelines and the Request form are available at <http://disabilities.mines.edu/>.*



## Services

### **Academic Advising & Support Services Center for Academic Services and Advising (CASA)**

**Academic Advising:** All students entering CSM are assigned an Academic Advising Coordinator. This assignment is made by last name. This Coordinator serves as the student's academic advisor until they formally declare their major or intended degree. This declaration occurs in their sophomore year. Incoming students have only noted an interest and are not declared.

The Coordinators will host individual, walk-in, and group advising sessions throughout the semester. Every student is required to meet with their Coordinator at least once per semester. The Coordinator will administer a PIN for course registration, each semester. Students unsure of their academic path (which major to choose) should work with their Coordinator to explore all different options.

CASA also hosts Peer 2 Peer advising. Students may walk-in and speak with a fellow student on various issues pertaining to course, such as course registration).

**CSM101:** The First-Year Symposium, is a required, credit-bearing class. CSM101 aims to facilitate the transition from high school to college; create community among peers and upper-class students; assess and monitor academic progress; and provide referrals to appropriate campus resources. CSM101 is taught by 38 professional staff members (including faculty) and 76 Peer Mentor students.

**Tutoring Services:** CASA offers weekly tutoring services for all core-curriculum courses. Our services run Sunday through Thursday and are hosted in CASA, the Student Center, and the Library. Students may also request to meet with a private tutor at a time, location, and date of their mutual choosing. All tutoring services are free to students.

**Academic Support Services:** Routinely, CASA offers great support workshops and events. CASA hosts pre-finals workshops as well as mid-term exam prep session. As well, students can work with our staff to develop the skills and technique of studying well in college – such as test-prep and cognitive learning development. CASA hosts late-night programs in the residence halls and Greek houses.

**Academic Excellence Workshops (AEW):** First-Year students are encouraged to attend our AEW workshops. These workshops run concurrent to many of the first-year classes (Calc, Chem, Physics, etc.) and reiterate/strengthen material taught in class. They are offered in the evening and are free to all students.

**Faculty in CASA:** Faculty from various departments host their regular office hours in CASA. Students are encouraged to utilize these professors for assistance with material and/or questions on course planning.

Website: CASA maintains an extensive website with resources, helpful tips, and guides. Check out CASA at <http://casa.mines.edu>.

### **Motor Vehicles Parking**

*All motor vehicles on campus must be registered with the campus Parking Services Division of Facilities Management, 1318 Maple Street, and must display a CSM parking permit. Vehicles must be registered at the beginning of each semester or upon bringing your vehicle on campus, and updated whenever you change your address.*

## Public Safety

The Colorado School of Mines Department of Public Safety is a full service, community oriented law enforcement agency, providing 24/7 service to the campus. It is the mission of the Colorado School of Mines Police Department to make the Mines campus the safest campus in Colorado.

The department is responsible for providing services such as:

- Proactive patrol of the campus and its facilities
- Investigation and reporting of crimes and incidents
- Motor vehicle traffic and parking enforcement
- Crime and security awareness programs
- Alcohol / Drug abuse awareness / education
- Self defense classes
- Consultation with campus departments for safety and security matters
- Additional services to the campus community such as: vehicle unlocks and jumpstarts, community safe walks (escorts), authorized after-hours building and office access, and assistance in any medical, fire, or other emergency situation.

The police officers employed by the Department of Public Safety are fully trained police officers in accordance with the Peace Officer Standards and Training (P.O.S.T.) Board and the Colorado Revised Statute.

## Career Center

The Mines Career Center mission is to assist students in developing, evaluating, and/or implementing career, education, and employment decisions and plans. Career development is integral to the success of Mines graduates and to the mission of Mines. All Colorado School of Mines graduates will be able to acquire the necessary job search and professional development skills to enable them to successfully take personal responsibility for the management of their own careers. Services are provided to all students and for all recent graduates, up to 24 months after graduation. Students must adhere to the ethical and professional business and job searching practices as stated in the Career Center Student Policy, which can be found in its entirety on the Student's Homepage of DiggerNet.

In order to accomplish our mission, we provide a comprehensive array of career services:

### **Career, Planning, Advice, and Counseling**

- "The Mines Strategy" a practical, user-friendly career manual with interview strategies, resume and cover letter examples, career exploration ideas, and job search tips;
- Online resources for exploring careers and employers at <http://careers.mines.edu>;
- Individual resume and cover letter critiques;
- Individual job search advice;
- Practice video-taped interviews;
- Job Search Workshops - successful company research, interviewing, resumes, business etiquette, networking skills;
- Salary and overall outcomes data;
- Information on applying to grad school;
- Career resource library.

### **Job Resources and Events**

- Career Day (Fall and Spring);

- Online and in-person job search assistance for internships, CO-OPs, and full-time entry-level job postings;
- Virtual Career Fairs and special recruiting events;
- On-campus interviewing - industry and government representatives visit the campus to interview students and explain employment opportunities;
- General employment board;
- Employer searching resource;
- Cooperative Education Program - available to students who have completed three semesters at Mines (two for transfer students). It is an academic program which offers 3 semester hours of credit in the major for engineering work experience, awarded on the basis of a term paper written following the CO-OP term. The type of credit awarded depends on the decision of the department, but in most cases is additive credit. CO-OP terms usually extend from May to December, or from January to August, and usually take a student off campus full time. Students must apply for CO-OP before beginning the job (a no credit, no fee class), and must write learning objectives and sign formal contracts with their company's representative to ensure the educational component of the work experience.

## Identification Cards (BLASTER CARD)

Blaster Cards are made in the Student Activities Office in the Parker Student Center, and all new students must have a card made as soon as possible after they enroll. Each semester the Student Activities Office issues RTD Bus Pass stickers for student ID's. Students can replace lost, stolen, or damaged Blaster Cards for a small fee.

The Blaster Card can be used as a debit card to make purchases at all campus food service facilities, to check material out of the CSM Library, to make purchases at the campus residence halls, and may be required to attend various CSM campus activities.

Please visit the website at <http://www.is.mines.edu/BlasterCard> for more information.

## Student Publications

Two student publications are published at CSM by the Associated Students of CSM. Opportunities abound for students wishing to participate on the staffs.

The *Oredigger* is the student newspaper, published weekly during the school year. It contains news, features, sports, letters and editorials of interest to students, faculty, and the Golden community.

The literary magazine, *High Grade*, is published each semester. Contributions of poetry, short stories, drawings, and photographs are encouraged from students, faculty and staff. A Board of Student Publications acts in an advisory capacity to the publications staffs and makes recommendations on matters of policy. The Public Affairs Department staff members serve as daily advisors to the staffs of the *Oredigger* and *Prospector*. The Division of Liberal Arts and International Studies provides similar service to the *High Grade*.

## Veterans Services

The Registrar's Office provides veterans services for students attending the School and using educational benefits from the Veterans Administration.

## Tutoring

Individual tutoring in most courses is available through the Office for Student Development and Academic Services. This office also sponsors group tutoring sessions and Academic Excellence Workshops which

are open to all interested CSM students. For more information about services and eligibility requirements, contact the Student Development and Academic Services office.

## Activities

### Student Activities Office

The Office of Student Activities coordinates the various activities and student organizations on the Mines campus. Student government, professional societies, living groups, honor societies, interest groups and special events add a balance to the academic side of the CSM community. Participants take part in management training, event planning, and leadership development. To obtain an up-to-date listing of the recognized campus organizations or more information about any of these organizations, contact the Student Activities office.

### Student Government

**Associated Students of CSM (ASCSM)** is sanctioned by the Board of Trustees of the School. The purpose of ASCSM is, in part, to advance the interest and promote the welfare of CSM and all of the students and to foster and maintain harmony among those connected with or interested in the School, including students, alumni, faculty, trustees and friends.

Through funds collected as student fees, ASCSM strives to ensure a full social and academic life for all students with its organizations, publications, and special events. As the representative governing body of the students ASCSM provides leadership and a strong voice for the student body, enforces policies enacted by the student body, works to integrate the various campus organizations, and promotes the ideals and traditions of the School.

**The Graduate Student Association** was formed in 1991 and is recognized by CSM through the student government as the representative voice of the graduate student body. GSA's primary goal is to improve the quality of graduate education and offer academic support for graduate students.

**The Mines Activity Council (MAC)** serves as the campus special events board. The majority of all-student campus events are planned by MAC. Events planned by MAC include comedy shows to the campus on most Fridays throughout the academic year, events such as concerts, hypnotists, and one time specialty entertainment; discount tickets to local sporting events, theater performances, and concerts, movie nights bringing blockbuster movies to the Mines campus; and E-Days and Homecoming.

## Special Events

**Engineers' Days** festivities are held each spring. The three day affair is organized entirely by students. Contests are held in drilling, hand-spiking, mucking, and oil-field olympics to name a few. Additional events include a huge fireworks display, the Ore-Cart Pull to the Colorado State Capitol, the awarding of scholarships to outstanding Colorado high school seniors and an Engineers' Day concert.

**Homecoming** weekend is one of the high points of the entire year's activities. Events include a football rally and game, campus decorations, election of Homecoming queen and best, parade, burro race, and other contests.

**International Day** is planned and conducted by the International Student Council and the International Student and Scholar Services Office. It includes exhibits and programs designed to further the cause of understanding among the countries of the world. The international dinner

and entertainment have come to be one of the campus social events of the year.

**Winter Carnival**, sponsored by Blue Key, is an all-school ski day held each year at one of the nearby ski areas. In addition to skiing, there are also fun competitions (snowman contest, sled races, etc.) throughout the day.

## Residence Hall Association (RHA)

Residence Hall Association (RHA) is a student-run organization developed to coordinate and plan activities for students living in the Residence Halls. Its membership is represented by students from each hall floor. Officers are elected each fall for that academic year. For more information, go to RHA (<http://residence-life.mines.edu/RSL-Residence-Hall-Association>).

## Social Fraternities and Sororities

There are seven national fraternities and three national sororities active on the CSM campus. Fraternities and Sororities offer the unique opportunity of leadership, service to one's community, and fellowship. Greeks are proud of the number of campus leaders, athletes and scholars that come from their ranks. Additionally, the Greek social life provides a complement to the scholastic programs at Mines. Colorado School of Mines chapters are:

- Alpha Phi
- Alpha Tau Omega
- Beta Theta Pi
- Kappa Sigma
- Phi Gamma Delta
- Pi Beta Phi
- Sigma Alpha Epsilon
- Sigma Kappa
- Sigma Nu
- Sigma Phi Epsilon

## Honor Societies

Honor societies recognize the outstanding achievements of their members in the areas of scholarship, leadership, and service. Each of the CSM honor societies recognizes different achievements in our students.

## Special Interest Organizations

Special interest organizations meet the special and unique needs of the CSM student body by providing co-curricular activities in specific areas.

## International Student Organizations

The International Student Organizations provide the opportunity to experience a little piece of a different culture while here at Mines, in addition to assisting the students from that culture adjust to the Mines campus.

## Professional Societies

Professional Societies are generally student chapters of the national professional societies. As a student chapter, the professional societies offer a chance for additional professional development outside the classroom through guest speakers, trips, and interactive discussions about the current activities in the profession. Additionally, many of the organizations offer internship, fellowship and scholarship opportunities.

## Recreational Organizations

The recreation organizations provide the opportunity for students with similar interests to participate as a group in these recreational activities. Most of the recreational organizations compete on both the local and regional levels at tournaments throughout the year.

## Outdoor Recreation Program

The Outdoor Recreation Program is housed at the Mines Park Community Center. The Program teaches classes in outdoor activities; rents mountain bikes, climbing gear, backpacking and other equipment; and sponsors day and weekend activities such as camping, snowshoeing, rock climbing, and mountaineering.

For a complete list of all currently registered student organizations, please visit the Student Activities office or website at <http://studentactivities.mines.edu/>.

## International Student Services

The International Students & Scholar Services Office (IS&SS) serves approximately 600 international students and scholars at CSM.

IS&SS provides the following services:

- Admission of undergraduate international students
- Advise on immigration regulations by individual appointment and group seminars
- Prepare legal documents that allow international students to gain work experience through a period of practical training
- Provide forms required by international students and their dependents to travel outside the U.S.
- Process legal documents required for the admission of all international students (including undergraduate, graduate, special, exchange, and visiting scholars)
- Organize orientation programs for entering international undergraduate and graduate students

IS&SS also sponsors events and programs to help students adjust to life in the U.S. and CSM, and provides counseling related to emergencies and unexpected immigration problems.

## Multicultural Engineering Program

### Multicultural Engineering Program

The Multicultural Engineering Program is located at 1400 Maple Street. The MEP meets the needs of minority students by providing various student services, summer programs, recruitment, academic/retention programs (academic advising, academic excellence workshops, counseling, tutoring and peer study groups), professional/career development (leadership workshops, career development, time management, study skills and national conferences), community outreach, and cultural and social activities.

Working through student professional societies-American Indian Science and Engineering Society (AISES), Society of Asian Scientists and Engineers (SASE), National Society of Black Engineers (NSBE), and Society of Hispanic Professional Engineers (SHPE) - the Office of Minority Engineering Program is a center for minority student activities, and a place for students to become a community of scholars with common goals and objectives in a comfortable learning environment.

**American Indian Science and Engineering Society (AISES)** chapter was established at the Colorado School of Mines in 1992. It is a peer support group for Native American students pursuing science and engineering careers. Its main goal is to help the students get through college so they can then use those new skills to create a better life for themselves and other Native Americans.

**Society of Asian Scientists and Engineers (SASE)** is a branch of the Minority Engineering Program which acknowledges the Asian heritage by involvement in various school activities, social activities, and activities with the other Minority Engineering chapters. SASE allows students with an Asian heritage or students interested in Asian heritage to assemble and voice shared interests and associate in organized group activities which include attending Nuggets games, bowling, ice skating and numerous other activities.

**National Society of Black Engineers (NSBE)** is a non-profit organization managed by students. It was founded to promote the recruitment, retention and successful graduation of Black and other under-represented groups in the field of engineering. NSBE operates through a university-based structure coordinated through regional zones, and administered by the National Executive Board. The local chapters, which are the center of NSBE activity, create and conduct projects in the areas of pre-college student interaction, university academic support mechanisms and career guidance programs. "We instill pride and add value to our members which causes them to want to give back to NSBE in order to produce a continuum of success."

**Society of Hispanic Professional Engineers (SHPE)** is a non-profit organization that exists for the advancement of Hispanic engineering (sciences) students to become professional engineers and scientists, to increase the number of Hispanics entering into the field of engineering, and to develop and implement programs benefiting Hispanics seeking to become engineers and scientists. Anyone interested in joining may do so. SHPE is a national organization with student and professional chapters in nearly 100 cities across the country. The organization is divided into five regions representing 76 student chapters. The SHPE organization is governed by a National Board of Directors which includes representatives from all regions including two student representatives.

## Office of International Programs/ Study Abroad/International Fellowships

The Office of International Programs (OIP), a program in Academic Affairs located at 1706 Illinois Street, develops international opportunities for students and faculty at CSM, including study abroad programs. OIP is also responsible for advising students about internationally competitive scholarships such as Fulbright, Marshall, Churchill, Rhodes and Mitchell. For information about the international activities of OIP, see the website at [oip.mines.edu](http://oip.mines.edu).

## Office of Women in Science, Engineering and Mathematics (WISEM)

The WISEM office in Academic Affairs is located in 300 Guggenheim Hall. The mission of WISEM is to enhance opportunities for women in science and engineering careers, to increase retention of women at CSM, and to promote equity and diversity in higher education. The office

sponsors programs for women students and faculty and produces the Chevron Lecture Series.

For further information, contact:

Debra K. Lasich, Executive Director of Women in Science, Engineering and Mathematics  
Colorado School of Mines  
1133 17th Street  
Golden, CO 80401-1869  
or call (303) 273-3097

## Tuition, Fees, Financial Assistance, Housing & Dining Rates

Tuition and fees are established by the Board of Trustees of the Colorado School of Mines following the annual budget process and action by the Colorado General Assembly and Governor.

### Undergraduate Tuition

The official tuition and approved charges for the 2011- 2012 academic year will be available prior to the start of the 2011-2012 academic year located at <http://inside.mines.edu/UserFiles/File/finance/budget/FY12/FY12-Tuition%20Schedule.pdf>.

### Fees

The official fees, approved charges, and fee descriptions for the 2011-2012 academic year will be available prior to the start of the 2011-2012 academic year and can be found at: <http://inside.mines.edu/UserFiles/File/finance/budget/FY12/FY12%20Fees%20and%20Charges.pdf>.

Please note that in all instances, the costs to collect fees are not reimbursed to the Student Receivables Office. The Colorado School of Mines does not automatically assess any optional fees or charges.

### Housing & Dining Rates

NOTE: Room and board charges are established by the Board of Trustees (BOT) and are subject to change. Payment of room and board charges falls under the same guidelines as payment of tuition and fees. Rates below are in effect for the 2012-2013 Academic Year. Included is a "flexible" meal plan which guarantees students a designated number of meals per week or per semester and gives them between \$100.00 and \$300.00 to spend as they wish on additional meals or at any of the other campus dining locations. For more information, go to Student Housing ([http://inside.mines.edu/Student\\_Housing](http://inside.mines.edu/Student_Housing)) or Campus Dining (<http://csmdiningservices.com>).

### Residence Halls (academic year rate)

\*Meal plans required. Room rates include \$50 Residence Hall Association fee.

#### Morgan/Thomas/Bradford/Randall Halls

Room Type	Rate
Double Room	\$4,720
Single Room	\$5,870

#### Weaver Towers

Room Type	Rate
Double Room	\$5,650
Single Room	\$6,430
"E" Room, Single	\$6,980

#### Maple Hall

Room Type	Rate
Double Room	\$5,974
Single Room	\$6,900

#### Residence Halls at Mines Park\*

Room Type	Rate
Double Room	\$5,470

\* Includes Mines Park Parking Permit

### Campus-Owned Fraternity & Sorority Houses

Fraternity/Sorority House	Rate
Alpha Phi Sorority	\$5,065 / academic year
FIJI Fraternity	\$5,181 / academic year
Pi Phi Sorority	\$5,065 / academic year
Sigma Kappa Sorority	\$5,065 / academic year
All CSM-owned Fraternity and Sorority Houses--Summer	\$73 / week

### Meal Plans

() indicates commuter meal plans available.

Meal Plan	Rate
Marble (Gold): Unlimited meals in Slate Cafe + \$100 Flex per semester	\$2,316 per semester
Quartz (Blue): 14 meals/week + \$200 Flex Dollars per semester	\$2,261 per semester
Granite (Bronze): 160 meals/semester + \$250 Flex per semester	\$2,125 per semester
Topaz (Silver): 115 meals per semester + \$300 Flex per semester	\$1,907 per semester
Agate (commuter only): 25 meal block	\$200 per block purchased

### Summer Session Housing (Weekly Rate)

Room Type	Rate
Double Room	\$80
Single Room	\$125

### Apartment Housing (monthly rate)

#### Family Housing at Mines Park

# of Bedrooms	Rate
1 Bedroom	\$817
2 Bedroom	\$896

#### Single Student Apartments at Mines Park

# of Bedrooms	Rate
1 Bedroom	\$817
2 Bedroom	\$1,075
3 Bedroom	\$1,470

#### Single Student Apartments at Jones Road

# of Bedrooms	Rate
1 Bedroom	\$695

- \* Tenant pays gas and electric utilities. CSM provides free wireless and wired internet, basic expanded cable, water, sewer, public electric, unlimited laundry, and Jones Road/ Mines Park parking permit. Tenant may pay \$18.50 for landline phone (optional).

## Residence Hall Application

Information and application for residence hall space is included in the packet offering admission to the student. Students desiring accommodations are requested to forward their inquiries at the earliest possible date.

The submission of a room application does not in itself constitute a residence hall reservation. A residence hall contract will be sent electronically and made available on the Residence Life website, to be signed by the student and his or her parents and returned to the Residence Life Office.

Only upon receipt of the residence hall contract by the specified deadline by the Residence Life Office will the student be assured of a room reservation.

Rooms and roommates are assigned in accordance with student preference insofar as possible, with earlier applications receiving priority.

## Advance Deposits

An advance deposit made payable to Colorado School of Mines must accompany each application received. This deposit will be refunded in full (or in part if there are charges against the room) when the student leaves the residence hall.

If a student wishes to cancel a residence hall reservation, half of the deposit will be refunded if notice of the cancellation is received in writing by the Residence Life Office on or before May 1 of the current year.

Contracts are issued for the full academic year and no cancellation will be accepted after May 1, except for those who decide not to attend CSM. Those contracts separately issued only for entering students second semester may be cancelled no later than December 1. After that date no cancellation will be accepted except for those who decide not to attend CSM.

## Payments and Refunds

### Payment Information

A student is expected to complete the registration process, including the payment of tuition and fees, room and board, before attending class. Students can mail their payment to:

Cashier  
1600 Maple Street  
Colorado School of Mines  
Golden, CO 80401-1887

### Financial Responsibility

It is important for students to recognize their financial responsibilities when registering for classes at the school. If students do not fulfill their financial obligations by published deadlines:

- Late payment penalties will accrue on any outstanding balance.
- Transcripts will not be issued.
- Past due accounts will be turned over to Colorado Central Collection Services in accordance with Colorado law.
- Collection costs will be added to a student's account.
- The student's delinquency may be reported to national credit bureaus.

## Late Payment Penalties

A penalty will be assessed against a student if payment is not received in full by the official day of registration. The penalty is described in the schedule of courses for each semester. If payment is not completed by the sixth week of class, the student may be officially withdrawn from classes. Students will be responsible for all collection costs.

## Encumbrances

A student will not be permitted to register for future classes, graduate, or secure an official transcript of his/her academic record while indebted in any way to CSM. Students will be responsible for payment of all reasonable costs of collection.

## Refunds

Refunds for tuition and fees are made according to the following policy:

- The amount of tuition and fee assessments is based primarily on each student's enrolled courses. In the event a student withdraws from a course or courses, assessments will be adjusted as follows:
- If the withdrawal is made prior to the end of the add/drop period for the term of enrollment, as determined by the Registrar, tuition and fees will be adjusted to the new course level without penalty.
- If the withdrawal from a course or courses is made after the add/drop period, and the student does not officially withdraw from school, no adjustment in charges will be made.
- If the withdrawal from courses is made after the add/drop period, and the student withdraws from school, tuition and fee assessments will be reduced according to the following schedule:
- Within the 7 calendar days following the end of the add/drop period, 60 percent reduction in charges.
- Within the next following 7 calendar days, a 40 percent reduction in charges.
- Within the next following 7 calendar days, a 20 percent reduction in charges.
- After that period, no reduction of charges will be made.

The schedule above applies to the Fall and Spring semesters. The time periods for the Summer sessions - Summer I and Summer II - will be adjusted in proportion to the reduced number of days in these semesters.

Room and board refunds are pro-rated to the date of checkout from the Residence Hall. Arrangements must be made with the Housing Office. Student health insurance charges are not refundable. The insurance remains in effect for the entire semester.

PLEASE NOTE: Students receiving federal financial aid under the Title IV programs may have a different refund determined as required by federal law or regulations.

## State of Colorado Residency Qualifications

A student is classified as a resident or nonresident for tuition purposes at the time admission is granted and upon completion of the CSM Colorado Residency for Tuition Classification Form. The classification is based upon information furnished by the student. The student who, due to subsequent events, becomes eligible for resident tuition must make formal application to the Registrar for a change of status.

A student who willfully gives wrong information to evade payment of nonresident tuition shall be subject to serious disciplinary action. The final decision regarding tuition status rests with the Tuition Appeals Committee of Colorado School of Mines.

## Resident Students

A person whose legal residence is permanently established in Colorado may continue to be classified as a resident student so long as such residence is maintained even though circumstances may require extended absences from the state.

Qualification for resident tuition requires both

1. proof of adoption of the state as a fixed and permanent home, demonstrating physical presence within the state at the time of such adoption, together with the intention of making Colorado the true home; and
2. living within the state for 12 consecutive months immediately prior to the first day of classes for any given term.

These requirements must be met by one of the following:

1. the father, mother, or guardian of the student if an unemancipated minor, or
2. the student if married or over 22, or
3. the emancipated minor.

The home of the unemancipated minor is assumed to be that of the parents, or if there is a legal guardian of the student, that of such guardian. If the parents are separated or divorced and either separated or divorced parent meet the Colorado residency requirements, the minor also will be considered a resident. Statutes provide for continued resident status, in certain cases, following parents' moving from Colorado. Please check Colorado Revised Statutes 1973, 23-7-103(2)(m)(II) for exact provisions. In a case where a court has appointed a guardian or granted custody, it shall be required that the court certify that the primary purpose of such appointment was not to qualify the minor for resident tuition status.

## Nonresident Students

To become a resident of Colorado for tuition classification under state statutes, a student must be domiciled in Colorado for one year or more immediately preceding the first day of class for the semester for which such classification is sought. A person must be emancipated before domicile can be established separate from the domicile of the parents. Emancipation for tuition purposes takes place automatically when a person turns 23 years of age or marries.

The establishment of domicile for tuition purposes has two inseparable elements:

1. a permanent place of habitation in Colorado and
2. intent to remain in Colorado with no intent to be domiciled elsewhere.

The twelve-month waiting period does not begin until both elements exist. Documentation of the following is part of the petitioning process to document physical presence: copies of rental arrangements, rent receipts, copy of warranty deed if petitioner owns the personal residence property and verification of dates of employment. Documentation of the following is part of the petitioning process to document intent: Colorado drivers license, motor vehicle registration (as governed by Colorado Statute), voter registration, payment of Colorado state income taxes, ownership of residential real estate property in the state (particularly if the petitioner resides in the home), any other factor peculiar to the individual which tends to establish the necessary intent to make Colorado one's permanent place of habitation.

Nonresident students wishing to obtain further information on the establishment of residency or to apply for resident status should contact

the Registrar's Office. The "Petition for In-State Tuition Classification" is due in the Registrar's Office by the first day of classes of the term the student is requesting resident status.

## College Opportunity Fund

The College Opportunity Fund provides State financial support to eligible students for higher education. It was created by an Act of the Colorado State Legislature and signed into law by Governor Owens in May 2004.

*What does it mean?* In the past, the State gave money directly to the colleges. Now, if you authorize use of the stipend for any given term, the college you are attending will receive the funding, and you will see it appear as a credit on your tuition bill.

*Who is eligible?* Undergraduate students who are eligible for in-state tuition, and who apply for COF, are admitted to and enrolled in an eligible institution of higher education, and who authorize the institution to collect the funds on their behalf. Once enrolled at the Colorado School of Mines, the student must authorize the School to collect these funds from the state on the student's behalf. Once authorized, the School will continue to collect these funds on the student's behalf unless and until the student chooses to revoke the authorization.

*How much is the stipend?* It will vary. The amount will be determined each year by the Colorado Legislature.

For additional information please refer to:

Colorado School of Mines website:  
<http://inside.mines.edu/College-Opportunity-Fund-Application-Authorization>

Colorado Department of Higher Education's website:  
<http://highered.colorado.gov/Finance/COF/default.html>

The College Opportunity Fund website:  
<https://cof.college-assist.org/COFApp/COFApp/Default.aspx>

## Financial Aid and Scholarships

### Undergraduate Student Financial Assistance

The role of the CSM Financial Assistance Program is to enable students to enroll and complete their educations, regardless of their financial circumstances. In fulfilling this role, the Office of Financial Aid administered over \$37 million in total assistance in 2010-2011, including over \$17.5 million in grants and scholarships. Additional information may be found at the CSM financial aid web site, [finaid.mines.edu](http://finaid.mines.edu).

### Applying for Assistance

The CSM Application for Admission serves as the application for CSM merit-based scholarships for new students (except for the Engineers' Days Scholarship which is an essay contest run by a student government committee, and the Athletic and Military Science Departments which have their own application procedures for their scholarships). Continuing students may be recommended by their major department for scholarships designated for students from that department. To apply for need-based CSM, federal and Colorado assistance, students should complete the Free Application for Federal Student Aid.

Once evaluated, a financial aid award notification will be sent to the student. New students are sent a paper award letter beginning in early March. Continuing students are notified in mid May via their Mines email.

### Types of Financial Assistance

**Need-based assistance** will typically include grants, part-time employment, and student loans. Grants are provided by CSM, by

the State of Colorado (Colorado State Grants), and by the federal government (Pell Grants and Supplemental Educational Opportunity Grants).

**Work Study** funds also come from CSM, Colorado and the federal government. Students work between 8 and 10 hours a week, and typically earn between \$500 to \$1,500 to help pay for books, travel, and other personal expenses.

**Student Loans** may be offered from two federal programs: the Perkins Student Loan, or the Federal Direct Student Loan.

Supplemental student loans may also be offered through private bank loan programs.

The Alumni Association of CSM administers a loan program designed to assist juniors and seniors who have exhausted their other sources of funds. These are short term loans which require repayment within three years after graduation, and have been made available through the contributions of CSM alumni.

**Merit-based assistance** is offered to recognize students for their achievements. Academic awards to new students are made on the basis of their high school records and SAT or ACT composite test scores. Continuing students can receive departmental scholarships based on their academic performance at CSM, particularly in their major field of study, and on financial need.

**Alumni Association Grants** are awarded to students who are children of alumni who have been active in the CSM Alumni Association for the two years prior to the student's enrollment. The one-year grants carry a value of \$1,000. The students may also receive a senior award, based on their academic scholarship, and the availability of funds.

**Engineers' Day Scholarships** are available to Colorado residents. Based on high school records, an essay, and other information, a CSM Student Government committee selects students for these four-year awards.

**Athletic scholarships** may be awarded to promising student-athletes in seventeen men's and women's sports. The scholarships are renewable for up to three years, based on the recommendation of the Athletics Department.

**Army ROTC scholarships** are available from CSM and the U.S. Army for outstanding young men and women who are interested in a military career. The one, two, three, and four-year scholarships can provide up to full tuition and fees, a book allowance, and a monthly stipend for personal expenses. The CSM Military Science Department assists students in applying for these scholarships.

**U.S. Navy Scholarships** through the Civil Engineering Program, Nuclear Power Officer Program, and Baccalaureate Degree Completion Program are also available to CSM students. The local Navy Recruiting District Office provides information about these scholarships.

**U.S. Air Force ROTC Scholarships** are available from CSM and the U.S. Air Force. The three and four year scholarships can provide up to full tuition, fees, a book allowance, and a stipend. Further information is available through the Department of Aerospace Studies at the University of Colorado Boulder (the official home base for the CSM detachment).

In addition to scholarships through CSM, many students receive scholarships from their hometown civic, religious or other organizations. All students are urged to contact organizations with which they or their parents are affiliated to investigate such scholarships. The Financial Aid Office reserves the right, unless otherwise instructed by the student, to

release the student's information to scholarship providers for the purpose of assisting students in obtaining scholarships.

## Financial Aid Policies

### General

CSM students requesting or receiving financial assistance sponsored by the U.S. Government, the State of Colorado, or the Colorado School of Mines are required to report to the CSM Financial Aid Office all financial assistance offered or received from all sources including CSM immediately upon receipt or notification of such assistance. For the purpose of this paragraph, "financial assistance" shall include, but not be limited to, grants, scholarships, fellowships, or loans funded by public or private sources, as well as all income not considered taxable income by the Internal Revenue Service. Upon receipt of this information, CSM shall evaluate, and may adjust any financial assistance provided to the student from CSM, Colorado, or federal funds. No student shall receive financial assistance from CSM if such student's total assistance from all sources exceeds the total cost of the student's education at CSM. For the purpose of this paragraph, the "total cost of education" shall be defined to include the cost of tuition, fees, books, room and board, transportation, and personal expenses.

Funds for the Federal Pell Grant, Federal Supplemental Educational Opportunity Grant, Federal College Work-Study Program, Federal Perkins Loan, Federal Direct Stafford Loan, and Federal Direct PLUS Loans are provided in whole or part by appropriations of the United States Congress. The Colorado General Assembly provides funds for the Colorado Grant and Colorado Work-Study programs. These programs are all subject to renewed funding each year.

### Satisfactory Academic Progress

CSM students receiving scholarships must make satisfactory academic progress as specified in the rules and regulations for each individual scholarship.

Students receiving assistance from federal, Colorado or need-based CSM funds must make satisfactory academic progress toward their degree. Satisfactory progress is defined by maintaining adequate pace towards graduation and maintaining a 2.0 cumulative GPA at all times. Pace is measured by dividing the overall credit hours attempted by the overall credit hours completed. Students will be required to maintain a 75% completion rate at all times. Satisfactory standing is determined after each semester, including summer. If students are deficient in either the pace or grade average measure, they will receive a one semester warning period during which they must return to satisfactory standing.

If this is not done, their eligibility will be terminated until such time as they return to satisfactory standing. In addition, if students totally withdraw from CSM, or receive grades of F or INC in all of their courses, their future financial aid eligibility will be terminated without a warning period. Financial aid eligibility termination may be appealed to the Financial Aid Office on the basis of extenuating or special circumstances having negatively affected the student's academic performance. If approved, the student will receive a probationary period of one semester to regain satisfactory standing.

### Study Abroad

Students wishing to pursue study abroad opportunities should contact the Office of International Programs (OIP), listed under the Services section of this Bulletin, p.190. Colorado School of Mines encourages students to include an international study/work experience in their undergraduate education. CSM maintains student exchange programs with engineering universities in South America, Europe, Australia, Africa,



and Asia. Courses successfully passed abroad can be substituted for their equivalent course at CSM. Overall GPA is not affected by courses taken abroad. A well-planned study abroad program will not delay graduation. In addition, study abroad can be arranged on an individual basis at universities throughout the world.

Financial aid and selected scholarships and grants can be used to finance approved study abroad programs. The OIP has developed a resource center for study abroad information in its office, 1706 Illinois St., phone 303-384-2121. Students are invited to use the resource materials and meet with staff to discuss overseas study opportunities.

## **Withdrawals**

We understand that unexpected events occur in life that will cause a student to withdraw from classes at Colorado School of Mines. Federal regulation requires financial aid to be awarded under the assumption that a student will attend the institution for the entire period in which federal assistance was disbursed. The following policies will help you to understand the impact a withdrawal may have if you are receiving financial aid. The tuition and fees refund policy set by CSM is separate from the return calculation required by federal regulation.

An official withdrawal will be recorded once the withdrawal process has been completed by the student. Students who withdraw from the University should come to the financial aid office before completing the withdrawal process to determine what effect this will have on their financial aid. A withdrawal requires the financial aid office to determine how much of the federal, state and institutional financial aid the student has earned. Financial aid is not considered earned until the 60% point of the semester. The unearned portion will be returned to the program from which it came (i.e. student loans to the lender, Pell to the federal department of education, etc). Students need to be aware that they may owe Colorado School of Mines for unearned federal, state and/or institutional aid even if they are receiving a refund in tuition and fees.

Federal regulations consider a student to be an unofficial withdrawal if the student receives all failing grades for the term. If the student has not completely withdrawn and has failed to earn a passing grade in at least one class for the term, CSM is required to determine whether the student established eligibility for financial aid by attending at least one class or participating in any CSM academic-related activity. An unofficial withdrawal calculation will be performed and funds returned to their respective federal, state and/or institutional aid programs if there is not documentation supporting the student's last day of attendance, or the documentation indicates the student stopped attending prior to the 60% point of the semester.

## Housing & Dining

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[http://inside.mines.edu/Student\\_Housing](http://inside.mines.edu/Student_Housing)

### Residence Halls (<http://inside.mines.edu/Residence-Life>)

Residence hall living is an integral part of the Colorado School of Mines experience, although no students are required to live on campus. The “Traditional” residence halls (Morgan, Thomas, Bradford and Randall halls) house about 380 students in mostly double rooms with a central restroom/shower facility on each floor. Weaver Towers has living space for 230 students in suites with single and double rooms, a common living area, and two single restroom/shower facilities. There are a limited number of single rooms available. Weaver Towers features seven or eight person suites with each suite containing both single and double bedrooms, a living/study room and two bathrooms. Maple Hall is our 290-bed facility that houses 2- and 4-person suites, with single and double bedrooms and a private bathroom in each suite. Five social lounges, nine study rooms, community kitchen and activity room, central living room with fireplace, music practice room, student storage and workshop space, laundry facilities, vending, mailroom, and desk assistant services are available to all residents of Maple Hall.

The residence halls at Mines Park offer residence hall living in an apartment setting for freshmen and upper-class students. In addition to having all the amenities of the other residence halls, each apartment has a full kitchen. Each residence hall complex houses mailboxes, lounge areas, TV room, and washers and dryers. All residence hall spaces are equipped with a bed, desk, waste basket, and closet for each student, as well as wired and wireless internet connections. Cable TV connection with “expanded basic” service is included. The student is responsible for damage to the room or furnishings. Colorado School of Mines assumes no responsibility for loss or theft of personal belongings, and residents are encouraged to carry personal property insurance.

Additionally, Residence Life offers students an option to live and learn within a theme community that is a partnership between Residence Life, administrative departments, and faculty across campus. Theme Housing consists of intentionally designed living experiences centered around a variety of educational, cultural, organizational, and personal interests. These communities allow students with common interests and pursuits to live together and support each other through planned activities and informal interactions. Communities include Outdoor Recreation, Women In Engineering, Visual and Performing Arts, and Service & Social Justice. Theme Housing Webpage (<http://inside.mines.edu/RSL-Theme-Housing>)

For all Housing & Dining rates, go to Tuition, Fees, Financial Assistance, Housing (<https://nextbulletin.mines.edu/undergraduate/tuitionfeesfinancialassistancehousing>)

Campus Dining (<http://inside.mines.edu/CampusDining>)

Campus Dining at Mines operates a dining hall, known as the Slate Café, in the Ben H. Parker Student Center. Students who live in the residence halls are required to purchase a residential meal plan. Breakfast, lunch and dinner are served Monday through Friday, and brunch and dinner are served on Saturday and Sunday. Additional retail dining facilities, including the Diggers Den Food Court in the Student Center, Subway in the Student Recreation Center, Starbucks in Brown Hall, and Einstein Bros. Bagels in CTLM, serve students with meal plans and/or by cash/credit sales. Students not living in a residence hall may purchase any one of several meal plans which best meets their individual needs. Campus Dining options are limited during breaks (Thanksgiving, Fall, Winter and

Spring Break). For more information and hours, go to the Campus Dining website (<http://inside.mines.edu/CampusDining>).

For all Housing & Dining rates, go to Tuition, Fees, Financial Assistance, Housing (<https://nextbulletin.mines.edu/undergraduate/tuitionfeesfinancialassistancehousing>)

### Apartment Housing (<http://inside.mines.edu/Apartments-at-Mines-Park>)\*

The Mines Park apartment complex is located west of the 6th Avenue and 19th Street intersection on 55 acres owned by Mines. The complex houses upperclass undergraduate students, graduate students, and families. Jones Road apartments are located on Jones Road, south of 19th St. and consists of one-bedroom apartments for single students. Residents must be full-time students.

Units are complete with refrigerators, stoves, dishwashers, cable television, wired and wireless internet connections, and an optional campus phone line for an additional fee. There are two community centers which contain the laundry facilities, recreational and study space, and meeting rooms. For more information or to apply for apartment housing, go to the Apartment Housing website (<http://studentlife.mines.edu/Apartments-at-Mines-Park>).

For all Housing & Dining rates, go to Tuition, Fees, Financial Assistance, Housing (<https://nextbulletin.mines.edu/undergraduate/tuitionfeesfinancialassistancehousing>)

### Fraternities, Sororities

Any non-freshman student who is a member of one of the national Greek organizations on campus is eligible to live in Fraternity or Sorority housing after their freshman year. Several of the Greek Houses are owned and operated by the School, while the remaining houses are owned and operated by the organizations. All full time, undergraduate students are eligible to join these organizations. For information, go to Greek Life (<http://studentactivities.mines.edu/greeklife>).

For all Housing & Dining rates, go to Tuition, Fees, Financial Assistance, Housing (<https://nextbulletin.mines.edu/undergraduate/tuitionfeesfinancialassistancehousing>)

### Off-Campus Housing

Click here for Off-Campus Housing Resources (<http://studentlife.mines.edu/Off-Campus-Housing-Resources>).

## Undergraduate Information

### Undergraduate Bulletin

It is the responsibility of the student to become informed and to observe all regulations and procedures required by the program the student is pursuing. Ignorance of a rule does not constitute a basis for waiving that rule. The Undergraduate Bulletin, current at the time of the student's most recent admission, gives the academic requirements the student must meet to graduate. However, a student can change to the requirements in a later Bulletin published while the student is enrolled as an undergraduate. Changes to administrative policies and procedures become effective for all students as soon as the campus community is notified of the changes. The Undergraduate Bulletin is available to students in electronic format. Electronic versions of the Undergraduate Bulletin may be updated more frequently to reflect changes approved by, and communicated to, the campus community. As such, students are encouraged to refer to the most recently available electronic version of the Undergraduate Bulletin. This version is available at the CSM website. The electronic version of the Undergraduate Bulletin is considered the official version of this document. In case of disagreement between the electronic and print versions (if available), the electronic version will take precedence.

### Admission Requirements

Colorado School of Mines admits students who have demonstrated the ability to accomplish classroom and laboratory work and benefit from our programs. The decision to admit a student is based on his or her ability to earn a degree at CSM. Criteria considered in evaluating students include:

1. pattern of course work in high school or college,
2. grades earned in those courses,
3. ACT or SAT test scores,
4. rank in class, and
5. other available test scores.

No single criterion for admission is used; however, the most important factor is the academic record in high school or college.

The admission requirements below are minimum requirements which may change after a catalog has been finalized. The Board of Trustees, CSM governing board, reserves the right to deviate from published admission requirements. In such cases, changes in admission policy would be widely publicized.

### Freshmen

The minimum admission requirements for all high school graduates who have not attended a college or university are as follows:

1. An applicant must be a graduate of an accredited high school.
2. An applicant should rank in the upper quartile of their graduating class. Consideration will be given to applicants below this level on evidence of strong motivation, superior test scores, and recommendation from principal or counselor.
3. The following 17 units of secondary school work must be completed upon graduation from high school:

Algebra	2.0
Geometry	1.0
Advanced Mathematics (including Trigonometry)	1.0
English	4.0
History or Social Studies	3.0

Academic Elective	2.0
Laboratory Science	3.0
Foreign Language	1.0
Total Hours	17.0

One unit of laboratory science must be either chemistry or physics. The second and third units may be chemistry, physics, biology, zoology, botany, geology, etc. with laboratory. Both physics and chemistry are recommended for two of the three required units. General Science is not acceptable as a science unit, however it is acceptable as an academic elective unit.

4. The 2 units of academic electives (social studies, mathematics, English, science, or foreign language) must be acceptable to the applicant's high school to meet graduation requirements. For applicants submitting GED Equivalency Diplomas, these units may be completed by the GED test.
5. Applicants from the United States and Canada are required to submit the scores of either the Scholastic Aptitude Test (SAT) of the College Entrance Examination Board or the American College Test (ACT) battery. Applications for either the SAT or ACT may be obtained from the high school counselors, or by writing to:

Educational Testing Service  
P.O. Box 592  
Princeton, NJ 08541 for the SAT

or to the: American College Testing Program  
P.O. Box 168  
Iowa City, IA 52243 for the ACT

You may also register online at [www.collegeboard.com](http://www.collegeboard.com) (bulletin.mines.edu/undergraduate/undergraduateinformation/<http://www.collegeboard.com>) (SAT) and [www.act.org](http://www.act.org) (bulletin.mines.edu/undergraduate/undergraduateinformation/<http://www.act.org>) (ACT).

### Transfer Students

An applicant to CSM is considered to be a transfer student if he or she has enrolled in coursework at another college after graduating from high school. The minimum admissions requirements for all transfer students are as follows:

1. Students transferring from another college or university must have completed the same high school course requirements as entering freshmen. A transcript of the applicant's high school record is required. ACT or SAT test scores are not required if the student has completed a minimum of 30 credit hours of college credit.
2. Applicants must present official college transcripts from all colleges attended. Applicants should have an overall 2.75 grade point average or better. Students presenting a lower GPA will be given careful consideration and acted on individually.
3. An applicant who cannot re-enroll at the institution from which he or she wishes to transfer because of scholastic record or other reason will be evaluated on a case-by-case basis.
4. Completed or "in progress" college courses - which meet CSM graduation requirements - are eligible for transfer credit if the course is not remedial or vocational, and the grade earned is a "C" or better.

### Former Students

The minimum admission requirements for those students who have previously attended CSM are as follows:

1. Any student who has attended another college or university since last enrolling at CSM must re-apply for admission through the Admissions Office.
2. Any student who did not complete the semester immediately preceding the beginning of the period for which he or she wishes to enroll must be re-admitted to CSM by the Admissions Office.
3. A former student, returning after a period of suspension, must apply for admission to the Admissions Office and must furnish an approval for such re-enrollment from the Readmissions Committee of Colorado School of Mines. Appropriate forms to apply for admission may be obtained from the Admissions Office. Official transcripts for all coursework completed while away from Mines must be submitted to the Registrar's Office for review of transferability of the credit.

## Exchange Students

All students participating in the CSM Exchange Program (coming to CSM and CSM students going abroad) must be enrolled in a minimum of 15 semester credit hours at CSM or the foreign exchange university.

## International Students

For purposes of admission, international applicants are students in a non-immigrant status who are not U.S. citizens or do not have approved and finalized U.S. permanent residence, refugee status or political asylum. International students usually need an F1 or J1 visa to study in the United States.

Generally, international applicants seeking admission to Colorado School of Mines must meet the same academic standards for admission as those required of American applicants. There are wide variations, however, between educational systems throughout the world that make exact comparisons of educational standards difficult. International applicants are selected on the basis of their prior academic work, probability of success in the chosen curriculum (as evidenced by prior work in the academic area involved) and proof of English proficiency. After admission but prior to enrollment, certification of adequate financial resources is required.

International applicants must submit a completed international application form; a \$45 nonrefundable international document processing fee; translated secondary schooling records, and/or a credentials evaluation report; notarized affidavit of financial sponsorship; and when applicable, translated college transcripts.

## TOEFL/English Proficiency

Student applicants whose primary language is not English, must prove proficiency in the English language by achieving one of the following:

1. A TOEFL (Test of English as a Foreign Language) score of 550 on the paper-based test, or a score of 79 on the internet Based TOEFL (iBT).

Subject	Internet TOEFL (iBT)	Paper TOEFL (PBT)
Reading	20	54
Writing	17	55
Listening	21	55
Speaking	21	N/A
Total	79	550

2. An IELTS (International English Language Testing System) Score of 6.5, with no band below a 6.0.
3. A PTE A (Pearson Test of English) score of 70 or higher.

4. Transferable credit from an accredited US institution of higher education equivalent to 30 credits or more.

The above English Proficiency requirement applies to students currently studying in the United States and for students outside the country.

## Advanced Credit for International Evaluation

The following methods are used by Colorado School of Mines to validate the awarding of advanced standing credit for international students who have completed work in their home countries at the postsecondary level:

1. Credit is granted based upon recommendation by recognized academic publications, primarily the World Education Series of American Association of Collegiate Registrars and Admissions Officers.
2. Validation by a comparable credit-granting department at Colorado School of Mines. Validation by one of the following two options will be at the discretion of the credit-granting department.
  - A. Option A: Course-by-course evaluation examination by comparable Colorado School of Mines academic department.
  - B. Option B: The advisor and/or academic dean's office makes a preliminary evaluation of the level a student has completed and begins the student at that level. Upon successful completion of that course, all related lower-level courses in that area, as determined by the department granting credit, would be validated and credit awarded.

## Enrollment Requirements

All new students whose primary language is not English must demonstrate English Language proficiency before enrolling for the first time at the university. This requirement applies to international and non-international, permanent residents, immigrants, transfer and non-transfer students alike.

## Fraudulent Applications

Individuals who withhold or provide fraudulent information on applications for undergraduate admissions or readmissions are subject to immediate dismissal from the university. The decision for immediate dismissal will be made by the Director of Enrollment Management or the Director of International Admissions. This decision will be made after a complete and thorough review of the situation and an individual conference with the student involved. The individual dismissed has the right to appeal the decision to the committee on academic policy and procedure, whose decision will be final.

## Nondegree Students

A nondegree student is one who has not applied to pursue a degree program at CSM but wishes to take courses regularly offered on campus. Such students may take any course for which they have the prerequisites as listed in the CSM Bulletin or have the permission of the instructor. Transcripts or evidence of the prerequisites are required. An applicant for admission to the undergraduate school who does not meet admission requirements may not fulfill deficiencies through this means. Exception to this rule can be made only by the Director of Enrollment Management. A maximum of 12 hours of nondegree credit from Colorado School of Mines may be used toward an undergraduate degree program.

# Admission Procedures

## All Applicants

Documents received by CSM in connection with applications for admission or transfer of credit will not be duplicated, returned to the applicant, or forwarded to any agency or any other institution.

A \$45.00 non-refundable application fee is required from all applicants.

Applications for undergraduate study cannot be accepted later than 21 days prior to the date of registration confirmation for any academic semester or summer session. Admission for any semester or term may close whenever CSM's budgeted number of students has been met.

## High School Students

Applicants are encouraged to apply online at [www.mines.edu](http://www.mines.edu). Questions can be directed to the Admissions Office via email: [admit@mines.edu](mailto:admit@mines.edu); or via postal mail:

Admissions Office  
Colorado School of Mines  
1600 Maple Street  
Golden, CO 80401

A student may apply for admission any time after completing the 11th grade. The application will be evaluated upon receipt of the completed application form, a high school transcript showing courses completed, courses remaining to be completed, ranking in class, other pertinent data, and SAT or ACT test scores. High school seniors are encouraged to apply in the fall term of senior year. Additionally, it is recommended that the ACT and/or SAT be taken during this term. In some cases, the grades or marks received in courses taken during the first half of the senior year may be required. Applicants who meet freshman admission requirements are admitted subject to completion of all entrance requirements and high school graduation.

## Transfer Students

### Guaranteed Transfer

Colorado School of Mines is a signatory to the Colorado Statewide Engineering Articulation Agreement, which can be viewed at [www.state.co.us/cche](http://www.state.co.us/cche) (<http://www.state.co.us/cche>). Beginning with admissions in 2003–2004, this agreement determines transferability of coursework for engineering students in the State of Colorado. All students transferring into CSM under the terms of the statewide agreement are strongly encouraged to be advised by the CSM Admissions Office on their planned course of study. Credits earned more than 10 years prior will not transfer.

Additionally, Colorado School of Mines has formal transfer agreements with Red Rocks Community College (RRCC), Front Range Community College (FRCC), Community College of Denver (CCD), and Community College of Aurora (CCA). Students are encouraged to contact the Admissions Office at these institutions for additional information.

### Transfer by Review

Undergraduate students at another college or university who wish to transfer to CSM should apply online at [www.mines.edu](http://www.mines.edu).

A transfer student should apply for admission at the beginning of the final two quarters or semester of attendance at his or her present college. The application will be evaluated upon receipt of the completed application form, high school transcript, transcripts from each university or college attended, and a list of courses in progress. The Admissions Office will

then notify the student of his or her admission status. Admission is subject to satisfactory completion of current courses in progress and submission of a final transcript.

## Advanced Placement and International Baccalaureate

Course work completed for select subjects under the Advanced Placement Program in a high school may be accepted for college credit provided that the Advanced Placement Program Test grade is either 5 (highest honors) or 4 (honors).

In special cases, advanced placement may be granted for course work not completed under the College Entrance Examination Board Program. Students wishing such credit may demonstrate competence by writing the Advanced Placement Examination on the subject. Information can be secured from:

the College Entrance Examination Board  
P.O. Box 592  
Princeton, NJ 08541

More information on which subjects are accepted can be found on the web at [www.mines.edu](http://www.mines.edu).

Course work completed for select subjects under the International Baccalaureate Program in high school may be accepted for college credit provided that the International Baccalaureate Program Exam grade is a 5, 6, or 7 on selected standard and higher level exams. In some cases, departmental approval is required before credit is granted. More information on which subjects are accepted can be found on the web at [www.mines.edu](http://www.mines.edu).

## Declaration of Option (Major)

The curriculum during the first semester at CSM is generally the same across majors. Students are not required to choose a major before the end of the freshman year. All students must have declared a major by the beginning of the junior year.

## Medical Record

A health history prepared by the student, a medical examination performed by the student's physician and an updated immunization record completed by the student and the physician, nurse or health authority comprise the medical record. A medical record is required for full time students entering CSM for the first time, or following an absence of more than 12 calendar months.

The medical record will be sent to the student after acceptance for admission. The medical record must be updated and completed and then returned to the Student Health Center before permission to enroll is granted. Proof of immunity consists of an official Certificate of Immunization signed by a physician, nurse, or public health official which documents measles, mumps and rubella immunity. The Certificate must specify the type of vaccine and the dates (month, day, year) of administration or written evidence of laboratory tests showing immunity to measles, mumps and rubella.

The completed medical record is confidential and will be kept in the Student Health Center. The record will not be released unless the student signs a written release.

## Veterans

Colorado School of Mines is approved by the Colorado State Approving Agency for Veteran Benefits under chapters 30, 31, 32, 33, 35, 1606, and 1607. Undergraduates must register for and maintain 12 credit hours,

and graduate students must register for and maintain 9 credit hours of graduate work in any semester to be certified as a full-time student for full-time benefits. Any hours taken under the full-time category will decrease the benefits to 3/4 time, 1/2 time, or tuition payment only.

All changes in hours, program, addresses, marital status, or dependents are to be reported to the Veterans Certifying Officer as soon as possible so that overpayment or under payment may be avoided. Veterans must see the Veteran's Certifying Officer each semester to be certified for any benefits for which they may be eligible. In order for veterans to continue to receive benefits, they must make satisfactory progress as defined by Colorado School of Mines.

An honorably or generally discharged military veteran providing a copy of his/her DD214 is awarded two credit hours to meet the physical education requirement at CSM. Additionally, veterans may request substitution of a technical elective for the institution's core EPICS course requirement.

## Academic Regulations

### Deficiencies

The curricula at Colorado School of Mines have been especially designed so that the course work flows naturally from course to course and year to year. Thus, it is important that deficiencies in lower numbered courses be scheduled in preference to more advanced work.

### Prerequisites

*It is the responsibility of each student to make certain that the proper prerequisites for all courses have been met.* Registration in a course without the necessary prerequisite may result in dismissal from the class or a grade of F (Failed) in the course.

### Remediation

The Colorado Department of Higher Education specifies a remedial programs policy in which any first-time freshmen admitted to public institutions of higher education in Colorado with ACT (or equivalent) scores of less than 18 in reading or English, or less than 19 in mathematics, are required to participate in remedial studies. At the Colorado School of Mines, these remedial studies will be conducted through required tutoring in Nature and Human Values for reading and writing, and *Calculus for Scientists and Engineers I* for mathematics, and the consequent achievement of a grade of C or better.

## Transfer Credit

### New Transfer Students

Upon matriculation, a transfer student will receive the prescribed academic credit for courses taken at another institution if these courses are listed in a current articulation agreement and transfer guide between CSM and that institution. Credits earned more than 10 years in advance of admission will not transfer. When an articulation agreement does not exist with another institution, the transfer student may receive credit for a course taken at another institution, subject to review by the appropriate CSM department head or designate to ensure course equivalency.

### Continuing Students

Students who are currently enrolled at CSM may transfer credit in required courses only in extenuating circumstances, upon the advance approval of the Registrar, the department head of the appropriate course, and the department head of the student's option. Upon return, credit will be received subject to review by the Registrar. Physics courses are subject to post-approval from the department. Forms for this purpose are available in the Registrar's Office, and the process is reviewed

periodically by the Office of the Executive Vice President for Academic Affairs (EVPAA).

## Returning Students

Students who have matriculated at CSM, withdrawn, applied for readmission and wish to transfer in credit taken at an institution while they were absent from CSM, must obtain approval, upon return, of the department head of the appropriate course, the department head of the student's option, and the Registrar.

In all cases, requests for transfer credit are processed by the Registrar. Credits must be submitted on an official transcript from a regionally accredited institution and be academic in nature. Vocational credit is not accepted. Only courses completed with grades of "C" or better will be accepted.

## Course Withdrawals, Additions and Drops

Courses may be added or dropped without fee or penalty during the first 11 school days of a regular academic term (first 4 school days of a 6-week field course or the first 6 school days of the 8-week summer term).

Continuing students may withdraw from any course after the eleventh day of classes through the twelfth week for any reason with a grade of W. After the twelfth week, no withdrawals are permitted except in cases of withdrawal from school or for extenuating circumstances under the auspices of the Office of Academic Affairs and the Office of the Registrar. A grade of F will be given in courses which are withdrawn from after the deadline without approval.

Freshmen and transfer students in their first and second semesters are permitted to withdraw from courses with no grade penalty through the Friday prior to the last week of classes.

All adds/drops are initiated in the Registrar's Office. To withdraw from a course (with a "W") a student must obtain the appropriate form from the Registrar's office, have it initialed by the instructor and signed by the student's advisor to indicate acknowledgment of the student's action, and return it to the Registrar's Office by close of business on the last day that a withdrawal is authorized. Acknowledgment (by initials) by the division/department is required in only 2 cases:

1. when a course is added after the 11th day of the semester and
2. when the Registrar has approved, for extenuating circumstances, a withdrawal after the last date specified (a "late withdrawal").

Approval of a late withdrawal can be given by the Registrar acting on behalf of the Office of Academic Affairs in accordance with CSM's refund policy, and in compliance with federal regulations.

A \$5.00 fee will be charged for any change in class schedule after the first 11 days of class, except in cases beyond the student's control or withdrawal from school. All adds/drops are initiated in the Registrar's Office.

## Independent Study

For each semester credit hour awarded for independent study a student is expected to invest approximately 25 hours of effort in the educational activity involved. To register for independent study, a student should get from the Registrar's Office the form provided for that purpose, have it completed by the instructor involved and the appropriate department/division head, and return it to the Registrar's Office.

## Off-Campus Study

A student must enroll in an official CSM course for any period of off-campus, course-related study, whether U.S. or foreign, including faculty-

led short courses, study abroad, or any off-campus trip sponsored by CSM or led by a CSM faculty member. The registration must occur in the same term that the off-campus study takes place. In addition, the student must complete the necessary release, waiver, and emergency contact forms, transfer credit pre-approvals, and FERPA release, and provide adequate proof of current health insurance prior to departure. For additional information concerning study abroad requirements, contact the Office of International Programs at (303) 384-2121; for other information, contact the Registrar's Office.

## Absenteeism

Class attendance is required of all undergraduates unless the student has an official excused absence. Excused absences are granted for three general reasons:

1. Student is a varsity athlete and is representing the School in a varsity athletics activity.
2. Student is representing the School in an authorized activity related to a club or academic endeavor (academic competitions, student professional society conferences, club sport competition, program-sponsored competitions, etc.)
3. Student has a documented personal reason (illness, injury, jury duty, life-threatening illness or death in the immediate family, etc.).

Students who miss academic work (including but not limited to exams, homework, and labs) for one of the reasons listed above may be issued an excused absence. If an excused absence is received, the student must be given the opportunity to make up the missed work in a reasonable period of time without penalty. While the student is not responsible for actually issuing the excused absence, the student is responsible for making sure documentation is submitted appropriately and for contacting his/her faculty member(s) to initiate arrangements for making up any missed work.

## Varsity Athletics Absences:

The Athletics Department will authorize excused absences for all approved varsity athletics related absences. The Athletics Department will send notice of excused absences to faculty members on or before Census Day each semester. The student is responsible for contacting his/her faculty member(s) prior to the absence occurring to initiate arrangements for making up any missed work. The Faculty Oversight Committee on Sports and Athletics oversees the number of excused absences permitted per semester by varsity athletes.

## Authorized Activity Absences:

The Associate Dean of Students may authorize excused absences upon receipt of proper documentation of the school related activity. All excused absences for school-sponsored activities must be documented with the Associate Dean of Students by Census Day of each semester. If the absence will occur prior to Census Day, then the documentation should be received at least two weeks prior to the absence. Once documentation has been received and approved, the Associate Dean of Students will send notice of excused absences to faculty members. The student is responsible for contacting his/her faculty member(s) prior to the absence occurring to initiate arrangements for making up any missed work.

Requests for excused absence(s) related to an authorized activity received after Census Day may be denied or be documented as an excused/unexcused absence at the discretion of the faculty member.

## Personal Reason Absences:

The Associate Dean of Students may authorize excused absences upon receipt of proper documentation of the illness, injury, or other incident. The student must provide the documentation to the Associate Dean of Students within one week of returning to class. Once documentation has been received and approved, the Associate Dean of Students will send notice of excused absences to faculty members. The student is responsible for contacting his/her faculty member(s) to initiate arrangements for making up any missed work.

Important Note: Every effort will be made by the faculty to honor all excused absences. However, class attendance is essential for understanding of the material and for learning to take place. Excessive absence, regardless of reason, may result in a reduced or failing grade in the course based on course content and delivery. As content and delivery differ among the faculty and with each class, it is important for a student missing class to discuss the absences, excused or unexcused, with his/her faculty member(s) to determine what will be considered excessive.

## Unexcused Absences:

All absences that are not documented as excused absences are considered unexcused absences. Faculty members may deny a student the opportunity to make up some or all of the work missed due to unexcused absence(s). However, the faculty members do have the discretion to grant a student permission to make up any missed academic work for an unexcused absence. The faculty member may consider the student's class performance, as well as their attendance, in the decision.

## Withdrawal from School

A student may officially withdraw from CSM by processing a *Withdrawal from School* form available from the Registrar's Office. Completion of the form prior to the last day of scheduled classes for that term will result in W's being assigned to courses in progress. Failure to officially withdraw will result in the grades of courses in progress being recorded as F's. Leaving the School without having paid tuition and fees will result in a hold being placed against the transcript. Either of these actions would make future enrollment at CSM or another college more difficult.

# Undergraduate Grading System

## Grades

When a student registers in a course, one of the following grades will appear on his/her academic record. If a student registered as NC (audit) fails to satisfy all conditions, no record of this registration in the course will be made. The assignment of the grade symbol is based on the level of performance, and represents the extent of the student's demonstrated mastery of the material listed in the course outline and achievement of the stated course objectives.

Symbol	Interpretation
A	Excellent
A-	
B+	
B	Good
B-	
C+	
C	Satisfactory
C-	
D+	
D	Poor (lowest passing)
D-	
F	Failed
S	Satisfactory, C or better, used at mid-term
U	Unsatisfactory, below C, used at mid-term
PRG	Satisfactory Progress
PRU	Unsatisfactory Progress

In addition to these performance symbols, the following is a list of registration symbols that may appear on a CSM transcript:

Symbol	Interpretation
WI	Involuntary Withdrawn
W	Withdrew, No Penalty
T	Transfer Credit
INC	Incomplete
NC	Not for Credit (Audit)
Z	Grade not yet submitted

## Incomplete Grade

If a student, because of illness or other reasonable excuse, fails to complete a course, a grade of INC (Incomplete) is given. The grade INC indicates deficiency in quantity of work and is temporary.

A GRADE OF INC MUST BE REMOVED NOT LATER THAN THE FIRST FOUR WEEKS OF THE FIRST SEMESTER OF ATTENDANCE FOLLOWING THAT IN WHICH IT WAS RECEIVED. Upon failure to remove an INC within the time specified, it shall be changed to an F (failed) by the Registrar. In the event that an INC grade remains upon completion of degree, the INC will be converted to an F and included in the final GPA.

## NC Grade (Not for Credit or Audit)

A student may for special reasons, with the instructor's permission, register in a course on the basis of NC (Not for Credit). To have the grade NC appear on his/her transcript, the student must enroll at registration

time as a NC student in the course and comply with all conditions stipulated by the course instructor, except that if a student registered as NC fails to satisfy all conditions, no record of this registration in the course will be made. The Registration Action Form is used to request that a course be recorded as an audit. This form is available in the Registrar's Office.

## Grade Appeal Process

CSM faculty have the responsibility, and sole authority for, assigning grades. As instructors, this responsibility includes clearly stating the instructional objectives of a course, defining how grades will be assigned in a way that is consistent with these objectives, and then assigning grades. It is the student's responsibility to understand the grading criteria and then maintain the standards of academic performance established for each course in which he or she is enrolled.

If a student believes he or she has been unfairly graded, the student may appeal this decision first to the instructor of the course, and if the appeal is denied, to the Faculty Affairs Committee of the Faculty Senate. The Faculty Affairs Committee is the faculty body authorized to review and modify course grades, in appropriate circumstances. Any decision made by the Faculty Affairs Committee is final. In evaluating a grade appeal, the Faculty Affairs Committee will place the burden of proof on the student. For a grade to be revised by the Faculty Affairs Committee, the student must demonstrate that the grading decision was unfair by documenting that one or more of the following conditions applied:

1. The grading decision was based on something other than course performance, unless the grade was a result of penalty for academic dishonesty.
2. The grading decision was based on standards that were unreasonably different from those applied to other students in the same section of that course.
3. The grading decision was based on standards that differed substantially and unreasonably from those previously articulated by the instructor.

To appeal a grade, the student should proceed as follows:

1. The student should prepare a written appeal of the grade received in the course. This appeal must clearly define the basis for the appeal and must present all relevant evidence supporting the student's case.
2. After preparing the written appeal, the student should deliver this appeal to the course instructor and attempt to resolve the issue directly with the instructor. Written grade appeals must be delivered to the instructor no later than 10 business days after the start of the regular (fall or spring) semester immediately following the semester in which the contested grade was received. In the event that the course instructor is unavailable because of leave, illness, sabbatical, retirement, or resignation from the university, the course coordinator (first) or the Department Head/Division Director (second) shall represent the instructor.
3. If after discussion with the instructor, the student is still dissatisfied, he or she can proceed with the appeal by submitting three copies of the written appeal plus three copies of a summary of the instructor/student meetings held in connection with the previous step to the President of the Faculty Senate. These must be submitted to the President of the Faculty Senate no later than 25 business days after the start of the semester immediately following the semester in which the contested grade was received. The President of the



Faculty Senate will forward the student's appeal and supporting documents to the Faculty Affairs Committee, and the course instructor's Department Head/Division Director.

4. The Faculty Affairs Committee will request a response to the appeal from the instructor. On the basis of its review of the student's appeal, the instructor's response, and any other information deemed pertinent to the grade appeal, the Faculty Affairs Committee will determine whether the grade should be revised. The decision rendered will be either:
  - A. the original grading decision is upheld, or
  - B. sufficient evidence exists to indicate a grade has been assigned unfairly.

In this latter case, the Faculty Affairs Committee will assign the student a new grade for the course. The Committee's decision is final. The Committee's written decision and supporting documentation will be delivered to the President of the Faculty Senate, the office of the EVPAA, the student, the instructor, and the instructor's Department Head/Division Director no later than 15 business days following the Senate's receipt of the grade appeal.

The schedule, but not the process, outlined above may be modified upon mutual agreement of the student, the course instructor, and the Faculty Affairs Committee.

## Quality Hours and Quality Points

For graduation a student must successfully complete a certain number of required semester hours and must maintain grades at a satisfactory level. The system for expressing the quality of a student's work is based on quality points and quality hours. The numerical value associated with the specific grades are:

Grade	Numerical Value
A	4.000
A-	3.700
B+	3.300
B	3.000
B-	2.700
C+	2.300
C	2.000
C-	1.700
D+	1.300
D	1.000
D-	0.700
F	0.000

The number of quality points earned in any course is the number of semester hours assigned to that course multiplied by the numerical value of the grade received. To compute an overall or major grade-point average, the number of cumulative quality hours is divided into the cumulative quality points earned. Grades of W, WI, INC, PRG, PRU, or NC are not counted in quality hours.

## Transfer Credit

Transfer credit earned at another institution will have a T grade assigned but no grade points will be recorded on the student's permanent record. Calculation of the grade-point average will be made only from the courses completed at Colorado School of Mines.

## Semester Hours

The number of times a class meets during a week (for lecture, recitation, or laboratory) determines the number of semester hours assigned to that course. Class sessions are normally 50 minutes long and represent one hour of credit for each hour meeting. Two to four hours of laboratory work per week are equivalent to 1-semester hour of credit. For the average student, each hour of lecture and recitation requires at least two hours of preparation. No full-time undergraduate student may enroll for more than 19 credit hours in one semester. Physical education, advanced ROTC and Honors Program in Public Affairs courses are excepted. However, upon written recommendation of the faculty advisor, the better students may be given permission by the Registrar on behalf of Academic Affairs to take additional hours.

## Grade-Point Averages

Grade-Point Averages shall be specified, recorded, reported, and used to three figures following the decimal point for any and all purposes to which said averages may apply.

## Overall Grade-Point Average

Beginning Fall 2011, all attempts at every CSM course will count in the overall grade point average. No repeat exclusions apply.

The overall grade-point average includes all attempts at courses taken at Colorado School of Mines with the exception of courses which fall under the repeat policy in effect from Fall 2007 through Summer 2011.

If a course completed during the Fall 2007 term through Summer 2011 was a repeat of a course completed in any previous term and the course was not repeatable for credit, the grade and credit hours earned for the most recent occurrence of the course will count toward the student's grade-point average and the student's degree requirements. The most recent course occurrence must be an exact match to the previous course completed (subject and number). The most recent grade is applied to the overall grade-point average even if the previous grade is higher.

Courses from other institutions transferred to Colorado School of Mines are not counted in any grade-point average, and cannot be used under this repeat policy. Only courses originally completed and subsequently repeated at Colorado School of Mines during Fall 2007 through Summer 2011 with the same subject code and number apply to this repeat policy.

All occurrences of every course taken at Colorado School of Mines will appear on the official transcript along with the associated grade.

Courses from other institutions transferred to Colorado School of Mines are not counted in any grade-point average.

## Option (Major) Grade-Point Average

The grade-point average calculated for the option (major) is calculated in the same manner as the overall grade-point average. Starting Fall 2011 the repeat policy is no longer in effect and all attempts at major courses completed in the major department or division are included. However, the major grade point average includes only the most recent attempt of a repeated course if the most recent attempt of that course occurs from Fall 2007 through Summer 2011.

The major grade point average includes every course completed in the major department or division at Colorado School of Mines. In some cases, additional courses outside of the major department are also included in the major gpa calculation. The minimum major grade-point average required to earn a Mines undergraduate degree is a 2.000. For specifics concerning your major gpa, reference your online degree audit or contact your major department.

## Honor Roll and Dean's List

To be placed on the academic honor roll, a student must complete at least 14 semester hours with a 3.0-3.499 grade point for the semester, have no grade below C, and no incomplete grade. Those students satisfying the above criteria with a semester grade-point average of 3.5 or above are placed on the Dean's List.

Students are notified by the Dean of Students of the receipt of these honors. The Dean's List notation appears on the student's transcript.

## Graduation Awards

Colorado School of Mines awards the designations of Cum Laude, Magna Cum Laude, and Summa Cum Laude upon graduation. These designations are based on the following overall grade-point averages:

Grade-point average	Designation
3.500 - 3.699	Cum Laude
3.700 - 3.899	Magna Cum Laude
3.900 - 4.000	Summa Cum Laude

Commencement ceremony awards are determined by the student's cumulative academic record at the end of the preceding semester. For example, the overall grade-point average earned at the end of the fall term determines the honor listed in the May commencement program.

Final honors designations are determined once final grades have been awarded for the term of graduation. The final honors designation appears on the official transcript and is inscribed on the metal diploma. Official transcripts are available approximately one to two weeks after the term grades have been finalized. Metal diplomas are sent to the student approximately two months after final grades are posted. Mailing arrangements are made during Graduation Salute.

Undergraduate students are provided one metal diploma as part of the graduation fees. Additional metal diplomas and parchment diplomas can be ordered at the Registrar's Office for an additional charge. Graduating students should order these items before the end of the graduation term in order to ensure delivery approximately two months after final grades are awarded.

## Good Standing

A student is in good standing at CSM when he or she is enrolled in class(es) and is not on either academic or disciplinary probation, suspension, or dismissal.

## Academic Probation and Suspension

### Probation

A student whose cumulative grade-point average falls below the minimum requirements specified (see table below) will be placed on probation for the following semester. A student on probation is subject to the following restrictions:

1. may not register for more than 15 credit hours
2. may be required to withdraw from intercollegiate athletics
3. may not run for, or accept appointment to, any campus office or committee chairmanship. A student who is placed on probation while holding a position involving significant responsibility and commitment may be required to resign after consultation with the Associate Dean of Students or the President of Associated

Students. A student will be removed from probation when the cumulative grade-point average is brought up to the minimum, as specified in the table below.

## Suspension

A student on probation who fails to meet both the last semester grade period requirements and the cumulative grade-point average given in the table below will be placed on suspension. A student who meets the last semester grade period requirement but fails to achieve the required cumulative grade-point average will remain on probation.

total Quality Hours	Required Cumulative G.P. Average	Last Semester G.P. Average
0 - 18.5	1.7	--
19 - 36.5	1.8	2.0
37 - 54.5	1.8	2.0
55 - 72.5	1.9	2.1
73 - 90.5	1.9	2.1
91 - 110.5	2.0	2.2
111 - 130.5	2.0	2.2
131- end of program	2.0	2.3

A freshman or transfer student who fails to make a grade point average of 1.5 during the first grade period will be placed on suspension.

Suspension becomes effective immediately when it is imposed. Readmission after suspension requires written approval from the Readmissions Committee. While a one semester suspension period is normally the case, exceptions may be granted, particularly in the case of first-semester freshmen and new transfer students.

No student who is on suspension may enroll in any regular academic semester without the written approval of the Readmissions Committee. However, a student on suspension may enroll in a summer session (field camp, academic session, or both) with the permission of the Associate Dean of Students. Students on suspension who have been given permission to enroll in a summer session by the Associate Dean may not enroll in any subsequent term at CSM without the written permission of the Readmissions Committee. Readmissions Committee meetings are held prior to the beginning of each regular semester and at the end of the spring term.

A student who intends to appear in person before the Readmissions Committee must contact the Associate Dean of Students at least one week prior to desired appointment. Between regular meetings of the Committee, in cases where extensive travel would be required to appear in person, a student may petition in writing to the Committee, through the Associate Dean of Students.

Appearing before the Readmissions Committee by letter rather than in person will be permitted only in cases of extreme hardship. Such cases will include travel from a great distance, e.g. overseas, or travel from a distance which requires leaving a permanent job.

The Readmissions Committee meets on six separate occasions throughout the year. Students applying for readmission must appear at those times except under conditions beyond the control of the student. Such conditions include a committee appointment load, delay in producing notice of suspension, or weather conditions closing highways and airports.

All applications for readmission after a minimum period away from school, and all appeals of suspension or dismissal, must include a written statement of the case to be made for readmission.

A student who, after being suspended and readmitted twice, again fails to meet the required academic standards shall be automatically dismissed. The Readmissions Committee will hear a single appeal of automatic dismissal. The appeal will only be heard after demonstration of substantial and significant changes. A period of time sufficient to demonstrate such a change usually elapses prior to the student attempting to schedule this hearing. The decision of the Committee on that single appeal will be final and no further appeal will be permitted.

Readmission by the Committee does not guarantee that there is space available to enroll. A student must process the necessary papers with the Admissions Office prior to seeing the Committee.

## Notification

Notice of probation, suspension, or dismissal will be mailed to each student who fails to meet catalog requirements.

## Repeated Failure

A student who twice fails a required course at Colorado School of Mines and is not subject to academic suspension will automatically be placed on "Special Hold" status with the Registrar, regardless of the student's cumulative or semester GPA. The student must meet with the subject advisor or the faculty Readmissions Committee (in the case of three or more Fs in the same course) and receive written permission to remove the hold before being allowed to register. Transfer credit from another school will not be accepted for a twice-failed course.

## Access to Student Records

Students at the Colorado School of Mines are protected by the Family Educational Rights and Privacy Act of 1974 (FERPA) (<http://inside.mines.edu/FERPA>), as amended. This Act was designed to protect the privacy of education records, to establish the right of students to inspect and review their education records, and to provide guidelines for the correction of inaccurate or misleading data through informal and formal hearings. Students also have the right to file complaints with the FERPA office concerning alleged failures by the institution to comply with the Act. Copies of local policy, including the list of offices with access to student records based on legitimate educational interest, can be found in the Registrar's Office. Contact information for FERPA complaints is:

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

**Directory Information.** The School maintains lists of information which may be considered directory information as defined by the regulations. This information includes name, current and permanent addresses and phone numbers, date of birth, major field of study, dates of attendance, part or full-time status, degrees awarded, last school attended, participation in officially recognized activities and sports, class, and academic honors. Students who desire that this information not be printed or released must so inform the Registrar before the end of the first two weeks of the fall semester for which the student is registered. Information will be withheld for the entire academic year unless the student changes this request. The student's signature is required to make any changes for the current academic year. The request must be renewed each fall term for the upcoming year. The following student records are maintained by Colorado School of Mines at the various offices listed below:

1. General Records: Undergraduate-Registrar; Graduate- Graduate Dean

2. Transcript of Grades: Registrar
3. Computer Grade Lists: Registrar
4. Encumbrance List: Controller and Registrar
5. Academic Probation/Suspension List: Undergraduate Associate Dean of Students; Graduate-Graduate Dean
6. Advisor File: Academic Advisor
7. Option/Advisor/Enrolled/ Minority/Foreign List: Registrar, Dean of Students, and Graduate Dean
8. Externally Generated SAT/GRE Score Lists: Undergraduate-Registrar; Graduate-Graduate Dean
9. Financial Aid File: Financial Aid (closed records)
10. Medical History File: School Physician (closed records)

**Student Access to Records.** The undergraduate student wishing access to a record will make written request to the Registrar. The graduate student will make a similar request to the Dean of the Graduate School. This request will include the student's name, date of request and type of record to be reviewed. It will be the responsibility of the Registrar or Graduate School Dean to arrange a mutually satisfactory time for review. This time will be as soon as practical but is not to be later than 45 days from receipt of the request. The record will be reviewed in the presence of the designated representative. If the record involves a list including other students, steps will be taken to preclude the viewing of the other student name and information.

**Challenge of the Record.** If the student wishes to challenge any part of the record, the Registrar or Dean of the Graduate School will be so notified in writing. The Registrar or Dean may then

1. remove and destroy the disputed document, or
2. inform the student that the document represents a necessary part of the record; and, if the student wishes to appeal,
3. convene a meeting of the student and the document originator (if reasonably available) in the presence of the Associate Vice President for Academic Affairs as mediator, whose decision will be final.

**Destruction of Records.** Records may be destroyed at any time by the responsible official if not otherwise precluded by law except that no record may be destroyed between the dates of access request and the viewing of the record. If during the viewing of the record any item is in dispute, it may not be destroyed.

**Access to Records by Other Parties.** Colorado School of Mines will not permit access to student records by persons outside the School except as follows:

1. In the case of open record information as specified in the section under Directory Information.
2. To those people specifically designated by the student. Examples would include request for transcript to be sent to graduate school or prospective employer.
3. Information required by a state or federal agency for the purpose of establishing eligibility for financial aid.
4. Accreditation agencies during their on-campus review.
5. In compliance with a judicial order or lawfully issued subpoena after the student has been notified of the intended compliance.
6. Any institutional information for statistical purposes which is not identifiable with a particular student.
7. In compliance with any applicable statute now in effect or later enacted. Each individual record (general, transcript, advisor, and medical) will include a log of those persons not employed by

Colorado School of Mines who have requested or obtained access to the student record and the legitimate interest that the person has in making the request.

The School discloses education records without a student's prior written consent under the FERPA exception for disclosure to school officials with legitimate educational interests. A school official is a person employed by the School in an administrative, supervisory, academic or research, or support staff position (including law enforcement unit personnel and health staff); a person or company with whom the School has contracted as its agent to provide a service instead of using School employees or officials (such as an attorney, auditor, or collection agent); a person serving on the Board of Trustees; or a student serving on an official committee, such as a disciplinary or grievance committee, or assisting another school official in performing his or her tasks.

A school official has a legitimate educational interest if the official needs to review an education record in order to fulfill his or her professional responsibilities for the School.

## General Information

### Academic Calendar

The academic year is based on the early semester system. The first semester begins in late August and closes in mid-December; the second semester begins in mid-January and closes in mid-May.

### Classification of Students

Degree seeking undergraduates are classified as follows according to semester credit hours earned:

Undergraduate Year	Semester Credit Hours Earned
Freshman	0 to 29.9 semester credit hours
Sophomore	30 to 59.9 semester credit hours
Junior	60 to 89.9 semester credit hours
Senior	90 or more semester credit hours

### Part-Time Degree Students

A part-time degree student may enroll in any course for which he or she has the prerequisites or the permission of the department. Part-time degree students will be subject to all rules and regulations of Colorado School of Mines, but they may not:

1. Live in student housing;
2. Receive financial help in the form of School-sponsored scholarships or grants;
3. Participate in any School-recognized activity unless fees are paid;
4. Take advantage of activities provided by student fees unless such fees are paid.

Course work completed by a part-time degree student who subsequently changes to full-time status will be accepted as meeting degree requirements.

### Seniors in Graduate Courses

With the consent of the student's department/division and the Dean of Graduate Studies, a qualified senior may enroll in 500-level courses without being a registered graduate student. At least a 2.5 GPA is required. The necessary forms for attending these courses are available in the Registrar's Office. Seniors may not enroll in 600-level courses. Credits in 500-level courses earned by seniors may be applied toward an advanced degree at CSM only if:

1. The student gains admission to the Graduate School.
2. The student's graduate committee agrees that these credits are a reasonable part of his graduate program.
3. The student provides proof that the courses in question were not counted toward those required for the Bachelor's Degree.
4. Graduate courses applied to a graduate degree may not count toward eligibility for undergraduate financial aid. This may only be done if a student has been admitted to a Combined BS/MS degree program and has received the appropriate prior approvals.

Undergraduate students enrolled in graduate-level courses (500-level) are graded using the graduate grading system. See the CSM Graduate Bulletin for a description of the grading system used in graduate-level courses.

### Course Substitution

To substitute credit for one course in place of another course required as part of the approved curricula in the catalog, a student must receive the

approval of the Registrar, the heads of departments of the two courses, the head of the student's option department. There will be a periodic review by the Office of the Executive Vice President for Academic Affairs. Forms for this purpose are available in the Registrar's Office.

### Change of Bulletin

It is assumed that each student will graduate under the requirements of the bulletin in effect at the time of most recent admission. However, it is possible to change to any subsequent bulletin in effect while the student is enrolled in a regular semester.

To change bulletins, a form obtained from the Registrar's Office is presented for approval to the head of the student's option department. Upon receipt of approval, the form must be returned to the Registrar's Office.

### Students' Use of English

All Mines students are expected to show professional facility in the use of the English language.

English skills are emphasized, but not taught exclusively, in most of the humanities and social sciences courses and EPICS as well as in option courses in junior and senior years. Students are required to write reports, make oral presentations, and generally demonstrate their facility in the English language while enrolled in their courses.

The LAIS Writing Center is available to assist students with their writing. For additional information, contact the LAIS Division, Stratton 301; 303-273-3750.

### Summer Sessions

The summer term is divided into two independent units. Summer Session I is a 6-week period beginning on Monday following Spring Commencement. Summer Session II is a 6-week session which immediately follows Summer Session I.

### Dead Day

No required class meetings, examinations or activities may take place on the Friday immediately preceding final exams for the fall and spring terms. At their own discretion, faculty members may hold additional office hours or give a review session on Dead Day provided these activities are strictly optional. This day has been created as a break from regularly scheduled and/or required academic activities to allow students to prepare for their final examinations as they see fit.

### Final Examinations Policy

Final examinations are scheduled by the Registrar. With the exception of courses requiring a common time, all finals will be scheduled on the basis of the day and the hour the course is offered.

In general, all final examinations will be given only during the stated final examination period and are to appear on the Registrar's schedule. Faculty policy adopted in January 1976 provides that no exams (final or otherwise) may be scheduled during the week preceding final examinations week, with the possible exception of laboratory exams. The scheduling by an individual faculty member of a final exam during the week preceding final examinations week is to be avoided because it tends to hinder the students' timely completion of other course work and interfere with the schedules of other instructors. Faculty members should not override this policy, even if the students in the class vote to do so.

Academic activities that are explicitly disallowed by this policy include:

- Scheduling an in-class examination (final or otherwise, with the possible exception of laboratory exams) for any course during the week preceding final exams
- Scheduling an early make-up final examination - unless the student needs to miss the regularly scheduled final for school related business (athletics, school-related travel, etc...) and requested by the student and approved by the instructor.
- Assigning a take-home final examination for any course that is due during the week preceding final exams – unless the student needs to miss the regularly scheduled final for school related business (athletics, school-related travel, etc...) and requested by the student and approved by the instructor.

Academic activities that are allowable during the week preceding final exams include:

- The introduction of new materials
- Laboratory finals
- Required homework
- Required in-class assignments such as quizzes or worksheets (NO EXAMS)
  - Quizzes are shorter exercises which take place on a fairly regular basis (e.g. 15-30 minutes in duration, 6-10 times a semester).
  - Exams are major exercises which take place only a few times a semester (e.g. 50-120 minutes in duration, 2-4 times a semester).
- Major course assignments such as Final Presentations or Term Projects provided the assignment was assigned at least 4 weeks in advance or was clearly indicated in the course syllabus (Presentations must not be scheduled in conflict with regularly scheduled courses in departments outside of the one scheduling the presentation.)
- Take home finals (provided they are not due prior to finals week)
- Make-up exams for students who miss a scheduled exam in the prior week due to emergency, illness, athletic event, or other CSM sanctioned activity (provided this absence has been approved by the Associate Dean of Students)

(Note: These policies apply only to undergraduate courses. Students enrolled in graduate courses, are bound by policies outlined in the Graduate Bulletin.)

## Full-time Enrollment

Full-time enrollment for certification for Veterans Benefits, athletics, loans, most financial aid, etc. is 12 credit hours per semester for the fall and spring semesters. Full-time enrollment for Summer Session I and Summer Session II combined is 12 credit hours.

## Posthumous Degree Awards

The faculty may recognize the accomplishments of students who have died while pursuing their educational goals. If it is reasonable to expect that the student would have completed his or her degree requirements, the faculty may award a Baccalaureate or Graduate Degree that is in all ways identical to the degree the student was pursuing. Alternatively, the faculty may award a Posthumous BS, MS, or Ph.D. to commemorate students who distinguished themselves while at Mines by bringing honor to the School and its traditions.

Consideration for either of these degrees begins with a petition to the Faculty Senate from an academic department or degree granting unit. The petition should identify the degree sought. In the event that the degree-granting unit is seeking a conventional degree award, the

petition should include evidence of the reasonable expectations that the student would have completed his or her degree requirements. For a Baccalaureate, such evidence could consist of, but is not limited to:

- The student was a senior in the final semester of coursework,
- The student was enrolled in courses that would have completed the degree requirements at the time of death
- The student would have passed the courses with an acceptable grade, and would likely have fulfilled the requirements of the degree.

For a Graduate Degree:

- For graduate degrees not requiring a research product, the student was enrolled in courses that would have completed the degree requirements at the time of death, would have passed the courses with an acceptable grade, and would likely have fulfilled the requirements of the degree.
- For graduate degrees requiring a research product, the student had completed all course and mastery requirements pursuant to the degree and was near completion of the dissertation or thesis, and the student's committee found the work to be substantial and worthy of the degree.

The requirement that there be a reasonable expectation of degree completion should be interpreted liberally and weight should be given to the judgment of the departmental representative(s) supporting the petition.

In the event that the degree being sought is a Posthumous BS, MS, or Ph.D., the petition should include evidence that the student conducted himself or herself in the best tradition of a Mines' graduate and is therefore deserving of that honor.

## Curriculum Changes

The Board of Trustees of the Colorado School of Mines reserves the right to change any course of study or any part of the curriculum in keeping with educational and scientific developments. Nothing in this catalog or the registration of any student shall be considered as a contract between Colorado School of Mines and the student.

# Undergraduate Degree Requirements

## Bachelor of Science Degree

Upon completion of the requirements and upon being recommended for graduation by the faculty, and approved by the Board of Trustees, the undergraduate receives one of the following degrees:

- Bachelor of Science (Applied Mathematics and Statistics)
- Bachelor of Science (Chemical Engineering)
- Bachelor of Science (Chemical & Biochemical Engineering)
- Bachelor of Science (Chemistry)
- Bachelor of Science (Computer Science)
- Bachelor of Science (Economics)
- Bachelor of Science (Engineering)
- Bachelor of Science (Engineering Physics)
- Bachelor of Science (Geological Engineering)
- Bachelor of Science (Geophysical Engineering)
- Bachelor of Science (Metallurgical & Materials Engineering)
- Bachelor of Science (Mining Engineering)
- Bachelor of Science (Petroleum Engineering)

The following degrees have been approved by Colorado School of Mines and the Colorado Department of Higher Education. However, they do not yet have ABET accreditation:

- Bachelor of Science (Civil Engineering)
- Bachelor of Science (Electrical Engineering)
- Bachelor of Science (Environmental Engineering)
- Bachelor of Science (Mechanical Engineering)

## Degree Retirement Notification and Requirement Definition

Admission into the following degree program is suspended after the Fall 2012 semester:

- Mathematical and Computer Sciences

Both continuing students and students admitted into this degree program Fall, 2012 are encouraged to change programs to the newly approved programs replacing this older program (either Applied Mathematics and Statistics or Computer Science). Program requirements for students admitted Fall, 2012 wishing to remain in the older program are as defined in the 2011-2012 Undergraduate Bulletin.

## Graduation Requirements

To qualify for a Bachelor of Science degree from Colorado School of Mines, all candidates must satisfy the following requirements:

1. A minimum cumulative grade-point average of 2.000 for all academic work completed in residence.
2. A minimum cumulative grade-point average of 2.000 for courses in the candidate's major.
3. A minimum of 30 hours credit in 300 and 400 series technical courses in residence, at least 15 of which are to be taken in the senior year.
4. A minimum of 19 hours in humanities and social sciences courses.
5. The recommendation of their degree-granting department/ division to the faculty.

6. The certification by the Registrar that all required academic work is satisfactorily completed.
7. The recommendation of the faculty and approval of the Board of Trustees.

Seniors must submit an Application to Graduate two semesters prior to the anticipated date of graduation or upon completion of 90 hours, whichever comes first. Applications are available in the Registrar's Office.

Completed Minor and ASI forms are normally due to the Registrar's Office at the same as the application to graduate. If the Minor or ASI is added later, it is due no later than Census Day of the term in which the students is graduating.

The Registrar's Office provides the service of doing preliminary degree audits. *Ultimately, however, it is the responsibility of students to monitor the progress of their degrees.* It is also the student's responsibility to contact the Registrar's Office when there appears to be a discrepancy between the degree audit and the student's records.

All graduating students must officially check out of School. Checkout cards, available in the Dean of Student's Office, must be completed and returned one week prior to the expected date of completion of degree requirements.

No students, graduate or undergraduate, will receive diplomas until they have complied with all the rules and regulations of Colorado School of Mines and settled all accounts with the School. Transcript of grades and other records will not be provided for any student or graduate who has an unsettled obligation of any kind to the School.

**Multiple Degrees.** A student wishing to complete Bachelor of Science degrees in more than one degree program must receive permission from the heads of the appropriate departments to become a multiple degree candidate. The following requirements must be met by the candidate in order to obtain multiple degrees:

1. All requirements of each degree program must be met.
2. Any course which is required in more than one degree need be taken only once.
3. A course required in one degree program may be used as a technical elective in another, if it satisfies the restrictions of the elective.
4. Different catalogs may be used, one for each degree program.
5. No course substitutions are permitted in order to circumvent courses required in one of the degree programs, or reduce the number of courses taken. However, in the case of overlap of course content between required courses in the degree programs, a more advanced course may be substituted for one of the required courses upon approval of the head of each department concerned, and the Registrar on behalf of the office of Academic Affairs. The course substitution form can be obtained in the Registrar's Office.

**Degree Posting and Grade Changes.** Once the degree is posted, grade changes will be accepted for six weeks only. After six weeks has passed, no grade changes will be allowed for any courses on the official transcript.

**Commencement Participation.** To participate in May Commencement, no more than 6 semester credit hours can remain outstanding after the spring term. The student must show proof of summer registration for these 6 or fewer credits in order to be placed on the list for August completion. To participate in December convocation, the undergraduate student must be registered for all courses that lead to completion of the degree at the end of the same fall term.

**Courses Older Than 10 Years.** For returning students who wish to use courses completed more than 10 years prior, contact the Registrar's Office. These courses will not apply to current degrees without special approval from the degree-granting department or division.



## Undergraduate Programs

All programs are designed to fulfill the expectations of the *Profile of the Colorado School of Mines Graduate* in accordance with the mission and goals of the School. To enable this, the curriculum is made up of a common core, twelve undergraduate degree granting programs, and a variety of support and special programs. Each degree granting program has an additional set of goals which focus on the technical and professional expectations of that program. The common core and the degree granting programs are coupled through course sequences in mathematics and the basic sciences, in specialty topics in science and/or engineering, in humanities and the social sciences, and in design. Further linkage is achieved through a core course sequence which addresses system interactions among phenomena in the natural world, the engineered world, and the human world.

Through the alignment of the curriculum to these institutional goals and to the additional degree-granting program goals, all engineering programs are positioned for accreditation by the Accreditation Board for Engineering and Technology, and science programs are positioned for approval by their relevant societies, in particular the American Chemical Society for the Chemistry program.

## Course Numbering

### Numbering of Courses:

Course numbering is based on the content of material presented in courses.

### Course Numbering:

Material	Level	Division
100-199	Freshman level	Lower division
200-299	Sophomore level	Lower division
300-399	Junior level	Upper division
400-499	Senior level	Upper division
500-699	Graduate level	
Over 700	Graduate Research or Thesis level	

## Overview: Core & Distributed Course Requirements

Core & distributed course requirements for Bachelor of Science degrees are comprised of the four following groups:

- 1. Core Curriculum** - Students in all degree options (majors) are required to complete all course requirements listed in this group.
- 2. Distributed Humanities and Social Sciences Requirement** - Students in all degree options (majors) must complete this requirement.
- 3. Distributed Science Requirement** - Students in all degree options (majors) are required to complete a minimum of three out of five courses from this list. For some majors the three courses are prescribed, while other majors leave the choices to the student. See the DSR chart to determine the requirements for your particular major program.
- 4. Distributed Engineering Requirement** - Students pursuing an engineering-based degree are required to complete the courses in this list. However, each engineering program will place the courses in the sophomore year or later based on the flow of the particular program. These are not considered freshman year courses.

## 1) The Core Curriculum

Core requirements are applicable to all undergraduate students:

### In Mathematics and the Basic Sciences

MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0
MATH225	DIFFERENTIAL EQUATIONS *	3.0
CHGN121	PRINCIPLES OF CHEMISTRY I	4.0
PHGN100	PHYSICS I - MECHANICS	4.5

### In Design

EPIC151	DESIGN (EPICS) I	3
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### In Systems

SYGN200	HUMAN SYSTEMS	3.0
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### In Humanities and the Social Sciences

LAIS100	NATURE AND HUMAN VALUES	4.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0

### In Physical Education (four separate semesters including the following) \*\*

PAGN101	PHYSICAL EDUCATION	0.5
PAGN102	PHYSICAL EDUCATION	0.5
PAGN2XX	PHYSICAL EDUCATION	0.5
PAGN2XX	PHYSICAL EDUCATION	0.5

### In Freshman Orientation and Success

CSM101	FRESHMAN SUCCESS SEMINAR	0.5
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### Free electives \*\*\*

Total Hours		39.0
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\* 2 semester hours in Differential Equations for Geological Engineering majors.

\*\* A minimum of 2 credit hours. Neither PAGN101 nor PAGN102 may be repeated for credit. See the Physical Education and Athletics section for specifics.

\*\*\* A minimum of 9 hours are included within each degree granting program. With the exception of the restrictions mentioned below, the choice of free elective courses to satisfy degree requirements is unlimited. The restrictions are:

1. The choice must not be in conflict with any Graduation Requirements ([bulletin.mines.edu/undergraduate/sectionundergraduateinformation/generalinformation](http://bulletin.mines.edu/undergraduate/sectionundergraduateinformation/generalinformation)).
2. Free electives to satisfy degree requirements may not exceed three semester hours in activity courses such as band, chorus, studio art, physical education, and athletics courses combined.

## 2) Distributed Humanities and Social Science Requirement

DHSS Requirements are applicable to all undergraduate students:

Two courses from the approved list of requirements *	6.0
At least one course at the 400-level from approved list of requirements *	3.0
Total Hours	9.0

\* See the approved list in the Liberal Arts and International Studies (<https://nextbulletin.mines.edu/undergraduate/programs/earthscieng/liberalartsandinternationalstudies>) section of this Bulletin.

Complete a minimum of three of the five courses listed according to your major requirements on the following chart: (REQ = Required, CHOICE = Student's Choice, NA = Not allowed)

### 3) Distributed Science Requirement

DS Requirements are applicable to all undergraduate students:

Program	BELS101	SYGN101	PHGN200	CHGN122	CSCI101
APPLIED MATHEMATICS AND STATISTICS	CHOICE	CHOICE	REQ	CHOICE	REQ
CHEMISTRY	CHOICE	CHOICE	REQ	REQ	NA
CHEMICAL ENGINEERING	REQ	NA	REQ	REQ	NA
CHEMICAL & BIOCHEMICAL ENGINEERING	REQ	NA	REQ	REQ	NA
CIVIL ENGINEERING	NA	REQ	REQ	REQ	NA
COMPUTER SCIENCE	CHOICE	CHOICE	REQ	CHOICE	REQ
ECONOMICS	CHOICE	CHOICE	CHOICE	CHOICE	CHOICE
ELECTRICAL ENGINEERING	CHOICE	CHOICE	REQ	CHOICE	CHOICE
ENGINEERING-CIVIL SPECIALTY	CHOICE	CHOICE	REQ	REQ	CHOICE
ENGINEERING-ELECTRICAL SPECIALTY	CHOICE	CHOICE	REQ	CHOICE	CHOICE
ENGINEERING-ENVIRONMENTAL SPECIALTY	CHOICE	CHOICE	REQ	REQ	NA
ENGINEERING-MECHANICAL SPECIALTY	CHOICE	CHOICE	REQ	REQ	CHOICE
ENVIRONMENTAL ENGINEERING	NA	REQ	REQ	REQ	NA
GEOLOGICAL-ENGINEERING	NA	REQ	REQ	REQ	CHOICE
GEOPHYSICAL-ENGINEERING	CHOICE	REQ	REQ	CHOICE	CHOICE
MATHEMATICAL & COMPUTER SCIENCES	CHOICE	CHOICE	REQ	CHOICE	REQ
MECHANICAL ENGINEERING	CHOICE	CHOICE	REQ	REQ	CHOICE
METALLURGICAL & MATERIALS ENGINEERING	CHOICE	CHOICE	REQ	REQ	NA
MINING ENGINEERING	NA	REQ	REQ	REQ	NA
PETROLEUM ENGINEERING	NA	REQ	REQ	REQ	NA
ENGINEERING PHYSICS	CHOICE	CHOICE	REQ	REQ	NA

### 4) Distributed Engineering Requirement (see major program listing)

DE Requirements are applicable to undergraduate students in engineering disciplines as specified by the major program. See Department and Division program descriptions in this Bulletin for specific courses required.

EPIC251	DESIGN (EPICS) II (Required by all ABET accredited engineering degree programs.)	3.0
One of the following Thermodynamics courses may be required:		3.0
DCGN209	DIST CORE THERMO	
DCGN210	INTRO TO ENG THERMODYNAMICS	
EGGN371	THERMODYNAMICS I	
DCGN241	DIST CORE - STATICS	3
EGGN281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER	3
Total Hours		12.0

### The Freshman Year

Freshmen in all programs normally take similar subjects, as listed below:

*subject code\*\* and course number*

Freshman		lec	lab	sem.hrs
Fall				
CHGN121	PRINCIPLES OF CHEMISTRY	3.0	3.0	4

MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4
EBGN201	PRINCIPLES OF ECONOMICS*	3.0		3
LAIS100	NATURE AND HUMAN VALUES*	4.0		4
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5
PAGN101	PHYSICAL EDUCATION		0.5	0.5
<b>Spring</b>			<b>lec</b>	<b>lab</b>
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4
EPIC151	DESIGN (EPICS) I*	2.0	3.0	3
PHGN100	PHYSICS I - MECHANICS	3.5	3.0	4.5
PAGN102	PHYSICAL EDUCATION		2.0	0.5
Distributed Science Course*				4.0
				<b>16.0</b>

Total Hours: 32.0

\* For scheduling purposes, registration in combinations of SYGN101, BELS101, LAIS100, EBG201, and EPIC151 will vary between the fall and spring semesters. Students admitted with acceptable advanced placement credits will be registered in accordance with their advanced placement status.

\*\* Key to Subject Codes  
 ChEN Chemical Engineering  
 CHGC Geochemistry  
 CHGN Chemistry  
 CSCI Computer Science  
 DCGN Core Science and Engineering Fundamentals  
 EBGN Economics and Business  
 EGES Engineering Systems (Engineering)  
 EGGN Engineering  
 ENGY Energy  
 EPIC EPICS  
 ESGN Environmental Science and Engineering  
 GEGN Geological Engineering  
 GEGX Geochemical Exploration (Geology)  
 GEOC Oceanography (Geology)  
 GEOL Geology  
 GOGN Geo-Engineering (Mining)  
 GPGN Geophysical Engineering  
 HNRS Honors Program  
 LAIS Liberal Arts & International Studies  
 LICM Communication  
 LIFL Foreign Languages  
 LIMU Band; Choir MATH Mathematics  
 MNGN Mining Engineering  
 MSGN Military Science  
 MTGN Metallurgical & Materials Engr'ng  
 NUGN Nuclear Engineering  
 PAGN Physical Education and Athletics  
 PEGN Petroleum Engineering  
 PHGN Physics  
 SYGN Core sequence in Systems

## The Sophomore Year

Requirements for the sophomore year are listed within each degree granting program. Continuing requirements for satisfying the core are met in the sophomore, junior and senior years. It is advantageous, but not essential, that students select one of the undergraduate degree programs early in the sophomore year.

## Curriculum Changes

In accordance with the statement on Curriculum Changes ([bulletin.mines.edu/undergraduate/sectionundergraduateinformation/generalinformation](http://bulletin.mines.edu/undergraduate/sectionundergraduateinformation/generalinformation)), the Colorado School of Mines makes improvements in its curriculum from time to time. To confirm that they are progressing according to the requirements of the curriculum, students should consult their academic advisors on a regular basis and should carefully consult any Bulletin Addenda that may be published.

# Core & Distributed Course Requirements - Course Descriptions

## 1) Core Curriculum Mathematics and the Basic Sciences

### Chemistry

CHGN121. PRINCIPLES OF CHEMISTRY I (I, II) Study of matter and energy based on atomic structure, correlation of properties of elements with position in periodic chart, chemical bonding, geometry of molecules, phase changes, stoichiometry, solution chemistry, gas laws, and thermochemistry. 3 hours lecture, 3 hours lab; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-SC1.

### Mathematics

MATH111. CALCULUS FOR SCIENTISTS AND ENGINEERS I (I, II, S) First course in the calculus sequence, including elements of plane geometry. Functions, limits, continuity, derivatives and their application. Definite and indefinite integrals; Prerequisite: precalculus. 4 hours lecture; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-MA1.

MATH112. CALCULUS FOR SCIENTISTS AND ENGINEERS II (I, II, S) Vectors, applications and techniques of integration, infinite series, and an introduction to multivariate functions and surfaces. Prerequisite: Grade of C or better in MATH111. 4 hours lecture; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-MA1.

MATH113. CALCULUS FOR SCIENTISTS AND ENGINEERS II - SHORT FORM (I, II) This is a bridge course for entering freshmen and new transfer students to CSM who have either a score of 5 on the BC AP Calculus exam or who have taken an appropriate Calculus II course at another institution (determined by a departmental review of course materials). Two, three and n-dimensional space, vectors, curves and surfaces in 3-dimensional space, cylindrical and spherical coordinates, and applications of these topics. Prerequisites: Consent of Department. 1 hour lecture; 1 semester hour.

MATH122. CALCULUS FOR SCIENTISTS AND ENGINEERS II HONORS (I) Same topics as those covered in MATH112 but with additional material and problems. Prerequisite: Consent of Department. 4 hours lecture; 4 semester hours.

MATH213. CALCULUS FOR SCIENTISTS AND ENGINEERS III (I, II, S) Multivariable calculus, including partial derivatives, multiple integration, and vector calculus. Prerequisite: Grade of C or better in MATH112 or MATH122. 4 hours lecture; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-MA1.

MATH214. CALCULUS FOR SCIENTIST AND ENGINEERS III - SHORT FORM (I, II) This is a bridge course for entering freshmen and new transfer students to CSM who have taken an appropriate Calculus III course at another institution (determined by a departmental review of course materials). Vector Calculus including line and surface integrals with applications to work and flux, Green's Theorem, Stokes' Theorem and the Divergence Theorem. Prerequisites: Consent of Department. 1 hour lecture; 1 semester hour.

MATH222. INTRODUCTION TO DIFFERENTIAL EQUATIONS FOR GEOLOGISTS & GEOLOGICAL ENGINEERS (II). An introduction to

differential equations with a special emphasis on problems in the earth related fields. Topics include first and second order ordinary differential equations, Laplace Transforms, and applications relevant to the earth related fields. Prerequisites: MATH213 or MATH223 or MATH224. Student must also be a declared major in Geology and Geological Engineering. 2 hours lecture; 2 semester hours.

Note: Only one of MATH222 and MATH225 can be counted toward graduation. Any student who completes MATH222 and then changes majors out of Geology and Geological Engineering will be expected to complete MATH225 to meet graduation requirements. (In this case, MATH222 cannot be counted toward graduation in any manner - even as a free elective.)

**MATH223. CALCULUS FOR SCIENTISTS AND ENGINEERS III HONORS (II)** Same topics as those covered in MATH213 but with additional material and problems. Prerequisite: Grade of C or better in MATH122. 4 hours lecture; 4 semester hours.

**MATH224. CALCULUS FOR SCIENTISTS AND ENGINEERS III HONORS(AP) (I)** Early introduction of vectors, linear algebra, multivariable calculus. Vector fields, line and surface integrals. Prerequisite: Consent of Department. 4 hours lecture; 4 semester hours.

**MATH225. DIFFERENTIAL EQUATIONS (I, II, S)** Classical techniques for first and higher order equations and systems of equations. Laplace transforms. Phase plane and stability analysis of non-linear equations and systems. Applications to physics, mechanics, electrical engineering, and environmental sciences. May not also receive credit for MATH222. Prerequisite: MATH213, MATH223 or MATH224. 3 hours lecture; 3 semester hours.

**MATH235. DIFFERENTIAL EQUATIONS HONORS (II)** Same topics as those covered in MATH315 but with additional material and problems. Prerequisite: Consent of Department. 3 hours lecture; 3 semester hours.

## Physics

**PHGN100. PHYSICS I - MECHANICS (I, II, S)** A first course in physics covering the basic principles of mechanics using vectors and calculus. The course consists of a fundamental treatment of the concepts and applications of kinematics and dynamics of particles and systems of particles, including Newton's laws, energy and momentum, rotation, oscillations, and waves. Prerequisite: MATH111 and concurrent enrollment in MATH112/122 or consent of instructor. 2 hours lecture; 4 hours studio; 4.5 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-SC1.

## Design

### Engineering Practices Introductory Course Sequence (EPICS)

**EPIC151 Design EPICS I (I,II,S).** Design EPICS I introduces students to a design process that includes open-ended problem solving and teamwork integrated with the use of computer software as tools to solve engineering problems. Computer applications emphasize graphical visualization and production of clear and coherent graphical images, charts, and drawings. Teams assess engineering ethics, group dynamics and time management with respect to decision-making. The course emphasizes written technical communications and introduces oral presentations. 3 semester hours.

**EPIC155. EPICS I Graphics (I,II).** Instruction and practice in mechanical sketching and computer-aided drafting methods. Specific lessons include perspective sketching, geometric construction, isometric and orthographic views, dimensions, and sections. Homework is assigned

weekly. Each unit culminates in one in-class proficiency examination or extended written assignment, plus one capstone design portfolio. Prerequisites: permission of the EPICS Program Director. 1hour lecture, 1 hour laboratory, 1 semester hour.

**Note:** Completion of this course in lieu of EPIC 151 is by permission only and does not alter total hours required for completion of the degree.

## Systems

**SYGN200. HUMAN SYSTEMS (I, II)** This course in the CSM core curriculum articulates with LAIS100: Nature and Human Values and with the other systems courses. Human Systems is an interdisciplinary historical examination of key systems created by humans - namely, political, economic, social, and cultural institutions - as they have evolved world-wide from the inception of the modern era (ca. 1500) to the present. This course embodies an elaboration of these human systems as introduced in their environmental context in Nature and Human Values and will reference themes and issues explored therein. It also demonstrates the cross-disciplinary applicability of the "systems" concept. Assignments will give students continued practice in writing. Prerequisite: LAIS100. 3 semester hours.

## Humanities and the Social Sciences

**EBGN201. PRINCIPLES OF ECONOMICS-(I,II,S)** Introduction to microeconomics and macroeconomics. This course focuses on applying the economic way of thinking and basic tools of economic analysis. Economic effects of public policies. Analysis of markets for goods, services and resources. Tools of cost-benefit analysis. Measures of overall economic activity. Determinants of economic growth. Monetary and fiscal policy. Prerequisites: None. 3 hours lecture; 3 semester hours.

**LAIS100. NATURE AND HUMAN VALUES (NHV)** Nature and Human Values will focus on diverse views and critical questions concerning traditional and contemporary issues linking the quality of human life and Nature, and their interdependence. The course will examine various disciplinary and interdisciplinary approaches regarding two major questions: 1) How has Nature affected the quality of human life and the formulation of human values and ethics? (2) How have human actions, values, and ethics affected Nature? These issues will use cases and examples taken from across time and cultures. Themes will include but are not limited to population, natural resources, stewardship of the Earth, and the future of human society. This is a writing-intensive course that will provide instruction and practice in expository writing, using the disciplines and perspectives of the Humanities and Social Sciences. 4 hours lecture/ seminar; 4 semester hours.

## Physical Education

**PAGN101. PHYSICAL EDUCATION (I) (Required)** A general overview of life fitness basics which includes exposure to educational units of Nutrition, Stress Management, Drug and Alcohol Awareness. Instruction in Fitness units provides the student an opportunity for learning and the beginning basics for a healthy life style.

**PAGN102. PHYSICAL EDUCATION (II) (Required)** Sections in physical fitness and team sports, relating to personal health and wellness activities. Prerequisite: PAGN101 or consent of the Department Head. See Physical Education and Athletics section toward the end of the Bulletin for available 200-level courses.

## Freshman Orientation and Success

**CSM101. FIRST-YEAR ADVISING AND MENTORING PROGRAM** is a "college transition" course, taught in small groups. Emphasis is placed on fostering connectedness to CSM, developing an appreciation of the

value of a Mines education, and learning the techniques and University resources that will allow freshmen to develop to their fullest potential at CSM. Course Objectives: Become an integrated member of the CSM community; explore, select and connect with an academic major; and develop as a person and a student. 9 meetings during semester; 0.5 semester hours.

## 2) Distributed Humanities and Social Science Requirement

See Liberal Arts and International Studies (<http://lais.mines.edu/LAIS-HSS-Requirements>) section for the list of approved courses and the associated course descriptions.

## 3) Distributed Science Requirement

BELS101 BIOLOGICAL AND ENVIRONMENTAL SYSTEMS (I,II)

This course presents the basic principles and properties of biological and environmental systems. It considers the chemistry of life and the structure and function of cells and organisms. Concepts related to physiology, energetics, and genetics are introduced. The fundamentals of environmental science are presented and we consider how organisms interact with each other and with their environment and discuss the possibilities and problems of these interactions. Basic engineering principles of thermodynamics, kinetics, mass balance, transport phenomena and material science are presented and applied to biological systems. 4 semester hours

CHGN122. PRINCIPLES OF CHEMISTRY II (I, II, S) Continuation of CHGN121 concentrating on chemical kinetics, thermodynamics, electrochemistry, organic nomenclature, and chemical equilibrium (acid-base, solubility, complexation, and redox). Laboratory experiments emphasizing quantitative chemical measurements. Prerequisite: Grade of C or better in CHGN121. 3 hours lecture; 3 hours lab, 4 semester hours.

CSCI101. INTRODUCTION TO COMPUTER SCIENCE (I, II, S) An introductory course to the building blocks of Computer Science. Topics include conventional computer hardware, data representation, the role of operating systems and networks in modern computing, algorithm design, large databases, SQL, and security. A popular procedural programming language will be learned by students and programming assignments will explore ideas in algorithm runtimes, computer simulation, computational techniques in optimization problems, client-server communications, encryption, and database queries. Prerequisite: none. 3 hours lecture; 3 semester hours.

PHGN200. PHYSICS II-ELECTROMAGNETISM AND OPTICS (I, II, S) Continuation of PHGN100. Introduction to the fundamental laws and concepts of electricity and magnetism, electromagnetic devices, electromagnetic behavior of materials, applications to simple circuits, electromagnetic radiation, and an introduction to optical phenomena. Prerequisite: Grade of C or higher in PHGN100, concurrent enrollment in MATH213/223. 2 hours lecture; 4 hours studio; 4.5 semester hours.

SYGN101. EARTH AND ENVIRONMENTAL SYSTEMS (I, II, S)

Fundamental concepts concerning the nature, composition and evolution of the lithosphere, hydrosphere, atmosphere and biosphere of the earth integrating the basic sciences of chemistry, physics, biology and mathematics. Understanding of anthropological interactions with the natural systems, and related discussions on cycling of energy and mass, global warming, natural hazards, land use, mitigation of environmental problems such as toxic waste disposal, exploitation and conservation of energy, mineral and agricultural resources, proper use of water resources, biodiversity and construction. 3 hours lecture, 3 hours lab; 4 semester hours.

## 4) Distributed Engineering Requirement

DCGN209. INTRODUCTION TO CHEMICAL THERMODYNAMICS

(I, II, S) Introduction to the fundamental principles of classical thermodynamics, with particular emphasis on chemical and phase equilibria. Volume- temperature-pressure relationships for solids, liquids, and gases; ideal and non-ideal gases. Introduction to kinetic-molecular theory of ideal gases and the Maxwell-Boltzmann distributions. Work, heat, and application of the First Law to closed systems, including chemical reactions. Entropy and the Second and Third Laws; Gibbs Free Energy. Chemical equilibrium and the equilibrium constant; introduction to activities & fugacities. One- and two-component phase diagrams; Gibbs Phase Rule. Prerequisites: CHGN121, CHGN124, MATH111, MATH112, PHGN100. 3 hours lecture; 3 semester hours. Students with credit in DCGN210 may not also receive credit in DCGN209.

DCGN210. INTRODUCTION TO ENGINEERING THERMODYNAMICS

(I, II) Introduction to the fundamental principles of classical engineering thermodynamics. Application of mass and energy balances to closed and open systems including systems undergoing transient processes. Entropy generation and the second law of thermodynamics for closed and open systems. Introduction to phase equilibrium and chemical reaction equilibria. Ideal solution behavior. Prerequisites: CHGN121, CHGN124, MATH111, MATH112, PHGN100. 3 hours lecture; 3 semester hours. Students with credit in DCGN209 may not also receive credit in DCGN210.

DCGN241. STATICS (I, II, S) Forces, moments, couples, equilibrium, centroids and second moments of areas, volumes and masses, hydrostatics, friction, virtual work. Applications of vector algebra to structures. Prerequisite: PHGN100 and credit or concurrent enrollment in MATH112. 3 hours lecture; 3 semester hours.

EGGN371. THERMODYNAMICS I (I, II, S) A comprehensive treatment of thermodynamics from a mechanical engineering point of view.

Thermodynamic properties of substances inclusive of phase diagrams, equations of state, internal energy, enthalpy, entropy, and ideal gases. Principles of conservation of mass and energy for steady-state and transient analyses. First and Second Law of thermodynamics, heat engines, and thermodynamic efficiencies. Application of fundamental principles with an emphasis on refrigeration and power cycles. Prerequisite: MATH213/223. 3 hours lecture; 3 semester hours.

EGGN281. INTRODUCTION TO ELECTRICAL CIRCUITS,

ELECTRONICS AND POWER (I, II, S) This course provides an engineering science analysis of electrical circuits. DC and single-phase AC networks are presented. Transient analysis of RC, RL, and RLC circuits is studied as is the analysis of circuits in sinusoidal steady-state using phasor concepts. The following topics are included: DC and single-phase AC circuit analysis, current and charge relationships. Ohm's Law, resistors, inductors, capacitors, equivalent resistance and impedance, Kirchhoff's Laws, Thévenin and Norton equivalent circuits, superposition and source transformation, power and energy, maximum power transfer, first order transient response, algebra of complex numbers, phasor representation, time domain and frequency domain concepts, and ideal transformers. The course features PSPICE, a commercial circuit analysis software package. Prerequisite: PHGN200. 3 hours lecture; 3 semester hours.

**Beginning Fall 2011, EPIC2xx courses can be taken in lieu of EPIC251, subject to approval by academic departments granting ABET-accredited engineering degrees. These courses adhere to the Design EPICS II learning objectives, which are described for each course.**

EPIC251 Design EPICS II (I,II,S). Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communications with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. Teams analyze team dynamics through weekly team meetings and progress reports. The course emphasizes oral presentations and builds on written communications techniques introduced in Design EPICS I. Prerequisite: EPIC151. 3 semester hours.

EPIC252 Leadership in Global Design EPICS II (I,II). EPIC252 can be taken in place of EPIC251. Students integrate teamwork, communications, computer software applications and project management skills to solve engineering problems, and the deliverables are equivalent to those for EPICS 251. In addition, students examine the global nature of modern engineering design by combining a project of global interest with an emphasis on leadership and communications skills across a variety of cultures. To support these objectives, students conduct research in the effect of international influences and cultural diversity on the acceptance and implementation of their design solutions. Prerequisite: EPIC151. 4 semester hours.

EPIC261 – GIS (I,II): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. EPICS261 – EPICS II GIS incorporates instruction and practice in ArcView, a geographic information system software package, to enable students to capture, manage, analyze and display geographic information in maps, charts or tables, with projects that depend on GIS for their design solutions. Recent projects involving the use of GIS include campus emergency management and room usage maps, groundwater testing well analysis and reporting for the Colorado Department of Agriculture and trail maps for the Foothills Recreation District. Students interested in Petroleum Engineering, or another major where GIS is used, should consider registering for this section. Geology and Geological Engineering students are directed to register for EPIC264 – EPICS II Geology GIS, which is a different course. Prerequisite: EPIC151. 3 semester hours.

EPIC262-AUTOCAD (I,II): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. AutoCAD incorporates semester-long instruction and practice in AutoCAD computer-aided drawing, with projects involving the use of AutoCAD in design solutions. Recent projects include remodeling plans for the Ford Building, a solar tree house education center, an environmentally sustainable house, and new structural designs for use in Haiti following the January 2010 earthquake in Haiti. Students in the Civil Engineering specialty in Engineering, the Environmental Engineering specialty in Engineering, or Mining Engineering, should consider registering for this course. Prerequisite: EPIC151. 3 semester hours.

EPIC263 – DRILLING ENGINEERING (S): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and

communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. This course implements the design process with drilling technology and automated drilling processes to solve multidisciplinary drilling project issues. Based on the project conditions set by the client, various alternatives and configurations are possible to meet the project objectives. Teams select and build a body of evidence to market their most desirable alternatives. Prerequisite: EPIC151. 3 semester hours.

EPIC264 – GEOLOGY GIS(II): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. There are typically eight geology-based projects in the course, based on the needs of multiple outside clients. Many of the course deliverables are maps with associated data sets. Prerequisite: EPIC151. 3 semester hours.

EPIC265 – BIOCHEMICAL PROCESSES (I,II): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. This course emphasizes steady-state design in biochemical production processes and provides exposure to information about various manufacturing and research segments. Projects are selected to represent real-world biochemical engineering problems in biofuels, food sciences and pharmaceuticals, wherein creative and critical thinking skills are necessary. These projects may often involve computer-based optimization to obtain a solution. Students are exposed to the range of core engineering computation skills that are utilized in both the chemical and biochemical engineering disciplines, and subsequently employ these skills to their design projects. This approach also integrates the content of future courses with the application of engineering design. Prerequisite: EPIC151. 3 semester hours.

EPIC266 – CHEMICAL PROCESSES (I, II): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. This course emphasizes steady-state design in chemical production processes and provides exposure to information about various manufacturing and research segments. Projects are selected to represent real-world chemical engineering problems in the energy sectors, chemicals and environmental stewardship, wherein creative and critical thinking skills are necessary. These projects may often involve computer-based optimization to obtain a solution. Students are exposed to the range of core engineering computation skills that are utilized in both the chemical and biochemical engineering disciplines, and subsequently employ these skills to their design projects. This approach also integrates the content of future courses with the application of engineering design. Prerequisite: EPIC151. 3 semester hours.

EPIC267 – CIVIL ENGINEERING (II): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. Prerequisite: EPIC151. 3 semester hours.

EPIC268 – GEOPHYSICAL ENGINEERING (II): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. Students work on projects from the geophysical engineering practice in which they analyze (process, model, visualize) data. In their projects, students encounter limitations and uncertainties in data and learn quantitative means for handling them. They learn how to analyze errors in data, and their effects on data interpretation and decision making. Prerequisite: EPIC151. 3 semester hours.

# Combined Undergraduate/ Graduate Degree Programs

## A. Overview

Many degree programs offer CSM undergraduate students the opportunity to begin work on a Graduate Certificate, Professional Master's Degree, Master's Degree or Doctoral Degree while completing the requirements for their Bachelor's Degree. These combined Bachelors-Masters/Doctoral programs have been created by Mines faculty in those situations where they have deemed it academically advantageous to treat undergraduate and graduate degree programs as a continuous and integrated process. These are accelerated programs that can be valuable in fields of engineering and applied science where advanced education in technology and/or management provides the opportunity to be on a fast track for advancement to leadership positions. These programs also can be valuable for students who want to get a head start on graduate education.

The combined programs at Mines offer several advantages to students who choose to enroll in them:

1. Students can earn a graduate degree in their undergraduate major or in a field that complements their undergraduate major.
2. Students who plan to go directly into industry leave Mines with additional specialized knowledge and skills which may allow them to enter their career path at a higher level and advance more rapidly. Alternatively, students planning on attending graduate school can get a head start on their graduate education.
3. Students can plan their undergraduate electives to satisfy prerequisites, thus ensuring adequate preparation for their graduate program.
4. Early assignment of graduate advisors permits students to plan optimum course selection and scheduling in order to complete their graduate program quickly.
5. Early acceptance into a Combined Degree Program leading to a Graduate Degree assures students of automatic acceptance into full graduate status if they maintain good standing while in early-acceptance status.
6. In many cases, students will be able to complete both a Bachelor's and a Master's Degrees in five years of total enrollment at Mines.

Certain graduate programs may allow Combined Degree Program students to fulfill part of the requirements of their graduate degree by including up to six hours of specified course credits which also were used in fulfilling the requirements of their undergraduate degree. These courses may only be applied toward fulfilling Doctoral degree or, Master's degree requirements beyond the institutional minimum Master's degree requirement of 30 credit hours. Courses must meet all requirements for graduate credit, but their grades are not included in calculating the graduate GPA. Check the departmental section of the Bulletin to determine which programs provide this opportunity.

## B. Admission Process

A student interested in applying into a graduate degree program as a Combined Degree Program student should first contact the department or division hosting the graduate degree program into which he/she wishes to apply. Initial inquiries may be made at any time, but initial contacts made soon after completion of the first semester, Sophomore year are recommended. Following this initial inquiry, departments/ divisions will

provide initial counseling on degree application procedures, admissions standards and degree completion requirements.

Admission into a graduate degree program as a Combined Degree Program student can occur as early as the first semester, Junior year, and must be granted no later than the end of registration, last semester Senior year. Once admitted into a graduate degree program, students may enroll in 500-level courses and apply these directly to their graduate degree. To apply, students must submit the standard graduate application package for the graduate portion of their Combined Degree Program. Upon admission into a graduate degree program, students are assigned graduate advisors. Prior to registration for the next semester, students and their graduate advisors should meet and plan a strategy for completing both the undergraduate and graduate programs as efficiently as possible. Until their undergraduate degree requirements are completed, students continue to have undergraduate advisors in the home department or division of their Bachelor's Degrees.

## C. Requirements

Combined Degree Program students are considered undergraduate students until such time as they complete their undergraduate degree requirements. Combined Degree Program students who are still considered undergraduates by this definition have all of the privileges and are subject to all expectations of both their undergraduate and graduate programs. These students may enroll in both undergraduate and graduate courses (see section D below), may have access to departmental assistance available through both programs, and may be eligible for undergraduate financial aid as determined by the Office of Financial Aid. Upon completion of their undergraduate degree requirements, a Combined Degree Program student is considered enrolled full-time in his/her graduate program. Once having done so, the student is no longer eligible for undergraduate financial aid, but may now be eligible for graduate financial aid. To complete their graduate degree, each Combined Degree Program student must register as a graduate student for at least one semester.

Once admitted into a graduate program, undergraduate Combined Degree Program students must maintain good standing in the Combined Degree Program by maintaining a minimum semester GPA of 3.0 in all courses taken. Students not meeting this requirement are deemed to be making unsatisfactory academic progress in the Combined Degree Program. Students for whom this is the case are subject to probation and, if occurring over two semesters, subject to discretionary dismissal from the graduate portion of their program as defined in the Unsatisfactory Academic Performance section of this Bulletin.

Upon completion of the undergraduate degree requirements, Combined Degree Program students are subject to all requirements (e.g., course requirements, departmental approval of transfer credits, research credits, minimum GPA, etc.) appropriate to the graduate program in which they are enrolled

## D. Enrolling in Graduate Courses as a Senior in a Combined Program

As described in the Undergraduate Bulletin, seniors may enroll in 500-level courses. In addition, undergraduate seniors who have been granted admission through the Combined Degree Program into thesis-based degree programs (Masters or Doctoral) may, with graduate advisor approval, register for 700-level research credits appropriate to Masters-level degree programs. With this single exception, while a Combined Degree Program student is still completing his/her undergraduate degree, all of the conditions described in the Undergraduate Bulletin for undergraduate enrollment in graduate-level courses apply. 700-



level research credits are always applied to a student's graduate degree program.

If an undergraduate Combined Degree Program student would like to enroll in a 500-level course and apply this course directly to his/her graduate degree, he/she must be formally accepted as a combined program student through the Office of Graduate Studies and notify the Registrar of the intent to do so at the time of enrollment in the course. The Registrar will forward this information to Financial Aid for appropriate action. Be aware that courses taken as an undergraduate student but applied directly toward a graduate degree are not eligible for undergraduate financial aid or the Colorado Opportunity Fund. If prior consent is not received or if the student has not been accepted by OGS as a combined program student, all 500-level graduate courses taken as an undergraduate Combined Degree Program student will be applied to the student's undergraduate degree transcript. If these are not used toward an undergraduate degree requirement, they may, with program consent, be applied to a graduate degree program as transfer credit. All regular regulations and limitations regarding the use of transfer credit to a graduate degree program apply to these credits.

# Applied Mathematics & Statistics

<http://ams.mines.edu>

## Program Description

The Applied Mathematics and Statistics Department (AMS) offers an undergraduate degree in which the student will be exposed to a breadth of coursework in computational mathematics, applied mathematics, and statistics. In the senior year, students may choose an area of emphasis in either Computational and Applied Mathematics (CAM) or Statistics (STAT). Both of these options emphasize technical competence, problem solving, teamwork, projects, relation to other disciplines, and verbal, written, and graphical skills.

The Department provides the teaching skills and technical expertise to develop capabilities in computational mathematics, applied mathematics, and statistics for all Colorado School of Mines (CSM) students. In addition, AMS programs support targeted undergraduate majors and graduate degree programs relevant to mathematical and statistical aspects of the CSM mission.

In a broad sense, these programs stress the development of practical application and techniques to enhance the overall attractiveness of applied mathematics and statistics majors to a wide range of employers in industry. More specifically, we utilize a summer field session program to introduce concepts and techniques in advanced mathematics and the senior capstone experiences in Computational and Applied Mathematics, and Statistics to engage high-level undergraduate students in problems of practical applicability for potential employers. These courses are designed to simulate an industrial job or research environment. The close collaboration with potential employers or professors improves communication between our students and the private sector as well as with sponsors from other disciplines on campus. Applied Mathematics and Statistics majors can use their free electives to take additional courses of special interest to them. This adds to the flexibility of the program and qualifies students for a wide variety of careers.

The AMS Department also supports the legacy Bachelor of Mathematical and Computer Sciences degree with options in Computational and Applied Mathematics (CAM), Statistics (STAT), and Computer Science (CS). For more information about the Bachelor of Mathematical and Computer Sciences degree please refer to previous years' bulletins.

## Program Educational Objectives

### (Bachelor of Science in Applied Mathematics and Statistics)

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria, the Applied Mathematics and Statistics Program at CSM has established the following program educational objectives:

Students will demonstrate technical expertise within mathematics and statistics by:

- Designing and implementing solutions to practical problems in science and engineering, and
- Using appropriate technology as a tool to solve problems in mathematics.

Students will demonstrate a breadth and depth of knowledge within mathematics by:

- Extending course material to solve original problems,
- Applying knowledge of mathematics to the solution of problems,
- Identifying, formulating and solving mathematics problems, and
- Analyzing and interpreting statistical data.

Students will demonstrate an understanding and appreciation for the relationship of mathematics to other fields by:

- Applying mathematics and statistics to solve problems in other fields,
- Working in cooperative multidisciplinary teams, and
- Choosing appropriate technology to solve problems in other disciplines.

Students will demonstrate an ability to communicate mathematics effectively by:

- Giving oral presentations,
- Completing written explanations,
- Interacting effectively in cooperative teams, and
- Understanding and interpreting written material in mathematics.

## Curriculum

The calculus sequence emphasizes mathematics applied to problems students are likely to see in other fields. This supports the curricula in other programs where mathematics is important, and assists students who are under prepared in mathematics. Priorities in the mathematics curriculum include: applied problems in the mathematics courses and ready utilization of mathematics in the science and engineering courses.

This emphasis on the utilization of mathematics continues through the upper division courses. Another aspect of the curriculum is the use of a spiraling mode of learning in which concepts are revisited to deepen the students' understanding.

The applications, teamwork, assessment, and communications emphasis directly address ABET criteria and the CSM graduate profile. The curriculum offers the following two areas of emphases:

### Degree Requirements (Applied Mathematics and Statistics)

#### Computational and Applied Mathematics (CAM) EMPHASIS

Freshman		lec	lab	sem.hrs
Fall				
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4
CSC1101	INTRODUCTION TO COMPUTER SCIENCE	3.0		3
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4
LAIS100	NATURE AND HUMAN VALUES	4.0		4
PAGN101	PHYSICAL EDUCATION	0.5		0.5
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5

**16.0**

<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4
PHGN100	PHYSICS I - MECHANICS	3.0	3.0	4.5
DSCI	DISTRIBUTED SCIENCE ELECTIVE <sup>1</sup>	4.0		4.0
EPIC151	DESIGN (EPICS) I	3.0		3
PAGN102	PHYSICAL EDUCATION	0.5		0.5
				<b>16.0</b>

**Sophomore**

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4
MATH225	DIFFERENTIAL EQUATIONS			3
CSCI261	PROGRAMMING CONCEPTS	3.0		3
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.0	3.0	4.5
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>15.0</b>

<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH323	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0		3
MATH332	LINEAR ALGEBRA or 342	3.0		3
CSCIxxx	COMPUTER ELECTIVE <sup>2</sup>	3.0		3.0
SYGN200	HUMAN SYSTEMS	3.0		3
EBGN201	PRINCIPLES OF ECONOMICS			3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>15.5</b>

<b>Summer</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH300	FOUNDATIONS OF ADVANCED MATHEMATICS			4
				<b>4.0</b>

**Junior**

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH301	INTRODUCTION TO ANALYSIS			3
MATH331	MATHEMATICAL BIOLOGY			3
MATH334	INTRODUCTION TO PROBABILITY			3
MATH398	APPLIED NUMERICAL METHODS	3.0		3.0
LAIS/EBGN	H&SS ELECTIVE I	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
				<b>18.0</b>

<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0		3
MATH407	INTRODUCTION TO SCIENTIFIC COMPUTING	3.0		3
MATH454	COMPLEX ANALYSIS	3.0		3
MATH458	ABSTRACT ALGEBRA	3.0		3
LAIS/EBGN	H&SS ELECTIVE II	3.0		3.0

FREE	FREE ELECTIVE	1.0		1.0
				<b>16.0</b>

**Senior**

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0		3
MATH440	PARALLEL SCIENTIFIC COMPUTING (CAM required)	3.0		3
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3.0		3
FREE	FREE ELECTIVE	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
				<b>15.0</b>

**Spring**

		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH	MATHEMATICS-CAM ELECTIVE <sup>3</sup>	3.0		3.0
MATH	MATHEMATICS-CAM ELECTIVE <sup>3</sup>	3.0		3.0
MATH484	MATHEMATICAL AND COMPUTATIONAL MODELING (CAPSTONE)	3.0		3
LAIS/EBGN	H&SS ELECTIVE III	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
				<b>15.0</b>

Total Hours: 130.5

- Students may choose from the remainder of the Distributed Science (SYGN101, BELS101, CHGN122) course list for this course.
- May be satisfied by CSCI262 or any other approved computationally intensive course.
- CAM area of emphasis electives include: Functional Analysis, Complex Analysis II, Numerical PDEs, Integral Equations, Modeling with Symbolic Software, and other appropriate courses with departmental approval.

**Statistics (STATS) EMPHASIS**

**Freshman**

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4
CSCI101	INTRODUCTION TO COMPUTER SCIENCE	3.0		3
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4
LAIS100	NATURE AND HUMAN VALUES	4.0		4
PAGN101	PHYSICAL EDUCATION	0.5		0.5
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5
				<b>16.0</b>

**Spring**

		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4
PHGN100	PHYSICS I - MECHANICS	3.0	3.0	4.5
EPIC151	DESIGN (EPICS) I	3.0		3

DSCI	DISTRIBUTED SCI. ELECTIVE <sup>1</sup>	4.0		4.0			
PAGN102	PHYSICAL EDUCATION	0.5		0.5			
				<b>16.0</b>			
<b>Sophomore</b>							
<b>Fall</b>							
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4			
MATH225	DIFFERENTIAL EQUATIONS			3			
CSCI261	PROGRAMMING CONCEPTS	3.0		3			
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.0	3.0	4.5			
PAGN2XX	PHYSICAL EDUCATION			0.5			
				<b>15.0</b>			
<b>Spring</b>							
MATH323	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0		3			
MATH332	LINEAR ALGEBRA or 342	3.0		3			
CSCIXXX	COMPUTER SCIENCE ELECTIVE <sup>2</sup>	3.0		3.0			
SYGN200	HUMAN SYSTEMS	3.0		3			
EBGN201	PRINCIPLES OF ECONOMICS			3			
PAGN2XX	PHYSICAL EDUCATION			0.5			
				<b>15.5</b>			
<b>Summer</b>							
MATH300	FOUNDATIONS OF ADVANCED MATHEMATICS			4			
				<b>4.0</b>			
<b>Junior</b>							
<b>Fall</b>							
MATH301	INTRODUCTION TO ANALYSIS			3			
MATH331	MATHEMATICAL BIOLOGY			3			
MATH334	INTRODUCTION TO PROBABILITY	3.0		3			
MATH398	APPLIED NUMERICAL METHODS	3.0		3.0			
LAIS/EBGN	H&SS ELECTIVE I	3.0		3.0			
FREE	FREE ELECTIVE	3.0		3.0			
				<b>18.0</b>			
<b>Spring</b>							
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0		3			
MATH407	INTRODUCTION TO SCIENTIFIC COMPUTING	3.0		3			
MATH454	COMPLEX ANALYSIS	3.0		3			
MATH458	ABSTRACT ALGEBRA	3.0		3			
LAIS/EBGN	H&SS ELECTIVE II	3.0		3.0			
FREE	FREE ELECTIVE	1.0		1.0			
				<b>16.0</b>			

<b>Senior</b>							
<b>Fall</b>							
MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0					3
MATH432	SPATIAL STATISTICS						3
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3.0					3
FREE	FREE ELECTIVE	3.0					3.0
LAIS/EBGN	H&SS FREE ELECTIVE III	3.0					3.0
				<b>15.0</b>			
<b>Spring</b>							
MATH	STAT ELECTIVE <sup>3</sup>	3.0					3.0
MATH	STAT ELECTIVE <sup>3</sup>	3.0					3.0
MATH482	STATISTICS PRACTICUM (STAT Capstone)	3.0					3
FREE	FREE ELECTIVE	3.0					3.0
FREE	FREE ELECTIVE	3.0					3.0
				<b>15.0</b>			

Total Hours: 130.5

- 1 Students may choose from the remainder of the Distributed Science (SYGN101, BELS101, CHGN122) course list for this course.
- 2 May be satisfied by CSCI262 or any other approved computationally intensive course.
- 3 STAT area of emphasis electives include: Advanced Statistical Modeling, Multivariate Analysis, Stochastic Modeling, Survival Analysis, and other appropriate courses with departmental approval.

General CSM Minor/ASI requirements can be found here (p. 195).

### Minor/ASI Computational and Applied Mathematics (CAM)

For an Area of Special Interest (ASI) in Computational and Applied Mathematics (CAM), the student should take the following:

MATH225	DIFFERENTIAL EQUATIONS	3
or MATH235	DIFFERENTIAL EQUATIONS HONORS	
MATH332	LINEAR ALGEBRA	3
or MATH342	HONORS LINEAR ALGEBRA	
MATH398	APPLIED NUMERICAL METHODS	3.0

3 credit hours of CAM courses (1 course) from the CAM Courses List below.

For a Minor in Computational and Applied Mathematics (CAM), the student should take the following:

MATH225	DIFFERENTIAL EQUATIONS	3
or MATH235	DIFFERENTIAL EQUATIONS HONORS	
MATH332	LINEAR ALGEBRA	3
or MATH342	HONORS LINEAR ALGEBRA	
MATH398	APPLIED NUMERICAL METHODS	3.0

9 credit hours of CAM courses (3 courses) from the CAM Courses List below.

**CAM Courses**

MATH301	INTRODUCTION TO ANALYSIS	3.0
MATH331	MATHEMATICAL BIOLOGY	3.0
MATH348	ADVANCED ENGINEERING MATHEMATICS	3
MATH406	ALGORITHMS	3
MATH407	INTRODUCTION TO SCIENTIFIC COMPUTING	3
MATH440	PARALLEL SCIENTIFIC COMPUTING	3
MATH441	COMPUTER GRAPHICS	3
MATH454	COMPLEX ANALYSIS	3
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3
MATH457	INTEGRAL EQUATIONS	3
MATH484	MATHEMATICAL AND COMPUTATIONAL MODELING (CAPSTONE)	3
MATH498	SPECIAL TOPICS (in CAM)	3.0
MATH5XX	GRADUATE CAM ELECTIVE	3.0

**Minor/ASI Statistics**

**For an Area of Special Interest (ASI) in Statistics, the student should take the following:**

MATH323	PROBABILITY AND STATISTICS FOR ENGINEERS	3
MATH334	INTRODUCTION TO PROBABILITY	3
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3
MATH424	INTRODUCTION TO APPLIED STATISTICS	3

**For a Minor in Statistics, the student should take the following:**

MATH323	PROBABILITY AND STATISTICS FOR ENGINEERS	3
MATH334	INTRODUCTION TO PROBABILITY	3
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3
MATH424	INTRODUCTION TO APPLIED STATISTICS	3

6 credit hours of Statistics courses (2 courses) from the Statistics Courses List below.

MATH432	SPATIAL STATISTICS	3
MATH436	ADVANCED STATISTICAL MODELING	3
MATH438	STOCHASTIC MODELS	3
MATH439	SURVIVAL ANALYSIS	3
MATH498	SPECIAL TOPICS (in STATISTICS)	3.0
MATH5XX	GRADUATE STATISTICS ELECTIVE	3.0

**Mathematical Sciences (could include a mixture of CAM and STATISTICS courses).**

**For an Area of Special Interest (ASI) in Mathematical Sciences, the student should take the following:**

MATH225	DIFFERENTIAL EQUATIONS	3
or MATH235	DIFFERENTIAL EQUATIONS HONORS	

9 credit hours of Mathematics courses (5 courses) from either the CAM or STATISTICS Courses listed above, including one course at the 400-level.

**For a Minor in Mathematical Sciences, the student should take the following:**

MATH225	DIFFERENTIAL EQUATIONS	3
or MATH235	DIFFERENTIAL EQUATIONS HONORS	

15 credit hours of Mathematics courses (5 courses) from either the CAM or STATISTICS Courses listed above, including one course at the 400-level.

**Courses****MATH100. INTRODUCTORY TOPICS FOR CALCULUS. 2.0 Hours.**

(S) An introduction and/or review of topics which are essential to the background of an undergraduate student at CSM. This course serves as a preparatory course for the Calculus curriculum and includes material from Algebra, Trigonometry, Mathematical Analysis, and Calculus. Topics include basic algebra and equation solving, solutions of inequalities, trigonometric functions and identities, functions of a single variable, continuity, and limits of functions. Does not apply toward undergraduate degree or g.p.a. Prerequisite: Consent of Instructor. 2 hours lecture, 2 semester hours.

**MATH111. CALCULUS FOR SCIENTISTS AND ENGINEERS I. 4.0 Hours.**

(I, II, S) First course in the calculus sequence, including elements of plane geometry. Functions, limits, continuity, derivatives and their application. Definite and indefinite integrals; Prerequisite: precalculus. 4 hours lecture; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-MA1.

**MATH112. CALCULUS FOR SCIENTISTS AND ENGINEERS II. 4.0 Hours.**

(I, II, S) Vectors, applications and techniques of integration, infinite series, and an introduction to multivariate functions and surfaces. Prerequisite: Grade of C or better in MATH111. 4 hours lecture; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-MA1.

**MATH113. CALCULUS FOR SCIENTISTS AND ENGINEERS II - SHORT FORM. 1.0 Hour.**

(I, II) This is a bridge course for entering freshmen and new transfer students to CSM who have either a score of 5 on the BC AP Calculus exam or who have taken an appropriate Calculus II course at another institution (determined by a departmental review of course materials). Two, three and n-dimensional space, vectors, curves and surfaces in 3-dimensional space, cylindrical and spherical coordinates, and applications of these topics. Prerequisites: Consent of Department. 1 hour lecture; 1 semester hour.

**MATH122. CALCULUS FOR SCIENTISTS AND ENGINEERS II HONORS. 4.0 Hours.**

(I) Same topics as those covered in MATH112 but with additional material and problems. Prerequisite: Consent of Department. 4 hours lecture; 4 semester hours.

**MATH199. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**MATH213. CALCULUS FOR SCIENTISTS AND ENGINEERS III. 4.0 Hours.**

(I, II, S) Multivariable calculus, including partial derivatives, multiple integration, and vector calculus. Prerequisite: Grade of C or better in MATH112 or MATH122. 4 hours lecture; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-MA1.

**MATH214. CALCULUS FOR SCIENTIST AND ENGINEERS III - SHORT FORM. 1.0 Hour.**

(I, II) This is a bridge course for entering freshmen and new transfer students to CSM who have taken an appropriate Calculus III course at another institution (determined by a departmental review of course materials). Vector Calculus including line and surface integrals with applications to work and flux, Green's Theorem, Stokes' Theorem and the Divergence Theorem. Prerequisites: Consent of Department. 1 hour lecture; 1 semester hour.

**MATH222. INTRODUCTION TO DIFFERENTIAL EQUATIONS FOR GEOLOGISTS & GEOLOGICAL ENGINEERS. 2.0 Hours.**

(II) An introduction to differential equations with a special emphasis on problems in the earth related fields. Topics include first and second order ordinary differential equations, Laplace Transforms, and applications relevant to the earth related fields. Prerequisites: MATH213 or MATH223 or MATH224. Student must also be a declared major in Geology and Geological Engineering. 2 hours lecture; 2 semester hours. Note: Only one of MATH222 and MATH225 can be counted toward graduation in GE. Any student who completes MATH222 and then changes majors out of Geology and Geological Engineering, will be expected to complete MATH225 to meet graduation requirements. (In this case, MATH222 cannot be counted toward graduation in any manner – even as a free elective.

**MATH223. CALCULUS FOR SCIENTISTS AND ENGINEERS III HONORS. 4.0 Hours.**

(II) Same topics as those covered in MATH213 but with additional material and problems. Prerequisite: Grade of C or better in MATH122. 4 hours lecture; 4 semester hours.

**MATH224. CALCULUS FOR SCIENTISTS AND ENGINEERS III HONORS. 4.0 Hours.**

(I) Early introduction of vectors, linear algebra, multivariable calculus. Vector fields, line and surface integrals. Prerequisite: Consent of Department. 4 hours lecture; 4 semester hours.

**MATH225. DIFFERENTIAL EQUATIONS. 3.0 Hours.**

(I, II, S) Classical techniques for first and higher order equations and systems of equations. Laplace transforms. Phase plane and stability analysis on nonlinear equations and systems. Applications to physics, mechanics, electrical engineering, and environmental sciences. Prerequisite: Grade of C or better in MATH112 or MATH122. 3 hours lecture; 3 semester hours.

**MATH235. DIFFERENTIAL EQUATIONS HONORS. 3.0 Hours.**

(II) Same topics as those covered in MATH225 but with additional material and problems. Prerequisite: Consent of Department. 3 hours lecture; 3 semester hours.

**MATH298. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MATH300. FOUNDATIONS OF ADVANCED MATHEMATICS. 4.0 Hours.**

(S) (WI) This course is an introduction to communication in mathematics as well computational tools for mathematics. This writing intensive course provides a transition from the Calculus sequence to the upper-division mathematics curriculum at CSM. Topics include logic and recursion, techniques of mathematical proofs, reading and writing proofs, mathematics software. Prerequisites: MATH213, MATH223 or MATH224. 2 hours lecture, 1 hour seminar, 2 hours lab; 4 semester hours.

**MATH301. INTRODUCTION TO ANALYSIS. 3.0 Hours.**

(I) This course is a first course in real analysis that lays out the context and motivation of analysis in terms of the transition from power series to those less predictable series. The course is taught from a historical perspective. It covers an introduction to the real numbers, sequences and series and their convergence, real-valued functions and their continuity and differentiability, sequences of functions and their pointwise and uniform convergence, and Riemann-Stieltjes integration theory. Prerequisite: MATH213, MATH223 or MATH224, and MATH332 or MATH342. 3 hours lecture; 3 semester hours.

**MATH323. PROBABILITY AND STATISTICS FOR ENGINEERS. 3.0 Hours.**

(I, II, S) Elementary probability, propagation of error, discrete and continuous probability models, interval estimation, hypothesis testing, and linear regression with emphasis on applications to science and engineering. Pre -requisite: MATH213, MATH223 or MATH224. 3 hours lecture; 3 semester hours.

**MATH331. MATHEMATICAL BIOLOGY. 3.0 Hours.**

(I) This course will discuss methods for building and solving both continuous and discrete mathematical models. These methods will be applied to population dynamics, epidemic spread, pharmacokinetics and modeling of physiologic systems. Modern Control Theory will be introduced and used to model living systems. Some concepts related to self-organizing systems will be introduced. Prerequisite: MATH225 or MATH235. 3 hours lecture, 3 semester hours.

**MATH332. LINEAR ALGEBRA. 3.0 Hours.**

(I, II) Systems of linear equations, matrices, determinants and eigenvalues. Linear operators. Abstract vector spaces. Applications selected from linear programming, physics, graph theory, and other fields. Prerequisite: MATH213, MATH223 or MATH224. 3 hours lecture; 3 semester hours.

**MATH334. INTRODUCTION TO PROBABILITY. 3.0 Hours.**

(I) An introduction to the theory of probability essential for problems in science and engineering. Topics include axioms of probability, combinatorics, conditional probability and independence, discrete and continuous probability density functions, expectation, jointly distributed random variables, Central Limit Theorem, laws of large numbers. Prerequisite: MATH213, MATH223 or MATH224. 3 hours lecture, 3 semester hours.

**MATH335. INTRODUCTION TO MATHEMATICAL STATISTICS. 3.0 Hours.**

(II) An introduction to the theory of statistics essential for problems in science and engineering. Topics include sampling distributions, methods of point estimation, methods of interval estimation, significance testing for population means and variances and goodness of fit, linear regression, analysis of variance. Prerequisite: MATH334. 3 hours lecture, 3 semester hours.

**MATH340. COOPERATIVE EDUCATION. 3.0 Hours.**

(I, II, S) (WI) Supervised, full-time engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade point average of at least 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions. Repeatable.

**MATH342. HONORS LINEAR ALGEBRA. 3.0 Hours.**

(II) Same topics as those covered in MATH332 but with additional material and problems as well as a more rigorous presentation. Prerequisite: MATH213, MATH223 or MATH224. 3 hours lecture; 3 semester hours.

**MATH348. ADVANCED ENGINEERING MATHEMATICS. 3.0 Hours.**

(I, II, S) Introduction to partial differential equations, with applications to physical phenomena. Fourier series. Linear algebra, with emphasis on sets of simultaneous equations. This course cannot be used as a MATH elective by MCS or AMS majors. Prerequisite: MATH225 or MATH235. 3 hours lecture; 3 semester hours.

**MATH358. DISCRETE MATHEMATICS. 3.0 Hours.**

(I, II) This course is an introductory course in discrete mathematics and algebraic structures. Topics include: formal logic; proofs, recursion, analysis of algorithms; sets and combinatorics; relations, functions, and matrices; Boolean algebra and computer logic; trees, graphs, finite-state machines and regular languages. Prerequisite: MATH213, MATH223 or MATH224. 3 hours lecture; 3 semester hours.

**MATH398. SPECIAL TOPICS. 6.0 Hours.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MATH399. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**MATH406. ALGORITHMS. 3.0 Hours.**

(I, II) Divide-and-conquer: splitting problems into subproblems of a finite number. Greedy: considering each problem piece one at a time for optimality. Dynamic programming: considering a sequence of decisions in problem solution. Searches and traversals: determination of the vertex in the given data set that satisfies a given property. Techniques of backtracking, branch-and-bound techniques, techniques in lower bound theory. Prerequisite: CSCI262 and (MATH213, MATH223 or MATH224, and MATH358/CSCI358). 3 hours lecture; 3 semester hours.

**MATH407. INTRODUCTION TO SCIENTIFIC COMPUTING. 3.0 Hours.**

(I, II) Round-off error in floating point arithmetic, conditioning and stability, solution techniques (Gaussian elimination, LU factorization, iterative methods) of linear algebraic systems, curve and surface fitting by the method of least-squares, zeros of nonlinear equations and systems by iterative methods, polynomial interpolation and cubic splines, numerical integration by adaptive quadrature and multivariate quadrature, numerical methods for initial value problems in ordinary differential equations. Emphasis is on problem solving using efficient numerical methods in scientific computing. Prerequisite: MATH225 or MATH235 and knowledge of computer programming. 3 hours lecture; 3 semester hours.

**MATH424. INTRODUCTION TO APPLIED STATISTICS. 3.0 Hours.**

(I) Linear regression, analysis of variance, and design of experiments, focusing on the construction of models and evaluation of their fit. Techniques covered will include stepwise and best subsets regression, variable transformations, and residual analysis. Emphasis will be placed on the analysis of data with statistical software. Prerequisites: MATH323 or MATH335. 3 hours lecture; 3 semester hours.

**MATH432. SPATIAL STATISTICS. 3.0 Hours.**

(I) Modeling and analysis of data observed in a 2- or 3-dimensional region. Random fields, variograms, covariances, stationarity, nonstationarity, kriging, simulation, Bayesian hierarchical models, spatial regression, SAR, CAR, QAR, and MA models, Geary/Moran indices, point processes, K-function, complete spatial randomness, homogeneous and inhomogeneous processes, marked point processes. Prerequisite: MATH335. Corequisite: MATH424. 3 hours lecture; 3 semester hours.

**MATH436. ADVANCED STATISTICAL MODELING. 3.0 Hours.**

(II) Modern methods for constructing and evaluating statistical models. Topics include generalized linear models, generalized additive models, hierarchical Bayes methods, and resampling methods. Prerequisites: MATH335 and MATH424. 3 hours lecture; 3 semester hours.

**MATH437. MULTIVARIATE ANALYSIS. 3.0 Hours.**

(II) Introduction to applied multivariate techniques for data analysis. Topics include principal components, cluster analysis, MANOVA and other methods based on the multivariate Gaussian distribution, discriminant analysis, classification with nearest neighbors. Prerequisites: MATH335 or MATH323. 3 hours lecture; 3 semester hours.

**MATH438. STOCHASTIC MODELS. 3.0 Hours.**

(II) An introduction to stochastic models applicable to problems in engineering, physical science, economics, and operations research. Markov chains in discrete and continuous time, Poisson processes, and topics in queuing, reliability, and renewal theory. Prerequisite: MATH334. 3 hours lecture, 3 semester hours.

**MATH439. SURVIVAL ANALYSIS. 3.0 Hours.**

(I) Basic theory and practice of survival analysis. Topics include survival and hazard functions, censoring and truncation, parametric and non-parametric inference, hypothesis testing, the proportional hazards model, model diagnostics. Prerequisite: MATH335 or permission of instructor. 3 hours lecture; 3 semester hours.

**MATH440. PARALLEL SCIENTIFIC COMPUTING. 3.0 Hours.**

(I) This course is designed to facilitate students' learning of parallel programming techniques to efficiently simulate various complex processes modeled by mathematical equations using multiple and multi-core processors. Emphasis will be placed on implementation of various scientific computing algorithms in FORTRAN 90 and its variants using MPI and OpenMP. Prerequisite: CSCI407/MATH407. 3 hours lecture; 3 semester hours.

**MATH441. COMPUTER GRAPHICS. 3.0 Hours.**

(I) Data structures suitable for the representation of structures, maps, three-dimensional plots. Algorithms required for windowing, color plots, hidden surface and line, perspective drawings. Survey of graphics software and hardware systems. Prerequisite: CSCI262. 3 hours lecture, 3 semester hours.

**MATH444. ADVANCED COMPUTER GRAPHICS. 3.0 Hours.**

(I, II) This is an advanced computer graphics course, focusing on modern rendering and geometric modeling techniques. Students will learn a variety of mathematical and algorithmic techniques that can be used to develop high-quality computer graphics software. In particular, the course will cover global illumination, GPU programming, geometry acquisition and processing, point based graphics and non-photorealistic rendering. Prerequisites: Basic understanding of computer graphics and prior exposure to graphics-related programming, for example, MATH441. 3 lecture hours, 3 credit hours.

**MATH447. SCIENTIFIC VISUALIZATION. 3.0 Hours.**

(I) Scientific visualization uses computer graphics to create visual images which aid in understanding of complex, often massive numerical representation of scientific concepts or results. The main focus of this course is on modern visualization techniques applicable to spatial data such as scalar, vector and tensor fields. In particular, the course will cover volume rendering, texture based methods for vector and tensor field visualization, and scalar and vector field topology. Basic understanding of computer graphics and analysis of algorithms required. Prerequisites: CSCI262 and MATH441. 3 lecture hours, 3 semester hours.

**MATH454. COMPLEX ANALYSIS. 3.0 Hours.**

(II) The complex plane. Analytic functions, harmonic functions. Mapping by elementary functions. Complex integration, power series, calculus of residues. Conformal mapping. Prerequisite: MATH225 or MATH235. 3 hours lecture, 3 semester hours.

**MATH455. PARTIAL DIFFERENTIAL EQUATIONS. 3.0 Hours.**

(I) Linear partial differential equations, with emphasis on the classical second-order equations: wave equation, heat equation, Laplace's equation. Separation of variables, Fourier methods, Sturm-Liouville problems. Prerequisite: MATH225 or MATH235. 3 hours lecture; 3 semester hours.

**MATH457. INTEGRAL EQUATIONS. 3.0 Hours.**

(I) This is an introductory course on the theory and applications of integral equations. Abel, Fredholm and Volterra equations. Fredholm theory: small kernels, separable kernels, iteration, connections with linear algebra and Sturm-Liouville problems. Applications to boundary-value problems for Laplace's equation and other partial differential equations. Prerequisites: MATH332 or MATH342, and MATH455. 3 hours lecture; 3 semester hours.

**MATH458. ABSTRACT ALGEBRA. 3.0 Hours.**

(II) This course is an introduction to the concepts of contemporary abstract algebra and applications of those concepts in areas such as physics and chemistry. Topics include groups, subgroups, isomorphisms and homomorphisms, rings, integral domains and fields. Prerequisites: MATH213, MATH223 or MATH224, and MATH300 or consent of the instructor. 3 hours lecture; 3 semester hours.

**MATH474. INTRODUCTION TO CRYPTOGRAPHY. 3.0 Hours.**

(II) This course is primarily oriented towards the mathematical aspects of cryptography, but is also closely related to practical and theoretical issues of computer security. The course provides mathematical background required for cryptography including relevant aspects of number theory and mathematical statistics. The following aspects of cryptography will be covered: symmetric and asymmetric encryption, computational number theory, quantum encryption, RSA and discrete log systems, SHA, steganography, chaotic and pseudo-random sequences, message authentication, digital signatures, key distribution and key management, and block ciphers. Many practical approaches and most commonly used techniques will be considered and illustrated with real-life examples. Prerequisites: CSCI262, MATH334/MATH335, MATH358. 3 credit hours.

**MATH482. STATISTICS PRACTICUM. 3.0 Hours.**

(II) This is the capstone course in the Statistics option. Students will apply statistical principles to data analysis through advanced work, leading to a written report and an oral presentation. Choice of project is arranged between the student and the individual faculty member who will serve as advisor. Prerequisites: MATH335 and MATH424. 3 hours lecture; 3 semester hours.

**MATH484. MATHEMATICAL AND COMPUTATIONAL MODELING (CAPSTONE). 3.0 Hours.**

(II) This is the capstone course in the Computational and Applied Mathematics option. Students will apply computational and applied mathematics modeling techniques to solve complex problems in biological, engineering and physical systems. Mathematical methods and algorithms will be studied within both theoretical and computational contexts. The emphasis is on how to formulate, analyze and use nonlinear modeling to solve typical modern problems. Prerequisites: MATH331, MATH407, and MATH455. 3 hours lecture; 3 semester hours.

**MATH491. UNDERGRADUATE RESEARCH. 1-3 Hour.**

(I) (WI) Individual investigation under the direction of a department faculty member. Written report required for credit. Prerequisite: Consent of Department Head. Variable - 1 to 3 semester hours. Repeatable for credit to a maximum of 12 hours.



**MATH492. UNDERGRADUATE RESEARCH. 1-3 Hour.**

(II) (WI) Individual investigation under the direction of a department faculty member. Written report required for credit. Prerequisite: Consent of Department Head. Variable - 1 to 3 semester hours. Repeatable for credit to a maximum of 12 hours.

**MATH498. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MATH499. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

# Civil and Environmental Engineering

<http://cee.mines.edu/>

## Program Description

The Department of Civil and Environmental Engineering offers design-oriented, interdisciplinary, non-traditional undergraduate programs in Civil Engineering and Environmental Engineering. The degrees emphasize fundamental engineering principles and require in-depth understanding of either Civil or Environmental Engineering. Graduates are in a position to take advantage of a broad variety of professional opportunities, and are well-prepared for an engineering career in a world of rapid technological change. This department also supports the legacy Bachelor of Science degree in Engineering with specialties in Civil or Environmental Engineering offered by the College of Engineering & Computational Sciences.

The legacy B.S. in Engineering degree is accredited by ABET. The B.S. degrees in Civil and Environmental Engineering are new as of the 2012-2013 school year and are therefore not yet accredited. Accreditation for those degrees will be sought during the 2013-2014 school year.

## Program Educational Objectives (Bachelor of Science in Civil Engineering and Bachelor of Science in Environmental Engineering)

The CEE Department contributes to the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria. In addition, the Civil and Environmental Engineering Programs at CSM have established the following program educational objectives:

Within three years of attaining the BS degree:

- Graduates will be situated in growing careers or will be successfully pursuing a graduate degree in civil or environmental engineering or a related field.
- Graduates will be advancing in their professional standing, generating new knowledge and/or exercising leadership in their field.
- Graduates will be contributing to the needs of society through professional practice, research, and/or service.

## Curriculum

During the first two years at CSM, students complete a set of core courses that includes mathematics, basic sciences, and engineering sciences. Course work in mathematics is an essential part of the curriculum which gives engineering students tools for modeling, analyzing, and predicting physical phenomena. The basic sciences are represented by physics and chemistry which provide an appropriate foundation in the physical sciences. Engineering sciences build upon the basic sciences and are focused on applications.

The first two years also include Engineering design course work within the Engineering Practice Introductory Course Sequence (EPICS I and II). This experience teaches design methodology and stresses the creative and synthesis aspects of the engineering profession. Finally, the first two years include systems-oriented courses with humanities and social sciences content; these courses explore the linkages within the environment, human society, and engineered systems.

In the final two years, students complete an advanced core that includes electric circuits, engineering mechanics, advanced mathematics, thermodynamics, economics (sophomore year for EV), engineering design, and additional studies in liberal arts topics. Students then also begin a set of unique upper-division course requirements. Free electives (9 to 12 credits), at the student's discretion, can be used to either satisfy a student's personal interest in a topic or they can be used as coursework as part of an "area of special interest" of at least 12 semester hours or a minor of at least 18 semester hours in another department or division.

All students must complete a capstone design course which is focused on an in-depth multi-disciplinary engineering project. The projects are generated by customer demand, and include experiential verification to ensure a realistic design experience.

Prospective students should note that this is an integrated, broad-based and interdisciplinary engineering program. Engineering analysis and design is emphasized with interdisciplinary application for industrial projects, structures and processes. For example, our unique Multidisciplinary Engineering Laboratory sequence promotes life-long learning skills using state-of-the-art instrumentation funded through a combination of grants from the U.S. Department of Education, private industry contributions, and investment by CSM.

The Civil Engineering degree builds on the multidisciplinary engineering principles of the core curriculum to focus in Geotechnical Engineering, Engineering Mechanics, Environmental Engineering, and Structural Engineering. Civil students are also asked to choose three civil elective courses from a list that includes offerings from CEE and other civil-oriented departments at CSM such as Geological Engineering and Mining Engineering. These electives give students the opportunity for further specialization in other areas of Civil Engineering.

The Environmental Engineering degree introduces students to the fundamentals of environmental engineering including the scientific and regulatory basis of public health and environmental protection. The degree is designed to prepare students to investigate and analyze environmental systems and assess risks to public health and ecosystems as well as evaluate and design natural and engineered solutions to mitigate risks and enable beneficial outcomes. Programs of study are interdisciplinary in scope, and consequently the appropriate coursework may be obtained from multiple departments at CSM. Topics covered include water reclamation and reuse, hazardous waste management, contaminated site remediation, environmental science, and regulatory processes.

Students interested in a more research-oriented component to their undergraduate curriculum are encouraged to take on an Independent Study project with one of the Civil and Environmental Engineering Faculty. These projects can offer a useful experience that is relevant to future graduate work.

## Bachelor of Science in Civil Engineering Degree Requirements:

### Freshman

Fall		lec	lab	sem.hrs
PAGN101	PHYSICAL EDUCATION			0.5
LAIS100	NATURE AND HUMAN VALUES			4

CHGN121	PRINCIPLES OF CHEMISTRY I			4	EGGN413	COMPUTER AIDED ENGINEERING			3
CSM101	FRESHMAN SUCCESS SEMINAR			0.5					<b>16.0</b>
SYGN101	EARTH & ENV SYSTEMS			4	<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4	EGCV	Civil Engineering Elective*			3.0
				<b>17.0</b>	ELECT				
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	FREE	Free Elective			3.0
PAGN102	PHYSICAL EDUCATION			0.5	DCGN210	INTRO TO ENG THERMODYNAMICS			3
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4	EGGN464	FOUNDATIONS			3
PHGN100	PHYSICS I - MECHANICS			4.5	EGGN444	DESIGN OF STEEL STRUCTURES or 445			3
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4	EGGN353	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I or 354			
EPIC151	DESIGN (EPICS) I			3					<b>18.0</b>
				<b>16.0</b>	<b>Senior</b>				
<b>Sophomore</b>					<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	EGCV	Civil Engineering Elective*			3.0
EBGN201	PRINCIPLES OF ECONOMICS			3	ELECT				
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS			4.5	LAIS/EBGN	H&SS Restricted Elective II			3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4	EGGN350	MULTIDISCIPLINARY ENGINEERING LABORATORY II			1.5
DCGN241	DIST CORE - STATICS			3	MATH323	PROBABILITY AND STATISTICS FOR ENGINEERS			3
CSCI260	FORTRAN PROGRAMMING, 261, or EGGN 205			2	EGGN315	DYNAMICS			3
PAGN2XX	PHYSICAL EDUCATION			0.5	EGGN491	SENIOR DESIGN I			3
				<b>17.0</b>					<b>16.5</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
SYGN200	HUMAN SYSTEMS			3	EGCV	Civil Engineering Elective*			3.0
EGGN250	MULTIDISCIPLINARY ENGINEERING LABORATORY			1.5	ELECT				
EGGN281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER			3	LAIS/EBGN	H&SS Restricted Elective III			3.0
EGGN351	FLUID MECHANICS			3	FREE	Free Elective			3.0
EGGN320	MECHANICS OF MATERIALS			3	FREE	Free Elective			3.0
EPIC251	DESIGN (EPICS) II			3	FREE	Free Elective			3.0
PAGN2XX	PHYSICAL EDUCATION			0.5	EGGN492	SENIOR DESIGN II			3
				<b>17.0</b>					<b>18.0</b>
<b>Summer</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	<hr/>				
EGGN234	ENGINEERING FIELD SESSION, CIVIL SPECIALTY			3	Total Hours: 138.5				
				<b>3.0</b>	* Civil Engineering students are required to take three Civil elective courses from the following lists. Students must take at least two electives from the A list.				
<b>Junior</b>					<b>List A Electives:</b>				
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	EGGN353	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I			3
LAIS/EBGN	H&SS Restricted Elective I			3.0	EGGN354	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II			3
EGGN361	SOIL MECHANICS			3	EGGN451	HYDRAULIC PROBLEMS			3
EGGN363	SOIL MECHANICS LABORATORY			1	EGGN453	WASTEWATER ENGINEERING			3
EGGN342	STRUCTURAL THEORY			3	EGGN454	WATER SUPPLY ENGINEERING			3
MATH225	DIFFERENTIAL EQUATIONS			3	EGGN455	SOLID AND HAZARDOUS WASTE ENGINEERING			3

EGGN456	SCIENTIFIC BASIS OF ENVIRONMENTAL REGULATIONS	3
EGGN457	SITE REMEDIATION ENGINEERING	3
EGGN307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3
EBGN321	ENGINEERING ECONOMICS	3
EGGN460	NUMERICAL METHODS FOR ENGINEERS	3
EGGN433	SURVEYING II	3
EGGN465	UNSATURATED SOIL MECHANICS	3
EGGN448	ADVANCED SOIL MECHANICS	3
EGGN534	SOIL BEHAVIOR	3
EGGN531	SOIL DYNAMICS	3
MNGN321	INTRODUCTION TO ROCK MECHANICS	3
EGGN422	ADVANCED MECHANICS OF MATERIALS	3
EGGN442	FINITE ELEMENT METHODS FOR ENGINEERS	3
EGGN473	FLUID MECHANICS II	3
EGGN478	ENGINEERING VIBRATION	3
EGGN441	ADVANCED STRUCTURAL ANALYSIS	3
EGGN444	DESIGN OF STEEL STRUCTURES	3
or EGGN445	DESIGN OF REINFORCED CONCRETE STRUCTURES	
EGGN447	TIMBER AND MASONRY DESIGN	3
or EGGN547	TIMBER AND MASONRY DESIGN	
EGGN549	ADVANCED DESIGN OF STEEL STRUCTURES	3
EGGN556	DESIGN OF REINFORCED CONCRETE STRUCTURES	3

**List B Electives:**

EBGN553	PROJECT MANAGEMENT	3
ESGN399	INDEPENDENT STUDY	1-6
EGGN490	SUSTAINABLE ENGINEERING DESIGN	3
MNGN404	TUNNELING	3
MNGN405	ROCK MECHANICS IN MINING	3
MNGN406	DESIGN AND SUPPORT OF UNDERGROUND EXCAVATIONS	3
GEGN466	GROUNDWATER ENGINEERING	3
GEGN468	ENGINEERING GEOLOGY AND GEOTECHNICS	4
GEGN473	GEOLOGICAL ENGINEERING SITE INVESTIGATION	3

**Bachelor of Science in Environmental Engineering Degree Requirements:**

**Freshman**

Fall		lec	lab	sem.hrs
CHGN121	PRINCIPLES OF CHEMISTRY I			4
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4
SYGN101	EARTH & ENV SYSTEMS			4
LAIS100	NATURE AND HUMAN VALUES			4

CSM101	FRESHMAN SUCCESS SEMINAR	0.5
PAGN101	PHYSICAL EDUCATION	0.5
		<b>17.0</b>

Spring		lec	lab	sem.hrs
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4
EPIC151	DESIGN (EPICS) I			3
PHGN100	PHYSICS I - MECHANICS			4.5
PAGN102	PHYSICAL EDUCATION			0.5
				<b>16.0</b>

**Sophomore**

Fall		lec	lab	sem.hrs
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4
SYGN200	HUMAN SYSTEMS			3
DCGN209	DIST CORE THERMO, 210, or EGGN 371			3
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS			4.5
DCGN241	DIST CORE - STATICS			3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>18.0</b>

Spring		lec	lab	sem.hrs
MATH225	DIFFERENTIAL EQUATIONS			3
EGGN281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER			3
EGGN320	MECHANICS OF MATERIALS			3
EBGN201	PRINCIPLES OF ECONOMICS			3
EGGN250	MULTIDISCIPLINARY ENGINEERING LABORATORY			1.5
EPIC251	DESIGN (EPICS) II			3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>17.0</b>

**Junior**

Fall		lec	lab	sem.hrs
BIOSCI ELECT	Bioscience Elective**			3.0
ESGN353	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I			3
CSCI260	FORTRAN PROGRAMMING or 261			2
EGGN315	DYNAMICS			3
EGGN351	FLUID MECHANICS			3
FREE	Free Elective			3.0
				<b>17.0</b>
Spring		lec	lab	sem.hrs
ESGN354	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II			3

ESGN355	ENVIRONMENTAL ENGINEERING LABORATORY			3
MATH323	PROBABILITY AND STATISTICS FOR ENGINEERS			3
EGGN350	MULTIDISCIPLINARY ENGINEERING LABORATORY II			1.5
EGEV ELECT	Environmental Engineering Elective*			3.0
LAIS/EBGN	H&SS Restricted Elective I			3.0
				<b>16.5</b>
<b>Summer</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
EGGN335	ENGINEERING FIELD SESSION, ENVIRONMENTAL SPECIALTY			3
				<b>3.0</b>
<b>Senior</b>				
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
EGGN491	SENIOR DESIGN I			3
ESGN459	HYDROLOGIC AND WATER RESOURCES ENGINEERING or EGGN 451			3
FREE	Free Elective			3.0
EGEV ELECT	Environmental Engineering Elective*			3.0
EGEV ELECT	Environmental Engineering Elective*			3.0
LAIS/EBGN	H&SS Restricted Elective II			3.0
				<b>18.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
EGGN492	SENIOR DESIGN II			3
ESGN490	ENVIRONMENTAL LAW			3
EGEV ELECT	Environmental Engineering Elective*			3.0
LAIS/EBGN	H&SS Restricted Elective III			3.0
FREE	Free Elective			3.0
				<b>15.0</b>

Total Hours: 137.5

\* Environmental Engineering students are required to take four Environmental Elective courses from the following list:

### Environmental Engineering Electives:

ESGN401	FUNDAMENTALS OF ECOLOGY			3
ESGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY			3
ESGN440	ENVIRONMENTAL POLLUTION: SOURCES, CHARACTERISTICS, TRANSPORT AND FATE			3.0
ESGN459	HYDROLOGIC AND WATER RESOURCES ENGINEERING			3
or EGGN451	HYDRAULIC PROBLEMS			
EGGN/ ESGN453	WASTEWATER ENGINEERING			3

EGGN/ ESGN454	WATER SUPPLY ENGINEERING			3
EGGN/ ESGN457	SITE REMEDIATION ENGINEERING			3
ESGN460	ONSITE WATER RECLAMATION AND REUSE			3
ESGN462	SOLID WASTE MINIMIZATION AND RECYCLING			3
ESGN463	POLLUTION PREVENTION: FUNDAMENTALS AND PRACTICE			3
ESGN490	ENVIRONMENTAL LAW			3
GEGN466	GROUNDWATER ENGINEERING			3
or GEGN467	GROUNDWATER ENGINEERING			

\*\* Environmental Engineering students are required to take one Bioscience Elective course from the following list:

### Environmental Engineering Bioscience Electives:

BELS101	BIOLOGICAL AND ENVIRONMENTAL SYSTEMS			4
BELS301	GENERAL BIOLOGY I			3
CHGN462	MICROBIOLOGY AND THE ENVIRONMENT			3
ESGN401	FUNDAMENTALS OF ECOLOGY			3
ESGN453	WASTEWATER ENGINEERING			3

General CSM Minor/ASI requirements can be found here (p. 195).

### Civil or Environmental Engineering Minor and ASI

The Civil and Environmental Engineering department supports the Civil Engineering and Environmental Engineering Specialty Minors housed within the College of Engineering and Computational Sciences. Please refer to the Minor tab within the Engineering section of the bulletin for more information.

### Courses

#### EGGN234. ENGINEERING FIELD SESSION, CIVIL SPECIALTY. 3.0 Hours.

(S) The theory and practice of modern surveying. Lectures and hands-on field work teaches horizontal, vertical, and angular measurements and computations using traditional and modern equipment. Subdivision of land and applications to civil engineering practice, GPS and astronomic observations. Prerequisite: EPIC251. Three weeks (6 day weeks) in summer field session; 3 semester hours.

#### EGGN320. MECHANICS OF MATERIALS. 3.0 Hours.

(I, II, S) Fundamentals of stresses and strains, material properties including axial, torsional, bending, and combined loadings. Stress at a point; stress transformations and Mohr's circle for stress; beam deflections, thin-wall pressure vessels, columns and buckling, and stress concentrations. 3 hours lecture; 3 semester hours. Prerequisite: DCGN241 or MNGN317. 3 hours lecture; 3 semester hours.

**EGGN335. ENGINEERING FIELD SESSION, ENVIRONMENTAL SPECIALTY. 3.0 Hours.**

(S) The environmental module is intended to introduce students to laboratory and field analytical skills used in the analysis of an environmental engineering problem. Students will receive instruction on the measurement of water quality parameters (chemical, physical, and bio logical) in the laboratory and field. The student will use these skills to collect field data and analyze a given environmental engineering problem.

Prerequisites:

EGGN353, EPIC251, MATH323. Three weeks in summer session; 3 semester hours.

**EGGN342. STRUCTURAL THEORY. 3.0 Hours.**

(I, II) Analysis of determinate and indeterminate structures for both forces and deflections. Influence lines, work and energy methods, moment distribution, matrix operations, computer methods. Prerequisite: EGGN320. 3 hours lecture; 3 semester hours.

**EGGN353. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I. 3.0 Hours.**

(I, II) Introductory level fundamentals in atmospheric systems, air pollution control, solid waste management, hazardous waste management, waste minimization, pollution prevention, role and responsibilities of public institutions and private organizations in environmental management (relative to air, solid and hazardous waste). Prerequisite: CHGN122, PHGN100 and MATH213, or consent of instructor. 3 hours lecture; 3 semester hours.

**EGGN354. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II. 3.0 Hours.**

(I, II) Topics covered include history of water related environmental law and regulation, major sources and concerns of water pollution, water quality parameters and their measurement, material and energy balances, water chemistry concepts, microbial concepts, aquatic toxicology and risk assessment. Prerequisite: CHGN122, PHGN100 and MATH213, or consent of instructor. 3 hours lecture; 3 semester hours.

**EGGN361. SOIL MECHANICS. 3.0 Hours.**

(I, II) An introductory course covering the engineering properties of soil, soil phase relationships and classification. Principle of effective stress. Seepage through soils and flow nets. Soil compressibility, consolidation and settlement prediction. Shear strength of soils. Prerequisite: EGGN320. 3 hours lecture; 3 semester hours.

**EGGN363. SOIL MECHANICS LABORATORY. 1.0 Hour.**

(I, II) Introduction to laboratory testing methods in soil mechanics. Classification, permeability, compressibility, shear strength. Prerequisite: EGGN361 or concurrent enrollment. 3 hours lab; 1 semester hour.

**EGGN398C. SPECIAL TOPICS IN ENGINEERING. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**EGGN431. SOIL DYNAMICS. 3.0 Hours.**

(II) Soil Dynamics combines engineering vibrations with soil mechanics, analysis, and design. Students will learn to apply basic principles of dynamics towards the analysis and design of civil infrastructure systems when specific issues as raised by the inclusion of soil materials must be considered. Prerequisites: EGGN320, EGGN361, and MATH225. 3 hours lecture; 3 semester hours.

**EGGN433. SURVEYING II. 3.0 Hours.**

(I) Engineering projects with local control using levels, theodolites and total stations, including surveying applications of civil engineering work in the "field". Also includes engineering astronomy and computer generated designs; basic road design including centerline staking, horizontal and vertical curves, slope staking and earthwork volume calculations. Use of commercial software for final plan/profile and earthwork involved for the road project data collected in the field. Conceptual and mathematical knowledge of applying GPS data to engineering projects. Some discussion of the principles and equations of projections (Mercator, Lambert, UTM, State Plane, etc.) and their relationship to the databases of coordinates based on (North American Datum) NAD '27, NAD '83 and (High Accuracy Reference Network) HARN. Prerequisite: EGGN234. 2 hours lecture; 8-9 field work days; 3 semester hours.

**EGGN435. HIGHWAY AND TRAFFIC ENGINEERING. 3.0 Hours.**

The emphasis of this class is on the multi-disciplinary nature of highway and traffic engineering and its application to the planning and design of transportation facilities. In the course of the class the students will examine design problems that will involve: geometric design, surveying, traffic operations, hydrology, hydraulics, elements of bridge design, statistics, highway safety, transportation planning, engineering ethics, soil mechanics, pavement design, economics, environmental science. 3 credit hours. Taught on demand.

**EGGN441. ADVANCED STRUCTURAL ANALYSIS. 3.0 Hours.**

(II) Introduction to advanced structural analysis concepts. Nonprismatic structures. Arches, Suspension and cable-stayed bridges. Structural optimization. Computer Methods. Structures with nonlinear materials. Internal force redistribution for statically indeterminate structures. Graduate credit requires additional homework and projects. Prerequisite: EGGN342. 3 hour lectures; 3 semester hours.

**EGGN442. FINITE ELEMENT METHODS FOR ENGINEERS. 3.0 Hours.**

(I, II) General theories of stress and strain; stress and strain transformations, principal stresses and strains, octahedral shear stresses, Hooke's law for isotropic material, and failure criteria. Introduction to elasticity and to energy methods. Torsion of noncircular and thin-walled members. Unsymmetrical bending and shear-center, curved beams, and beams on elastic foundations. Introduction to plate theory. Thick-walled cylinders and contact stresses. Prerequisite: EGGN320 3 hours lecture; 3 semester hours.

**EGGN444. DESIGN OF STEEL STRUCTURES. 3.0 Hours.**

(I, II) To learn application and use the American Institute of Steel Construction (AISC) Steel Construction Manual. Course develops an understanding of the underlying theory for the design specifications. Students learn basic steel structural member design principles to select the shape and size of a structural member. The design and analysis of tension members, compression members, flexural members, and members under combined loading is included, in addition to basic bolted and welded connection design. Prerequisite: EGGN342. 3 hours lecture; 3 semester hours.

**EGGN445. DESIGN OF REINFORCED CONCRETE STRUCTURES. 3.0 Hours.**

(I, II) This course provides an introduction to the materials and principles involved in the design of reinforced concrete. It will allow students to develop an understanding of the fundamental behavior of reinforced concrete under compressive, tensile, bending, and shear loadings, and gain a working knowledge of strength design theory and its application to the design of reinforced concrete beams, columns, slabs, and footings. Prerequisite: EGGN342. 3 hours lecture; 3 semester hours.

**EGGN447. TIMBER AND MASONRY DESIGN. 3.0 Hours.**

(II) The course develops the theory and design methods required for the use of timber and masonry as structural materials. The design of walls, beams, columns, beam-columns, shear walls, and structural systems are covered for each material. Gravity, wind, snow, and seismic loads are calculated and utilized for design. Prerequisite: EGGN320 or equivalent. 3 hours lecture; 3 semester hours. Spring odd years.

**EGGN448. ADVANCED SOIL MECHANICS. 3.0 Hours.**

Advanced soil mechanics theories and concepts as applied to analysis and design in geotechnical engineering. Topics covered will include seepage, consolidation, shear strength and probabilistic methods. The course will have an emphasis on numerical solution techniques to geotechnical problems by finite elements and finite differences. Prerequisite: EGGN361. 3 hour lectures; 3 semester hours. Fall even years.

**EGGN451. HYDRAULIC PROBLEMS. 3.0 Hours.**

(I) Review of fundamentals, forces on submerged surfaces, buoyancy and flotation, gravity dams, weirs, steady flow in open channels, backwater curves, hydraulic machinery, elementary hydrodynamics, hydraulic structures. Prerequisite: EGGN351. 3 hours lecture; 3 semester hours.

**EGGN453. WASTEWATER ENGINEERING. 3.0 Hours.**

(I) The goal of this course is to familiarize students with the fundamental phenomena involved in wastewater treatment processes (theory) and the engineering approaches used in designing such processes (design). This course will focus on the physical, chemical and biological processes applied to liquid wastes of municipal origin. Treatment objectives will be discussed as the driving force for wastewater treatment. Prerequisite: EGGN353/ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

**EGGN454. WATER SUPPLY ENGINEERING. 3.0 Hours.**

(I) Water supply availability and quality. Theory and design of conventional potable water treatment unit processes. Design of distribution systems. Also includes regulatory analysis under the Safe Drinking Water Act (SDWA). Prerequisite: EGGN353/ESGN353, or consent of instructor. 3 hours lecture; 3 semester hours.

**EGGN455. SOLID AND HAZARDOUS WASTE ENGINEERING. 3.0 Hours.**

(I) This course provides an introduction and overview of the engineering aspects of solid and hazardous waste management. The focus is on control technologies for solid wastes from common municipal and industrial sources and the end-of-pipe waste streams and process residuals that are generated in some key industries. Prerequisite: EGGN354/ESGN354. 3 hours lecture; 3 semester hours.

**EGGN456. SCIENTIFIC BASIS OF ENVIRONMENTAL REGULATIONS. 3.0 Hours.**

(II) A critical examination of the experiments, calculations and assumptions underpinning numerical and narrative standards contained in federal and state environmental regulations. Top-down investigations of the historical development of selected regulatory guidelines and permitting procedures. Student directed design of improved regulations. Prerequisite: EGGN/ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

**EGGN457. SITE REMEDIATION ENGINEERING. 3.0 Hours.**

(II) This course describes the engineering principles and practices associated with the characterization and remediation of contaminated sites. Methods for site characterization and risk assessment will be highlighted while the emphasis will be on remedial action screening processes and technology principles and conceptual design. Common isolation and containment and in situ and ex situ treatment technology will be covered. Computerized decision-support tools will be used and case studies will be presented. Prerequisite: EGGN/ESGN354 or consent of instructor. 3 hours lecture; 3 semester hours.

**EGGN460. NUMERICAL METHODS FOR ENGINEERS. 3.0 Hours.**

(S) Introduction to the use of numerical methods in the solution of problems encountered in engineering analysis and design, e.g. linear simultaneous equations (e.g. analysis of elastic materials, steady heat flow); roots of nonlinear equations (e.g. vibration problems, open channel flow); eigen-value problems (e.g. natural frequencies, buckling and elastic stability); curve fitting and differentiation (e.g. interpretation of experimental data, estimation of gradients); integration (e.g. summation of pressure distributions, finite element properties, local averaging); ordinary differential equations (e.g. forced vibrations, beam bending) All course participants will receive source code consisting of a suite of numerical methods programs. Prerequisite: CSCI260 or CSCI261, MATH225, EGGN320. 3 hours lecture; 3 semester hours.

**EGGN464. FOUNDATIONS. 3.0 Hours.**

(I, II) Techniques of subsoil investigation, types of foundations and foundation problems, selection of basis for design of foundation types. Open-ended problem solving and decision making. Prerequisite: EGGN361. 3 hours lecture; 3 semester hours.

**EGGN465. UNSATURATED SOIL MECHANICS. 3.0 Hours.**

The focus of this course is on soil mechanics for unsaturated soils. It provides an introduction to thermodynamic potentials in partially saturated soils, chemical potentials of adsorbed water in partially saturated soils, phase properties and relations, stress state variables, measurements of soil water suction, unsaturated flow laws, measurement of unsaturated permeability, volume change theory, effective stress principle, and measurement of volume changes in partially saturated soils. The course is designed for seniors and graduate students in various branches of engineering and geology that are concerned with unsaturated soil's hydrologic and mechanics behavior. Prerequisites: EGGN361 or consent of instructor. 3 hours lecture; 3 semester hours. Taught on demand.

**EGGN494. INTRODUCTION TO THE SEISMIC DESIGN OF STRUCTURES. 3.0 Hours.**

(I) This course provides students with an introduction to seismic design as it relates to structures. Students will become familiar with the sources of seismic disturbances, the physics of seismic energy transmission, and the relationship between ground disturbance and the resulting forces experienced by structures. The theory and basis for existing building code provisions relating to seismic design of structures will be introduced. Building code requirements and design methodologies will be examined and applied. Prerequisites: EGGN444, or EGGN445, or EGGN447. 3 hours lecture; 3 semester hours.

**EGGN498C. SPECIAL TOPICS IN ENGINEERING. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**EGGN499C. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**ESGN203. NATURAL AND ENGINEERED ENVIRONMENTAL SYSTEMS. 3.0 Hours.**

Introduction to natural and engineered environmental systems analysis. Environmental decision making, sustainable development, pollution sources, effects and prevention, and environmental life cycle assessment. The basic concepts of material balances, energy balances, chemical equilibrium and kinetics and structure and function of biological systems will be used to analyze environmental systems. Case studies in sustainable development, industrial ecology, pollution prevention and life cycle assessment will be covered. The goal of this course is to develop problem-solving skills associated with the analysis of environmental systems. Prerequisites: CHGN122 or concurrent; MATH112 or concurrent; PHGN 100; SYGN101. 3 semester hours.

**ESGN299. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**ESGN353. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I. 3.0 Hours.**

(I, II) Introductory level fundamentals in atmospheric systems, air pollution control, solid waste management, hazardous waste management, waste minimization, pollution prevention, role and responsibilities of public institutions and private organizations in environmental management (relative to air, solid and hazardous waste). Prerequisite: CHGN122, PHGN100 and MATH213, or consent of instructor. 3 hours lecture; 3 semester hours.

**ESGN354. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II. 3.0 Hours.**

(I, II) Topics covered include history of water related environmental law and regulation, major sources and concerns of water pollution, water quality parameters and their measurement, material and energy balances, water chemistry concepts, microbial concepts, aquatic toxicology and risk assessment. Prerequisite: CHGN122, PHGN100 and MATH213, or consent of instructor. 3 hours lecture; 3 semester hours.

**ESGN355. ENVIRONMENTAL ENGINEERING LABORATORY. 3.0 Hours.**

(I) This course introduces the laboratory and experimental techniques used for generating and interpreting data in environmental science and engineering related to water, land, and environmental health. An emphasis is placed on quantitative chemical and microbiological analysis of water and soil samples relevant to water supply and wastewater discharge. Topics include basic water quality measurements (pH, conductivity, etc.) and quantitative analysis of chemicals by chromatographic and mass spectrometric techniques. Advanced topics include quantitative and qualitative analysis of bioreactor performance, bench testing for water treatment, and measurement and control of disinfection by-products. Prerequisites: ESGN 353 or ESGN 354, or consent of instructor. 1 hour lecture, 6 hour lab. 3 semester hours.

**ESGN399. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**ESGN401. FUNDAMENTALS OF ECOLOGY. 3.0 Hours.**

(II) Biological and ecological principles discussed and industrial examples of their use given. Analysis of ecosystem processes, such as erosion, succession, and how these processes relate to engineering activities, including engineering design and plant operation. Criteria and performance standards analyzed for facility siting, pollution control, and mitigation of impacts. North American ecosystems analyzed. Concepts of forestry, range, and wildlife management integrated as they apply to all of the above. Three to four weekend trips will be arranged during the semester. 3 lecture hours, 3 semester hours.



**ESGN403. INTRODUCTION TO ENVIRONMENTAL CHEMISTRY. 3.0 Hours.**

(I) Processes by which natural and anthropogenic chemicals interact, react and are transformed and redistributed in various environmental compartments. Air, soil and aqueous (fresh and saline surface and groundwaters) environments are covered, along with specialized environments such as waste treatment facilities and the upper atmosphere. Prerequisites: SYGN101, DCGN209, and CHGN222. 3 hours lecture; 3 semester hours.

**ESGN440. ENVIRONMENTAL POLLUTION: SOURCES, CHARACTERISTICS, TRANSPORT AND FATE. 3.0 Hours.**

(I) This course describes the environmental behavior of inorganic and organic chemicals in multimedia environments, including water, air, sediment and biota. Sources and characteristics of contaminants in the environment are discussed as broad categories, with some specific examples from various industries. Attention is focused on the persistence, reactivity, and partitioning behavior of contaminants in environmental media. Both steady and unsteady state multimedia environmental models are developed and applied to contaminated sites. The principles of contaminant transport in surface water, groundwater and air are also introduced.

The course provides students with the conceptual basis and mathematical tools for predicting the behavior of contaminants in the environment. Prerequisite: EGGN/ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

**ESGN453. WASTEWATER ENGINEERING. 3.0 Hours.**

(I) The goal of this course is to familiarize students with the fundamental phenomena involved in wastewater treatment processes (theory) and the engineering approaches used in designing such processes (design). This course will focus on the physical, chemical and biological processes applied to liquid wastes of municipal origin. Treatment objectives will be discussed as the driving force for wastewater treatment. Prerequisite: EGGN/ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

**ESGN454. WATER SUPPLY ENGINEERING. 3.0 Hours.**

(II) Water supply availability and quality. Theory and design of conventional potable water treatment and processes. Design of distribution systems. Also includes regulatory analysis under the Safe Drinking Water Act (SDWA). Prerequisite: EGGN353/ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

**ESGN455. SOLID AND HAZARDOUS WASTE ENGINEERING. 3.0 Hours.**

(II) This course provides an introduction and overview of the engineering aspects of solid and hazardous waste management. The focus is on control technologies for solid wastes from common municipal and industrial sources and the end-of-pipe waste streams and process residuals that are generated in some key industries. Prerequisite: EGGN354/ESGN354. 3 hours lecture; 3 semester hours.

**ESGN456. SCIENTIFIC BASIS OF ENVIRONMENTAL REGULATIONS. 3.0 Hours.**

(I) A critical examination of the experiments, calculations and assumptions underpinning numerical and narrative standards contained in federal and state environmental regulations. Top-down investigations of the historical development of selected regulatory guidelines and permitting procedures. Student directed design of improved regulations. Prerequisite: EGGN/ESGN353. 3 hours lecture; 3 semester hours.

**ESGN457. SITE REMEDIATION ENGINEERING. 3.0 Hours.**

(II) This course describes the engineering principles and practices associated with the characterization and remediation of contaminated sites. Methods for site characterization and risk assessment will be highlighted while the emphasis will be on remedial action screening processes and technology principles and conceptual design. Common isolation and containment and in-situ and ex-situ treatment technology will be covered. Computerized decision-support tools will be used and case studies will be presented. Prerequisites: EGGN/ESGN354 or consent of instructor. 3 hours lecture; 3 semester hours.

**ESGN460. ONSITE WATER RECLAMATION AND REUSE. 3.0 Hours.**

(II). Appropriate solutions to water and sanitation in the U.S. and globally need to be effective in protecting public health and preserving water quality while also being acceptable, affordable and sustainable. Onsite and decentralized systems have the potential to achieve these goals in rural areas, peri-urban developments, and urban centers in small and large cities. Moreover they can improve water use efficiency, conserve energy and enable distributed energy generation, promote green spaces, restore surface waters and aquifers, and stimulate new green companies and jobs. A growing array of approaches, devices and technologies have evolved that include point-of-use water purification, waste source separation, conventional and advanced treatment units, localized natural treatment systems, and varied resource recovery and recycling options. This course will focus on the engineering selection, design, and implementation of onsite and decentralized systems for water reclamation and reuse. Topics to be covered include process analysis and system planning, water and waste stream attributes, water and resource conservation, confined unit and natural system treatment technologies, effluent collection and clustering, recycling and reuse options, and system management. Prerequisite: EGGN353/ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

**ESGN462. SOLID WASTE MINIMIZATION AND RECYCLING. 3.0 Hours.**

(I) The course objective is to put the student into the shoes of a plant manager having process responsibility for waste minimization, focusing on recycling. Emphasis is on proven and emerging solutions, especially those associated with heavy metals. Waste minimization generally requires a solid understanding of alternative raw materials and process technologies, in combination with creativity and sensitivity to economics. Prerequisites: Senior standing, or consent of instructor 3 hours lecture; 3 semester hours.

**ESGN463. POLLUTION PREVENTION: FUNDAMENTALS AND PRACTICE. 3.0 Hours.**

(II) The objective of this course is to introduce the principles of pollution prevention, environmentally benign products and processes, and manufacturing systems. The course provides a thorough foundation in pollution prevention concepts and methods. Engineers and scientists are given the tools to incorporate environmental consequences into decision-making. Sources of pollution and its consequences are detailed. Focus includes sources and minimization of industrial pollution; methodology for life-cycle assessments and developing successful pollution prevention plans; technological means for minimizing the use of water, energy, and reagents in manufacturing; and tools for achieving a sustainable society. Materials selection, process and product design, and packaging are also addressed. Prerequisite: EGGN/ESGN353 or EGGN354/ESGN354 or consent of instructor. 3 hours lecture; 3 semester hours.

**ESGN490. ENVIRONMENTAL LAW. 3.0 Hours.**

(I) Specially designed for the needs of the environmental quality engineer, scientist, planner, manager, government regulator, consultant, or advocate. Highlights include how our legal system works, environmental law fundamentals, all major US EPA/state enforcement programs, the National Environmental Policy Act, air and water pollutant laws, risk assessment and management, and toxic and hazardous substance laws (RCRA, CERCLA, TSCA, LUST, etc). Prerequisites: EGGN353/ESGN353 or EGGN354/ESGN354, or consent of instructor. 3 hours lecture; 3 semester hours.

**ESGN498. SPECIAL TOPICS IN ENVIRONMENTAL SCIENCE AND ENGINEERING. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**ESGN499. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

# Electrical Engineering and Computer Science

<http://eecs.mines.edu>

## Program Description

The Department of Electrical Engineering and Computer Science develops graduates that enable the management of tremendous amounts of data and energy around the world. The department offers two undergraduate degrees: Bachelor of Science in Computer Science and Bachelor of Science in Electrical Engineering. The department also supports the Electrical specialty in the interdisciplinary Bachelor of Science in Engineering degree. Graduates of both programs are in a position to take advantage of a broad variety of professional opportunities, and are well-prepared for a career in a world of rapid technological change.

## BS in Computer Science

Computing has become ubiquitous, impacting almost every aspect of modern life and playing an important role in many technological advances. Computing jobs are among the highest paid, and computing professionals generally report high job satisfaction. Graduates from our program have found employment with many different types of companies including technology, engineering, and financial companies.

The CS degree at CSM is designed to be accessible to students with or without prior programming experience. The Introduction to Computer Science course introduces students to the building blocks of CS and provides a brief introduction to procedural programming in Python. The second computing course, Programming Concepts, emphasizes development of programming skills in an object-oriented language. The third introductory course, Data Structures, provides an understanding of the classic data representation schemes, algorithms, and algorithm analysis that form the foundation for all advanced work in computing.

Required CS courses provide the fundamental skills and knowledge that are critical to success in computing. These courses reflect a mixture of theory and practice, including discrete structures, design and analysis of algorithms, principles of programming languages, computer architecture, operating systems, and software engineering. In the required Elements of Computing Systems course, students consolidate their understanding of CS by constructing a simulator for an entire modern computer from the ground up. The capstone field session course provides students an opportunity to work in teams to create software products for real clients.

Elective courses in CS allow students to explore a variety of important computing topics, such as graphics and visualization, human computer interaction, artificial intelligence, database management, and web programming. Elective courses often relate to recent trends in computing, covering topics such as security, high performance computing, wireless sensor networks, and mobile applications.

Computing is a broad field with applicability to most science and engineering domains. The CS minor is designed for students in other disciplines to receive a solid grounding in the basics, which should enable them to apply their computing skills to solve problems in other domains.

## ***Program Educational Objectives (Bachelor of Science in Computer Science)***

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile, the Computer Science Program at CSM has established the following program educational objectives:

Students will demonstrate technical expertise within computer science by:

- Designing and implementing solutions to practical problems in science and engineering,
- Using appropriate technology as a tool to solve problems in computer science, and
- Creating efficient algorithms and well-structured computer programs.

Students will demonstrate a breadth and depth of knowledge within computer science by:

- Extending course material to solve original problems,
- Applying knowledge of computer science to the solution of problems, and
- Identifying, formulating and solving computer science problems.

Students will demonstrate an understanding and appreciation for the relationship of computer science to other fields by:

- Applying computer science to solve problems in other fields,
- Working in cooperative multi-disciplinary teams, and
- Choosing appropriate technology to solve problems in other disciplines.

Students will demonstrate an ability to communicate computer science effectively by:

- Giving oral presentations,
- Completing written explanations,
- Interacting effectively in cooperative teams,
- Creating well-documented programs, and
- Understanding and interpreting written material in computer science.

## BS in Electrical Engineering

A distinguishing feature of the EE program at CSM is a focus in two specific areas: energy and power systems; and information and systems sciences, which includes embedded processors, signal processing and control systems. Graduates from our program find employment in the power industry, engineering consulting firms, renewable energy companies, aerospace and communications firms, as well as a wide variety of companies that rely on embedded intelligence to manage data and systems. Another popular choice of our students after graduation is graduate school, where an advanced degree will open up opportunities in corporate and government research labs or academia, and the opportunity to become technological leaders.

Students in the Electrical Engineering program complete a set of core courses that include mathematics, basic sciences, and engineering sciences during their first two years. Course work in mathematics is an essential part of the curriculum, which gives engineering students essential tools for modeling, analyzing, and predicting physical phenomena. The basic sciences are represented by physics and chemistry, which provide an appropriate foundation in the physical sciences. Engineering sciences build upon the basic sciences and are focused on applications.

The first two years also includes Engineering design course work within the Engineering Practice Introductory Course Sequence (EPICS I and II). This experience teaches design methodology and stresses the creative and synthesis aspects of the engineering profession. Finally, the first two years includes systems-oriented courses with humanities and social sciences content; these courses explore the linkages within the environment, human society, and engineered devices.

In the final two years, students complete an advanced core that includes circuit analysis, electronics, electromagnetic fields and waves, and digital systems. Because of our program focus, the core curriculum also includes courses in signal processing, embedded microprocessor systems design, machines and power systems, and control systems. Students can also take specialized electives that further develop their expertise in one of these focus areas, or in other areas such as robotics, biomedical engineering, and computing.

In their final year, students complete a capstone design course that is focused on an in-depth engineering project. The projects are generated by customer demand, and include experiential verification to ensure a realistic design experience.

The legacy B.S. in Engineering degree is accredited by ABET. The B.S. degree in Electrical Engineering is new as of the 2012-2013 school year and is therefore not yet accredited. Accreditation for those degrees will be sought during the 2013-2014 school year.

### Program Educational Objectives (Bachelor of Science in Electrical Engineering)

The Electrical Engineering program contributes to the educational objectives described in the CSM Graduate Profile. In addition, the Electrical Engineering Program at CSM has established the following program educational objectives:

Within three years of attaining the BS degree:

- Graduates will be situated in growing careers in their chosen field of electrical engineering or computer science, or will be successfully pursuing a graduate degree.
- Graduates will be advancing in their professional standing, generating new knowledge and/or exercising leadership in their field.
- Graduates will be contributing to the needs of society through professional practice, research, and/or service.

## Bachelor of Science in Computer Science Degree Requirements:

### Freshman

Fall		lec	lab	sem.hrs
CSCI101	INTRODUCTION TO COMPUTER SCIENCE			3
CHGN121	PRINCIPLES OF CHEMISTRY I			4
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4
LAIS100	NATURE AND HUMAN VALUES			4
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
PAGN101	PHYSICAL EDUCATION			0.5
				<b>16.0</b>
Spring		lec	lab	sem.hrs
CSCI261	PROGRAMMING CONCEPTS			3
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4
EPIC151	DESIGN (EPICS) I			3
PHGN100	PHYSICS I - MECHANICS			4.5

PAGN102	PHYSICAL EDUCATION			0.5
				<b>15.0</b>

### Sophomore

Fall		lec	lab	sem.hrs
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4
SYGN101	EARTH & ENV SYSTEMS, BELS 101, or CHGN 122			4
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS			4.5
CSCI262	DATA STRUCTURES			3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>16.0</b>

### Spring

		lec	lab	sem.hrs
CSCI341	COMPUTER ORGANIZATION			3
CSCI358	DISCRETE MATHEMATICS			3
EBGN201	PRINCIPLES OF ECONOMICS			3
MATH225	DIFFERENTIAL EQUATIONS			3
SYGN200	HUMAN SYSTEMS			3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>15.5</b>

### Junior

Fall		lec	lab	sem.hrs
CSCI306	SOFTWARE ENGINEERING			3
MATH323	PROBABILITY AND STATISTICS FOR ENGINEERS			3
MATH332	LINEAR ALGEBRA			3
FREE	Free Elective			3.0
FREE	Free Elective			3.0
				<b>15.0</b>

### Spring

		lec	lab	sem.hrs
CSCI406	ALGORITHMS			3
CSCI410	ELEMENTS OF COMPUTING SYSTEMS			3
CSCI ELECT	Computer Science Elective *			3.0
LAIS/EBGN	H&SS Restricted Elective I			3.0
FREE	Free Elective			3.0
FREE	Free Elective			1.0
				<b>16.0</b>

### Summer

		lec	lab	sem.hrs
CSCI370	ADVANCED SOFTWARE ENGINEERING			6
				<b>6.0</b>

### Senior

Fall		lec	lab	sem.hrs
CSCI442	OPERATING SYSTEMS			3
CSCI ELECT	Computer Science Elective *			3.0
CSCI ELECT	Computer Science Elective *			3.0
LAIS/EBGN	H&SS Restricted Elective II			3.0
FREE	Free Elective			3.0
				<b>15.0</b>

<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CSCI400	PRINCIPLES OF PROGRAMMING LANGUAGES			3
CSCI ELECT	Computer Science Elective *			3.0
LAIS/EBGN	H&SS Restricted Elective III			3.0
FREE	Free Elective			3.0
FREE	Free Elective			3.0
				<b>15.0</b>

Total Hours: 129.5

\* CSCI Electives can be chosen from any 400-level CSCI course. Please see the Courses Tab for course listings.

## Combined BS/MS in Computer Science

The Department of Electrical Engineering and Computer Science offers a combined Bachelor of Science/Master of Science program in Computer Science that enables students to work on a Bachelor of Science and a Master of Science simultaneously. Normally a Master's Degree requires 36 credit hours and takes two years to complete. Under the Combined Program, students will count two courses (CSCI406 and CSCI442) toward both degrees, so only 30 additional credit hours are needed to complete the degree. One additional 400-level course may be counted toward the graduate degree. Students selecting the Thesis option will be required to complete 18 hours of coursework and a thesis (12 credit hours). Students selecting the Non-Thesis option will be required to complete 30 credit hours of coursework. There are two required graduate-level courses: CSCI564 (Advanced Architecture) and CSCI561 (Theory of Computation). The remaining courses are all electives. Descriptions can be found in the EECS Graduate Bulletin.

Students may not apply for the combined program until they have taken five or more Computer Science classes at CSM (classes transferred from other universities will not be considered). This requirement may be met by any 200-level or above course with a CSCI prefix (e.g., CSCI261, CSCI306, CSCI442, etc.). Since CSCI370 (Field Session) is based almost exclusively on team work, it may not be counted as one of the five courses. Independent study courses (i.e., CSCI499) are also not included in the five courses. CSCI274 is a one credit hour course which also may not be counted as one of the five courses.

Students should have an overall GPA of at least 2.5 and a GPA of 3.2 for courses in the major. The calculation of GPA in the major will be based on *all* 200-level or above CSCI courses except those excluded above (i.e., CSCI274, CSCI370 and CSCI499). If a course is taken multiple times, all of the grades will be included into the GPA calculation. Interested students with a lower GPA must write an essay to explain why they should be admitted to the program.

## Bachelor of Science in Electrical Engineering Degree Requirements:

### Freshman

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
SYGN101	EARTH & ENV SYSTEMS, BELS 101, CSCI 101, or CHGN 122 (Distributed Science 1)			4
CHGN121	PRINCIPLES OF CHEMISTRY			4

MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4
LAIS100	NATURE AND HUMAN VALUES			4
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
PAGN101	PHYSICAL EDUCATION			0.5
				<b>17.0</b>

### Spring

		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4
EPIC151	DESIGN (EPICS) I			3
PHGN100	PHYSICS I - MECHANICS			4.5
PAGN102	PHYSICAL EDUCATION			0.5
CSCI101	INTRODUCTION TO COMPUTER SCIENCE, BELS 101, CHGN 122, or SYGN 101 (Distributed Science 2)			3
				<b>15.0</b>

### Sophomore

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
DCGN241	DIST CORE - STATICS			3
SYGN200	HUMAN SYSTEMS			3
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS			4.5
CSCI261	PROGRAMMING CONCEPTS			3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>18.0</b>

### Spring

		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH225	DIFFERENTIAL EQUATIONS			3
EBGN201	PRINCIPLES OF ECONOMICS			3
EGGN284	DIGITAL LOGIC			4
EGGN281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER			3
EGGN250	MULTIDISCIPLINARY ENGINEERING LABORATORY			1.5
EPIC251	DESIGN (EPICS) II			3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>18.0</b>

### Junior

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH323	PROBABILITY AND STATISTICS FOR ENGINEERS			3
EGGN315	DYNAMICS, 320, 351, or 371			3
EGGN382	ENGINEERING CIRCUIT ANALYSIS			3
EGGN383	MICROCOMPUTER ARCHITECTURE AND INTERFACING			4

EGGN388	INFORMATION SYSTEMS SCIENCE			4	
				<b>17.0</b>	
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	
MATH332	LINEAR ALGEBRA			3	
EGGN307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS			3	
EGGN385	ELECTRONIC DEVICES AND CIRCUITS			4	
EGGN386	FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS			3	
EGGN389	FUNDAMENTALS OF ELECTRIC MACHINERY			4	
				<b>17.0</b>	
<b>Summer</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	
EGGN334	ENGINEERING FIELD SESSION, ELECTRICAL SPECIALTY			3	
				<b>3.0</b>	
<b>Senior</b>					
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	
LAIS/EBGN	H&SS Restricted Elective I			3.0	
LAIS/EBGN	H&SS Restricted Elective II			3.0	
EGGN450	MULTIDISCIPLINARY ENGINEERING LABORATORY III			1	
EGGN491	SENIOR DESIGN I			3	
EGEL ELECT	Electrical Engineering Elective *			3.0	
EGEL ELECT	Electrical Engineering Elective *			3.0	
				<b>16.0</b>	
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	
LAIS/EBGN	H&SS Restricted Elective III			3.0	
EGGN492	SENIOR DESIGN II			3	
EGEL ELECT	Electrical Engineering Elective *			3.0	
FREE	Free Elective			3.0	
FREE	Free Elective			3.0	
FREE	Free Elective			3.0	
				<b>18.0</b>	

Total Hours: 139.0

\* Electrical Engineering students are required to take three Electrical Engineering Electives from the following list:

### Electrical Engineering Electives:

EGGN325	INTRODUCTION TO BIOMECHANICAL ENGINEERING			3
EGGN417	MODERN CONTROL DESIGN			3
EGGN460	NUMERICAL METHODS FOR ENGINEERS			3
EGGN481	DIGITAL SIGNAL PROCESSING			3
EGGN483	ANALOG & DIGITAL COMMUNICATION SYSTEMS			4

EGGN484	POWER SYSTEMS ANALYSIS			3
EGGN485	INTRODUCTION TO HIGH POWER ELECTRONICS			3
EGGN486	PRACTICAL DESIGN OF SMALL RENEWABLE ENERGY SYSTEMS			3
EGGN487	ANALYSIS AND DESIGN OF ADVANCED ENERGY SYSTEMS			3
CSCI341	COMPUTER ORGANIZATION			3
CSCI410	ELEMENTS OF COMPUTING SYSTEMS			3
CSCI440	PARALLEL COMPUTING FOR SCIENTISTS AND ENGINEERS			3
MATH334	INTRODUCTION TO PROBABILITY			3
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS			3
MATH455	PARTIAL DIFFERENTIAL EQUATIONS			3
PHGN300	PHYSICS III-MODERN PHYSICS I			3
PHGN320	MODERN PHYSICS II: BASICS OF QUANTUM MECHANICS			4
PHGN435	INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY			3
PHGN440	SOLID STATE PHYSICS			3
PHGN441	SOLID STATE PHYSICS APPLICATIONS AND PHENOMENA			3
PHGN462	ELECTROMAGNETIC WAVES AND OPTICAL PHYSICS			3

## Combined BS/MS in Electrical Engineering

The Department of Electrical Engineering and Computer Science offers a combined program in which students have the opportunity to supplement an undergraduate degree with graduate coursework. Upon completion of the program, students receive two degrees, the Bachelor of Science in Electrical Engineering and the Master of Science in Electrical Engineering.

Students must apply to enter this program by the beginning of their Senior year and must have a minimum GPA of 3.0. At the beginning of the Senior year, a pro forma graduate school application is submitted and as long as the undergraduate portion of the program is successfully completed, the student is admitted to the Engineering graduate program.

Students are required to take an additional 30 credit hours for the M.S. degree. Up to nine of the 30 credit hours beyond the undergraduate degree requirements can be 400-level courses. The remainder of the courses will be at the graduate level (500-level and above). The EECS Graduate Bulletin provides details for this program and includes specific instructions regarding required and elective courses. Students may switch from the combined program which includes a non-thesis Master of Science degree to an M.S. degree with a thesis optional however, if students change degree programs they must satisfy all degree requirements for the M.S. with thesis degree.

## Combined Engineering Physics or Chemistry Baccalaureate and Electrical Engineering Masters Degrees

The Department of Electrical Engineering and Computer Science, in collaboration with the Departments of Physics and Chemistry, offers five-year programs in which students have the opportunity to obtain specific engineering skill to complement their physics or chemistry background. Physics or chemistry students in this program fill in their

technical and free electives over their standard four year Engineering Physics or Chemistry B.S. program with a reduced set of Electrical Engineering classes. at the end of the fourth year, the student is awarded an Engineering Physics B.S or a Chemistry B.S., as appropriate. Course schedules for these five-year programs can be obtained in the EECS, Physics, and Chemistry Departmental Offices.

General CSM Minor/ASI requirements can be found here (p. 195).

## Computer Science

For an **Area of Special Interest in Computer Science**, the student should take:

CSCI262	DATA STRUCTURES	3
CSCI306	SOFTWARE ENGINEERING	3

and either

CSCI358	DISCRETE MATHEMATICS	3
CSCI406	ALGORITHMS	3

or

CSCI341	COMPUTER ORGANIZATION	3
CSCI442	OPERATING SYSTEMS	3

For a **Minor in Computer Science**, the student should take:

CSCI262	DATA STRUCTURES	3
CSCI306	SOFTWARE ENGINEERING	3

and either

CSCI358	DISCRETE MATHEMATICS	3
CSCI406	ALGORITHMS	3

or

CSCI341	COMPUTER ORGANIZATION	3
CSCI442	OPERATING SYSTEMS	3

along with

two 400- level Computer Science courses, which may not be languages transferred from another university.

## Electrical Engineering

The Electrical Engineering and Computer Science department supports the Electrical Engineering Specialty Minor housed within the College of Engineering and Computational Sciences. Please refer to the Minor tab within the Engineering section of the bulletin for more information.

## Courses

### CSCI101. INTRODUCTION TO COMPUTER SCIENCE. 3.0 Hours.

(I, II, S) An introductory course to the building blocks of Computer Science. Topics include conventional computer hardware, data representation, the role of operating systems and networks in modern computing, algorithm design, large databases, SQL, and security. A popular procedural programming language will be learned by students and programming assignments will explore ideas in algorithm runtimes, computer simulation, computational techniques in optimization problems, client-server communications, encryption, and database queries. Prerequisite: none. 3 hours lecture; 3 semester hours.

### CSCI260. FORTRAN PROGRAMMING. 2.0 Hours.

(I, II) Computer programming in Fortran90/95 with applications to science and engineering. Program design and structure, problem analysis, debugging, program testing. Language skills: arithmetic, input/output, branching and looping, functions, arrays, data types. Introduction to operating systems. Prerequisite: none. 2 hours lecture; 2 semester hours.

### CSCI261. PROGRAMMING CONCEPTS. 3.0 Hours.

(I, II, S) Computer programming in a contemporary language such as C++ or Java, using software engineering techniques. Problem solving, program design, documentation, debugging practices. Language skills: input/output, control, repetition, functions, files, classes and abstract data types, arrays, and pointers.

Introduction to operating systems and object-oriented programming.

Application to problems in science and engineering. Prerequisite: none. 3 hours lecture; 3 semester hours.

### CSCI262. DATA STRUCTURES. 3.0 Hours.

(I, II, S) Defining and using data structures such as linked lists, stacks, queues, binary trees, binary heap, hash tables. Introduction to algorithm analysis, with emphasis on sorting and search routines. Language skills: abstract data types, templates and inheritance. Prerequisite: CSCI261 with a grade of C- or higher. 3 hours lecture; 3 semester hours.

### CSCI274. INTRODUCTION TO THE LINUX OPERATING SYSTEM. 1.0 Hour.

(I,II) Introduction to the Linux Operating System will teach students how to become proficient with using a Linux operating system from the command line. Topics will include: remote login (ssh), file system navigation, file commands, editors, compilation, execution, redirection, output, searching, processes, usage, permissions, compression, parsing, networking, and bash scripting. Prerequisites: CSCI261 or instructor approval. 1 hour lecture; 1 semester hour.

### CSCI298. SPECIAL TOPICS. 1-6 Hour.

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### CSCI299. INDEPENDENT STUDY. 1-6 Hour.

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

### CSCI306. SOFTWARE ENGINEERING. 3.0 Hours.

(I, II) Introduction to software engineering processes and object-oriented design principles. Topics include the Agile development methodology, test-driven development, UML diagrams, use cases and several object-oriented design patterns. Course work emphasizes good programming practices via version control and code reviews. Prerequisite: CSCI262 with grade of C- or higher. 3 hours lecture; 3 semester hours.

### CSCI340. COOPERATIVE EDUCATION. 3.0 Hours.

(I, II, S) (WI) Supervised, full-time engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade point average of at least 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions. Repeatable.

**CSCI341. COMPUTER ORGANIZATION. 3.0 Hours.**

(I, II) Covers the basic concepts of computer architecture and organization. Topics include machine level instructions and operating system calls used to write programs in assembly language, computer arithmetics, performance, processor design, and pipelining techniques. This course provides insight into the way computers operate at the machine level. Prerequisite: CSCI261 and CSCI101 or permission of instructor. Co-requisites: CSCI262. 3 hours lecture; 3 semester hours.

**CSCI358. DISCRETE MATHEMATICS. 3.0 Hours.**

(I, II) This course is an introductory course in discrete mathematics and algebraic structures. Topics include: formal logic; proofs, recursion, analysis of algorithms; sets and combinatorics; relations, functions, and matrices; Boolean algebra and computer logic; trees, graphs, finite-state machines and regular languages.

Prerequisite: MATH213, MATH223 or MATH224. 3 hours lecture; 3 semester hours.

**CSCI370. ADVANCED SOFTWARE ENGINEERING. 6.0 Hours.**

(S) (WI) This is the capstone course in which students apply their course work knowledge to a challenging applied problem for a real client. The students work in groups of three or four for a period of six forty-hour weeks. Communication skills are emphasized. By the end of the field session they must have a finished product with appropriate supporting documents. Prerequisite: CSCI306. 6-week summer session; 6 semester hours.

**CSCI399. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**CSCI400. PRINCIPLES OF PROGRAMMING LANGUAGES. 3.0 Hours.**

(I, II) Study of the principles relating to design, evaluation and implementation of programming languages, including basic compiler techniques and context-free grammars. Students will be exposed to different categories of programming languages, such as functional, imperative, object-oriented and scripting. Best practices for programming will be explored, including effective use of exceptions and threads. The primary languages discussed are: Java, C++, Scheme, and Perl. Prerequisite: CSCI306. 3 hours lecture; 3 semester hours.

**CSCI403. DATA BASE MANAGEMENT. 3.0 Hours.**

(I, II) Design and evaluation of information storage and retrieval systems, including defining and building a database and producing the necessary queries for access to the stored information. Relational database management systems, structured query language, and data storage facilities. Applications of data structures such as lists, inverted lists and trees. System security, maintenance, recovery and definition. Interfacing host languages to database systems and object-relational mapping tools. NoSQL databases and distributed databases. Prerequisite: CSCI262 with a grade of C- or higher. 3 hours lecture; 3 semester hours.

**CSCI404. ARTIFICIAL INTELLIGENCE. 3.0 Hours.**

(I) General investigation of the Artificial Intelligence field. Several methods used in artificial intelligence such as search strategies, knowledge representation, logic and probabilistic reasoning are developed and applied to practical problems. Fundamental artificial intelligence techniques are presented, including neural networks, genetic algorithms, and fuzzy sets. Selected application areas, such as robotics, natural language processing and games, are discussed. Prerequisite: CSCI262 with a grade of C- or higher and MATH323 or consent of instructor. 3 hours lecture; 3 semester hours.

**CSCI406. ALGORITHMS. 3.0 Hours.**

(I, II) Reasoning about algorithm correctness (proofs, counterexamples). Analysis of algorithms: asymptotic and practical complexity. Review of dictionary data structures (including balanced search trees). Priority queues. Advanced sorting algorithms (heapsort, radix sort). Advanced algorithmic concepts illustrated through sorting (randomized algorithms, lower bounds, divide and conquer). Dynamic programming. Backtracking. Algorithms on unweighted graphs (traversals) and weighted graphs (minimum spanning trees, shortest paths, network flows and bipartite matching); NP-completeness and its consequences. Prerequisite: CSCI262 with a grade of C- or higher, MATH213, MATH223 or MATH224, MATH358/CSCI358. 3 hours lecture; 3 semester hours.

**CSCI407. INTRODUCTION TO SCIENTIFIC COMPUTING. 3.0 Hours.**

(I, II) Course goals are to introduce basic concepts of scientific computing, explain how, why, and when numerical methods can be expected to work, and provide a basis for future study in scientific computing. Topics include number representation and errors in a computer, locating roots of equations, interpolation and numerical differentiation, numerical integration, systems of linear equations (Gauss elimination with pivoting, LU factorization), approximation by spline functions, the method of least squares, ordinary differential equations. 3 hours lecture. 3 semester hours.

**CSCI410. ELEMENTS OF COMPUTING SYSTEMS. 3.0 Hours.**

(II) This comprehensive course will help students consolidate their understanding of all fundamental computer science concepts. Topics include symbolic communication, Boolean logic, binary systems, logic gates, computer architecture, assembly language, assembler construction, virtual machines, object-oriented programming languages, software engineering, compilers, language design, and operating systems. Using a hardware simulator and a programming language of their choice, students construct an entire modern computer from the ground up, resulting in an intimate understanding of how each component works. Prerequisites:.

**CSCI422. USER INTERFACES. 3.0 Hours.**

(I) User Interface Design is a course for programmers who want to learn how to create more effective software. This objective will be achieved by studying principles and patterns of interaction design, critiquing existing software using criteria presented in the textbooks, and applying criteria to the design and implementation of one larger product. Students will also learn a variety of techniques to guide the software design process, including Cognitive Walkthrough, Talk-aloud and others. Prerequisite: CSCI262. 3 hours lecture; 3 semester hours.



**CSCI440. PARALLEL COMPUTING FOR SCIENTISTS AND ENGINEERS. 3.0 Hours.**

(II) This course is designed to introduce the field of parallel computing to all scientists and engineers. The students will be taught how to solve scientific problems using parallel computing technologies. They will be introduced to basic terminologies and concepts of parallel computing, learn how to use MPI to develop parallel programs, and study how to design and analyze parallel algorithms. Prerequisite: CSCI262 with a grade of C- or higher. 3 hours lecture; 3 semester hours.

**CSCI441. COMPUTER GRAPHICS. 3.0 Hours.**

(I) This class focuses on the basic 3D rendering and modeling techniques. In particular, it covers ray tracing, graphics pipeline, modeling techniques based on polynomial curves and patches, subdivision for curves and surfaces, scene graphs, BSP trees and their applications, and elements of global illumination. Prerequisite: CSCI262 with a grade of C- or higher. 3 hours lecture, 3 semester hours.

**CSCI442. OPERATING SYSTEMS. 3.0 Hours.**

(I, II) Introduces the essential concepts in the design and implementation of operating systems: what they can do, what they contain, and how they are implemented. Despite rapid OS growth and development, the fundamental concepts learned in this course will endure. We will cover the following high-level OS topics, roughly in this order: computer systems, processes, processor scheduling, memory management, virtual memory, threads, and process/thread synchronization. This course provides insight into the internal structure of operating systems; emphasis is on concepts and techniques that are valid for all computers. We suggest the student takes "Introduction to the Linux Operating System" before this course (if the student is new to the Unix/Linux environment). Prerequisite: CSCI262 with a grade of C- or higher, CSCI341. 3 hours lecture; 3 semester hours.

**CSCI443. ADVANCED PROGRAMMING CONCEPTS USING JAVA. 3.0 Hours.**

(I, II) This course will quickly review programming constructs using the syntax and semantics of the Java programming language. It will compare the constructs of Java with other languages and discuss program design and implementation. Object oriented programming concepts will be reviewed and applications, applets, servlets, graphical user interfaces, threading, exception handling, JDBC, and network - ing as implemented in Java will be discussed. The basics of the Java Virtual Machine will be presented. Prerequisites: CSCI306. 3 hours lecture, 3 semester hours.

**CSCI444. ADVANCED COMPUTER GRAPHICS. 3.0 Hours.**

(I, II) This is an advanced computer graphics course, focusing on modern rendering and geometric modeling techniques. Students will learn a variety of mathematical and algorithmic techniques that can be used to develop high-quality computer graphic software. In particular, the course will cover global illumination, GPU programming, geometry acquisition and processing, point based graphics and non-photorealistic rendering. Prerequisites: Basic understanding of computer graphics and prior exposure to graphics-related programming, for example, MACS 441. 3 lecture hours, 3 credit hours.

**CSCI445. WEB PROGRAMMING. 3.0 Hours.**

(II) Web Programming is a course for programmers who want to develop web-based applications. It covers basic website design extended by client-side and server-side programming. Students should acquire an understanding of the role and application of web standards to website development. Topics include Cascading Style Sheets (CSS), JavaScript, PHP and database connectivity. At the conclusion of the course students should feel confident that they can design and develop dynamic Web applications on their own. Prerequisites: CSCI262 or consent of instructor. 3 hours lecture, 3 semester hours.

**CSCI446. WEB APPLICATIONS. 3.0 Hours.**

(I) Web Applications is a course for programmers who want to learn how to move beyond creating dynamic web pages and build effective web-based applications. At the completion of this course, students should know HTTP, Hypertext Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript, Ajax, Ruby, RESTful architectures and Web services. Additionally students should have considered a variety of issues related to web application architecture, including but not limited to security, performance and cloud-based deployment environments. Prerequisites: CSCI445. 3 hours lecture, 3 semester hours.

**CSCI447. SCIENTIFIC VISUALIZATION. 3.0 Hours.**

(I) Scientific visualization uses computer graphics to create visual images which aid in understanding of complex, often massive numerical representation of scientific concepts or results. The main focus of this course is on modern visualization techniques applicable to spatial data such as scalar, vector and tensor fields. In particular, the course will cover volume rendering, texture based methods for vector and tensor field visualization, and scalar and vector field topology. Basic understanding of computer graphics and analysis of algorithms required. Prerequisites: CSCI262 and MATH441. 3 lecture hours, 3 semester hours.

**CSCI471. COMPUTER NETWORKS I. 3.0 Hours.**

(I) This introduction to computer networks covers the fundamentals of computer communications, using TCP/IP standardized protocols as the main case study. The application layer and transport layer of communication protocols will be covered in depth. Detailed topics include application layer protocols (HTTP, FTP, SMTP, and DNS), transport layer protocols (reliable data transfer, connection management, and congestion control), network layer protocols, and link layer protocols. In addition, students will program client/server network applications. Prerequisite: CSCI442 or consent of instructor. 3 hours lecture, 3 semester hours.

**CSCI474. INTRODUCTION TO CRYPTOGRAPHY. 3.0 Hours.**

(II) This course is primarily oriented towards the mathematical aspects of cryptography, but is also closely related to practical and theoretical issues of computer security. The course provides mathematical background required for cryptography including relevant aspects of number theory and mathematical statistics. The following aspects of cryptography will be covered: symmetric and asymmetric encryption, computational number theory, quantum encryption, RSA and discrete log systems, SHA, steganography, chaotic and pseudo-random sequences, message authentication, digital signatures, key distribution and key management, and block ciphers. Many practical approaches and most commonly used techniques will be considered and illustrated with real-life examples. Prerequisites: CSCI262, MATH334/MATH335, MATH358. 3 credit hours.

**CSCI475. INFORMATION SECURITY AND PRIVACY. 3.0 Hours.**

(I) Information Security and Privacy provides a hands-on introduction to the principles and best practices in information and computer security. Lecture topics will include basic components of information security including threat assessment and mitigation, policy development, forensics investigation, and the legal and political dimensions of information security. Prerequisite: CSCI262 and CSCI341 (required); CSCI274 (recommended). 3 hours lecture; 3 semester hours.

**CSCI491. UNDERGRADUATE RESEARCH. 1-3 Hour.**

(I) (WI) Individual investigation under the direction of a department faculty member. Written report required for credit. Prerequisite: Consent of Department Head. Variable - 1 to 3 semester hours. Repeatable for credit to a maximum of 12 hours.

**CSCI492. UNDERGRADUATE RESEARCH. 1-3 Hour.**

(II) (WI) Individual investigation under the direction of a department faculty member. Written report required for credit. Prerequisite: Consent of Department Head. Variable - 1 to 3 semester hours. Repeatable for credit to a maximum of 12 hours.

**CSCI498. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**CSCI499. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**EGGN281. INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER. 3.0 Hours.**

This course provides an engineering science analysis of electrical circuits. DC and single-phase AC networks are presented. Transient analysis of RC, RL, and RLC circuits is studied as is the analysis of circuits in sinusoidal steady-state using phasor concepts. The following topics are included: DC and single-phase AC circuit analysis, current and charge relationships. Ohm's Law, resistors, inductors, capacitors, equivalent resistance and impedance, Kirchhoff's Laws, Thévenin and Norton equivalent circuits, superposition and source transformation, power and energy, maximum power transfer, first order transient response, algebra of complex numbers, phasor representation, time domain and frequency domain concepts, and ideal transformers. The course features PSPICE, a commercial circuit analysis software package. Prerequisites: PHGN200; 3 hours lecture; 3 semester hours.

**EGGN284. DIGITAL LOGIC. 4.0 Hours.**

(I, II) Fundamentals of digital logic design. Covers combinational and sequential logic circuits, programmable logic devices, hardware description languages, and computer-aided design (CAD) tools. Laboratory component introduces simulation and synthesis software and hands-on hardware design. Co-requisites: EGGN281 or PHGN215. 3 hours lecture; 3 hours lab; 4 semester hours.

**EGGN307. INTRODUCTION TO FEEDBACK CONTROL SYSTEMS. 3.0 Hours.**

(I, II) System modeling through an energy flow approach is presented, with examples from linear electrical, mechanical, fluid and/or thermal systems. Analysis of system response in both the time domain and frequency domain is discussed in detail. Feedback control design techniques, including PID, are analyzed using both analytical and computational methods. Prerequisites: (DCGN381 or PHGN215) and MATH225. 3 hours lecture; 3 semester hours.

**EGGN334. ENGINEERING FIELD SESSION, ELECTRICAL SPECIALTY. 3.0 Hours.**

(S) Experience in the engineering design process involving analysis, design, and simulation. Students use engineering, mathematics and computers to model, analyze, design and evaluate system performance. Teamwork emphasized. Prerequisites: EGGN382, EGGN388, and two of the following: EGGN384, EGGN385, EGGN389, and EPIC251. Three weeks in summer session; 3 semester hours.

**EGGN382. ENGINEERING CIRCUIT ANALYSIS. 3.0 Hours.**

(I, II) This course provides for the continuation of basic circuit analysis techniques developed in EGGN 381, by providing the theoretical and mathematical fundamentals to understand and analyze complex electric circuits. The key topics covered include: (i) Steady-state analysis of single-phase and three-phase ac power circuits, (ii) Laplace transform techniques, (iii) transfer functions, (iv) frequency response, (v) Bode diagrams, (vi) Fourier series expansions, and (vii) two-port networks. The course features PSPICE, a commercial circuit analysis software package. Prerequisites: EGGN281 or consent of instructor. 3 Semester Hours.

**EGGN383. MICROCOMPUTER ARCHITECTURE AND INTERFACING. 4.0 Hours.**

(I) Microprocessor and microcontroller architecture focusing on hardware structures and elementary machine and assembly language programming skills essential for use of microprocessors in data acquisition, control, and instrumentation systems. Analog and digital signal conditioning, communication, and processing. A/D and D/A converters for microprocessors. RS232 and other communication standards. Laboratory study and evaluation of microcomputer system; design and implementation of interfacing projects. Prerequisite: EGGN284 or consent of instructor. 3 hours lecture; 3 hours lab; 4 semester hours.

**EGGN385. ELECTRONIC DEVICES AND CIRCUITS. 4.0 Hours.**

(I, II) Semiconductor materials and characteristics, junction diode operation, bipolar junction transistors, field effect transistors, biasing techniques, four layer devices, amplifier and power supply design, laboratory study of semiconductor circuit characteristics. Prerequisite: EGGN382 or PHGN215. 3 hours lecture; 3 hours lab; 4 semester hours.

**EGGN386. FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS. 3.0 Hours.**

(II) This course provides an introduction to electromagnetic theory as applied to electrical engineering problems in wireless communications, transmission lines, and high-frequency circuit design. The theory and applications are based on Maxwell's equations, which describe the electric and magnetic force-fields, the interplay between them, and how they transport energy. Matlab and PSPICE will be used in homework assignments, to perform simulations of electromagnetic interference, electromagnetic energy propagation along transmission lines on printed circuit boards, and antenna radiation patterns. Prerequisites: EGGN382, MATH225 and/or consent of instructor. 3 hours lecture; 3 semester hours.

**EGGN388. INFORMATION SYSTEMS SCIENCE. 4.0 Hours.**

(I, II) The interpretation, representation and analysis of timevarying phenomena as signals which convey information and noise; applications are drawn from filtering, audio and image processing, and communications. Topics include convolution, Fourier series and transforms, sampling and discrete-time processing of continuous-time signals, modulation, and z-transforms. Prerequisite: DCGN381 or PHGN215 and MATH225. 4 hours lecture; 4 semester hours.

**EGGN389. FUNDAMENTALS OF ELECTRIC MACHINERY. 4.0 Hours.**

(I, II) This course provides an engineering science analysis of electrical machines. The following topics are included: DC, single-phase and three-phase AC circuit analysis, magnetic circuit concepts and materials, transformer analysis and operation, steady-state and dynamic analysis of rotating machines, synchronous and poly-phase induction motors, and laboratory study of external characteristics of machines and transformers. Prerequisite: EGGN382 or PHGN215. 3 hours lecture; 3 hours lab; 4 semester hours.

**EGGN398E. SPECIAL TOPICS IN ENGINEERING. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**EGGN399E. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**EGGN417. MODERN CONTROL DESIGN. 3.0 Hours.**

(I) Control system design with an emphasis on observer-based methods, from initial open-loop experiments to final implementation. The course begins with an overview of feedback control design technique from the frequency domain perspective, including sensitivity and fundamental limitations. State space realization theory is introduced, and system identification methods for parameter estimation are introduced. Computerbased methods for control system design are presented. Prerequisite: EGGN307. 3 lecture hours, 3 semester hours.

**EGGN481. DIGITAL SIGNAL PROCESSING. 3.0 Hours.**

(I) This course introduces the mathematical and engineering aspects of digital signal processing (DSP). An emphasis is placed on the various possible representations for discrete-time signals and systems (in the time, z-, and frequency domains) and how those representations can facilitate the identification of signal properties, the design of digital filters, and the sampling of continuous-time signals. Advanced topics include sigma-delta conversion techniques, multi-rate signal processing, and spectral analysis. The course will be useful to all students who are concerned with information bearing signals and signal processing in a wide variety of application settings, including sensing, instrumentation, control, communications, signal interpretation and diagnostics, and imaging. Prerequisite: EGGN388 or consent of instructor. 3 hours lecture; 3 semester hours.

**EGGN483. ANALOG & DIGITAL COMMUNICATION SYSTEMS. 4.0 Hours.**

(II) Signal classification; Fourier transform; filtering; sampling; signal representation; modulation; demodulation; applications to broadcast, data transmission, and instrumentation. Prerequisite: EGGN388 or consent of instructor. 3 hours lecture; 3 hours lab; 4 semester hours.

**EGGN484. POWER SYSTEMS ANALYSIS. 3.0 Hours.**

(I) 3-phase power systems, per-unit calculations, modeling and equivalent circuits of major components, voltage drop, fault calculations, symmetrical components and unsymmetrical faults, system grounding, power-flow, selection of major equipment, design of electric power distribution systems. Prerequisite: EGGN389. 3 hours lecture; 3 semester hours.

**EGGN485. INTRODUCTION TO HIGH POWER ELECTRONICS. 3.0 Hours.**

(II) Power electronics are used in a broad range of applications from control of power flow on major transmission lines to control of motor speeds in industrial facilities and electric vehicles, to computer power supplies. This course introduces the basic principles of analysis and design of circuits utilizing power electronics, including AC/DC, AC/AC, DC/DC, and DC/AC conversions in their many configurations. Prerequisites: EGGN385, EGGN389. 3 hours lecture; 3 semester hours.

**EGGN486. PRACTICAL DESIGN OF SMALL RENEWABLE ENERGY SYSTEMS. 3.0 Hours.**

(Taught on Demand) This course provides the fundamentals to understand and analyze renewable energy powered electric circuits. It covers practical topics related to the design of alternative energy based systems. It is assumed the students will have some basic and broad knowledge of the principles of electrical machines, thermodynamics, electronics, and fundamentals of electric power systems. One of the main objectives of this course is to focus on the interdisciplinary aspects of integration of the alternative sources of energy, including hydropower, wind power, photovoltaic, and energy storage for those systems. Power electronic systems will be discussed and how those electronic systems can be used for stand-alone and grid-connected electrical energy applications. Prerequisite: EGGN382 or consent of instructor. 3 hours lecture; 3 semester hours.

**EGGN487. ANALYSIS AND DESIGN OF ADVANCED ENERGY SYSTEMS. 3.0 Hours.**

(II) The course investigates the design, operation and analysis of complex interconnected electric power grids, the basis of our electric power infrastructure. Evaluating the system operation, planning for the future expansion under deregulation and restructuring, ensuring system reliability, maintaining security, and developing systems that are safe to operate has become increasingly more difficult. Because of the complexity of the problems encountered, analysis and design procedures rely on the use of sophisticated power system simulation computer programs. The course features some commonly used commercial software packages. Prerequisites: EGGN 484 or consent of instructor. 2 hours lecture, 3 hours laboratory; 3 semester hours.

**EGGN499E. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**ESGN459. HYDROLOGIC AND WATER RESOURCES ENGINEERING. 3.0 Hours.**

(II) This course introduces the principles of physical hydrology in the framework of hydrologic and water resources engineering. Topics include groundwater, surface water, infiltration, evapotranspiration, sediment transport, flood and drought analysis, lake and reservoir analysis, water-resources planning, water quality engineering, and storm-sewer hydraulics, water-wastewater distribution /collection, engineering design problems. Prerequisites: ESGN 353 or consent of instructor. 3 hour lecture; 3 semester hours.

# Engineering

<http://cecs.mines.edu>

## Program Description

The College of Engineering and Computational Sciences offers a design-oriented, interdisciplinary, accredited non-traditional undergraduate program in engineering with specialization in civil, electrical, environmental or mechanical engineering. The program emphasizes fundamental engineering principles and requires in-depth understanding within one of the four specialty areas that are offered. Graduates are in a position to take advantage of a broad variety of professional opportunities, and are well-prepared for an engineering career in a world of rapid technological change.

The program leading to the degree Bachelor of Science in Engineering is accredited by the:

Accreditation Board for Engineering and Technology (ABET)  
111 Market Place, Suite 1050  
Baltimore, MD 21202-4012  
telephone (410) 347-7700

## Combined Engineering Baccalaureate and Engineering Systems Masters Degrees

The College of Engineering & Computational Sciences offers a five year combined program in which students have the opportunity to obtain specific engineering skills supplemented with graduate coursework in Engineering. Upon completion of the program, students receive two degrees, the Bachelor of Science in Engineering and the Master of Science in Engineering.

Students must apply to enter this program by the beginning of their Senior year and must have a minimum GPA of 3.0. To complete the undergraduate portion of the program, students must successfully finish the classes indicated in any of the four specialty programs (civil, electrical, environmental or mechanical engineering). At the beginning of the Senior year, a *pro forma* graduate school application is submitted and as long as the undergraduate portion of the program is successfully completed, the student is admitted to the Engineering graduate program.

Students are required to take an additional thirty credit hours for the M.S. degree. Up to nine of the 30 credit hours beyond the undergraduate degree requirements can be 4XX level courses. The remainder of the courses will be at the graduate level (5XX and above). Students will need to choose a program specialty (Civil, Electrical, Mechanical, and Systems). The College of Engineering & Computational Sciences Graduate Bulletin provides details for each of these programs and includes specific instructions regarding required and elective courses. Students may switch from the combined program which includes a non-thesis Master of Science degree to a M.S. degree with a thesis option; however, if students change degree programs they must satisfy all degree requirements for the M.S. with thesis degree.

Interested students can obtain additional information from the College of Engineering & Computational Sciences.

## Combined Engineering Physics or Chemistry Baccalaureate and Engineering Systems Masters Degrees

The College of Engineering & Computational Sciences in collaboration with the Departments of Physics and Chemistry offers five-year programs in which students have the opportunity to obtain specific engineering

skills to complement their physics or chemistry background. Physics or chemistry students in this program fill in their technical and free electives over their standard four year Engineering Physics or Chemistry B.S. program with a reduced set of engineering classes. These classes come in one of two specialties within the College: Electrical engineering and Mechanical engineering. At the end of the fourth year, the student is awarded an Engineering Physics B.S. or Chemistry B.S., as appropriate. Students in this program are automatically entered into the Engineering Masters degree program. Course schedules for these five-year programs can be obtained in the Engineering, Physics and Chemistry Departmental Offices.

Students must apply to enter this program by the beginning of their Senior year and must have a minimum GPA of 3.0. To complete the undergraduate portion of the program, students must successfully finish the classes indicated by the "typical" class sequence for the appropriate track. At the beginning of the Senior year, a *pro forma* graduate school application is submitted and as long as the undergraduate portion of the program is successfully completed, the student is admitted to the Engineering graduate program.

Interested students can obtain additional information and detailed curricula from the College of Engineering & Computational Sciences or the Physics Department.

## Program Educational Objectives (Bachelor of Science in Engineering)

The Engineering program contributes to the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria. In addition, the Engineering Program at CSM has established the following program educational objectives: within three years of attaining the BS degree:

- Graduates will be situated in growing careers in their chosen engineering fields or will be successfully pursuing a graduate degree.
- Graduates will be advancing in their professional standing, generating new knowledge and/or exercising leadership in their field.
- Graduates will be contributing to the needs of society through professional practice, research, and/or service.

## Curriculum

During the first two years at CSM, students complete a set of core courses that include mathematics, basic sciences, and engineering sciences. Course work in mathematics is an essential part of the curriculum which gives engineering students essential tools for modeling, analyzing, and predicting physical phenomena. The basic sciences are represented by physics and chemistry which provide an appropriate foundation in the physical sciences. Engineering sciences build upon the basic sciences and are focused on applications.

The first two years also includes Engineering design course work within the Engineering Practice Introductory Course Sequence (EPICS I and II). This experience teaches design methodology and stresses the creative and synthesis aspects of the engineering profession. Finally, the first two years includes systems-oriented courses with humanities and social sciences content; these courses explore the linkages within the environment, human society, and engineered devices.

In the final two years, students complete an advanced core that includes electric circuits, engineering mechanics, advanced mathematics, thermodynamics, economics, engineering design, and additional studies in liberal arts and international topics. Students must choose a specialty in civil, electrical, environmental or mechanical engineering and each

specialty includes a set of unique upper-division course requirements. Free electives (9 credits), at the student's discretion, can be used to either satisfy a student's personal interest in a topic or they can be used as coursework as part of an "area of special interest" of at least 12 semester hours or a minor of at least 18 semester hours in another department or division.

All students must complete a capstone design course which is focused on an in-depth multidisciplinary engineering project. The projects are generated by customer demand, and include experiential verification to ensure a realistic design experience.

Prospective students should note that this is an integrated, broad-based and interdisciplinary engineering program. Engineering analysis and design is emphasized with interdisciplinary application for industrial projects, structures and processes. For example, our unique Multidisciplinary Engineering Laboratory sequence promotes life-long learning skills using state-of-the-art instrumentation funded through a combination of grants from the Department of Education, private industry contributions, and investment by CSM.

The **Civil Engineering Specialty** builds on the multidisciplinary engineering principles of the core curriculum to focus in Geotechnical and Structural Engineering. Civil Specialty students are also asked to choose three civil elective courses from a list that includes offerings from other civil-oriented departments at CSM such as Geological Engineering and Mining Engineering. These electives give students the opportunity for further specialization in other areas of Civil Engineering. Civil Specialty students interested in a more research-oriented component to their undergraduate curriculum are encouraged to take on an Independent Study project with one of the Civil Engineering Faculty. These projects can offer a useful experience that is relevant to future graduate work.

The **Electrical Engineering Specialty** builds on the engineering principles of the core curriculum to provide exposure to the fundamentals of electrical engineering. The program includes core electrical engineering coursework in circuit analysis, signal processing, electronics, electromagnetic fields and waves, digital systems, machines and power systems, and control systems. Students also take specialized electives in the areas of microprocessor-based systems design, digital signal processing, control systems, and power systems.

The **Environmental Engineering Specialty** introduces students to the fundamentals of environmental engineering including the scientific and regulatory basis of public health and environmental protection. Topics covered include environmental science and regulatory processes, water and waste-water engineering, solid and hazardous waste management, and contaminated site remediation.

The **Mechanical Engineering Specialty** complements the core curriculum with courses that provide depth in material mechanics and the thermal sciences with emphases in computational methods and engineering design. Topics such as computational engineering, machine design, control theory, fluid mechanics, and heat transfer are an important part of the mechanical engineering program. The Mechanical Engineering program has close ties to the metallurgical and materials engineering, physics, chemical engineering and biological life sciences communities on campus, and undergraduates are encouraged to get involved in one of the large number of research programs conducted by the Mechanical Engineering faculty. Many students go on to graduate school.

Students in each of the four specialties will spend considerable time in laboratories. The College is well equipped with basic laboratory

equipment, as well as PC-based instrumentation systems, and the program makes extensive use of computer-based analysis techniques.

The College of Engineering & Computational Sciences is housed in George R. Brown Hall. Emphasis on hands-on education is reflected in the division's teaching and research laboratories. All students are encouraged to take the Fundamental of Engineering examination before graduation.

## Degree Requirements in Engineering Civil Specialty

<b>Freshman</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
<b>Fall</b>				
PAGN101	PHYSICAL EDUCATION			0.5
LAIS100	NATURE AND HUMAN VALUES			4
CHGN121	PRINCIPLES OF CHEMISTRY I			4
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
BELS101	BIOLOGICAL AND ENVIRONMENTAL SYSTEMS, SYGN 101, or CSCI 101			4
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4
				<b>17.0</b>
<b>Spring</b>				
PAGN102	PHYSICAL EDUCATION			0.5
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4
PHGN100	PHYSICS I - MECHANICS			4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4
EPIC151	DESIGN (EPICS) I			3
				<b>16.0</b>
<b>Sophomore</b>				
<b>Fall</b>				
DCGN241	DIST CORE - STATICS	3.0		3
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.0	3.0	4.5
CSCI260	FORTRAN PROGRAMMING, 261, or EGGN 205	2.0		2
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>17.0</b>
<b>Spring</b>				
SYGN200	HUMAN SYSTEMS	3.0		3
EGGN281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER			3
EGGN250	MULTIDISCIPLINARY ENGINEERING LABORATORY		4.5	1.5
EGGN320	MECHANICS OF MATERIALS	3.0		3

EGGN351	FLUID MECHANICS	3.0		3
EPIC 25X	Design II	3.0	1.0	3.0
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>17.0</b>
<b>Summer</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
EGGN234	ENGINEERING FIELD SESSION, CIVIL SPECIALTY		3.0	3
				<b>3.0</b>
<b>Junior</b>				
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH225	DIFFERENTIAL EQUATIONS	3.0		3
EGGN342	STRUCTURAL THEORY	3.0		3
EGGN361	SOIL MECHANICS	3.0		3
EGGN363	SOIL MECHANICS LABORATORY		3.0	1
EGGN413	COMPUTER AIDED ENGINEERING	3.0		3
LAIS/EBGN	H&SS Restricted Elective I	3.0		3.0
				<b>16.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH348	ADVANCED ENGINEERING MATHEMATICS	3.0		3
EGGN464	FOUNDATIONS	3.0		3
DCGN210	INTRO TO ENG THERMODYNAMICS	3.0		3
EGGN444	DESIGN OF STEEL STRUCTURES or 445	3.0		3
EGCV ELECT	Civil Specialty Elective	3.0		3.0
FREE	Free Elective	3.0		3.0
				<b>18.0</b>
<b>Senior</b>				
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH323	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0		3
LAIS/EBGN	H&SS Restricted Elective II	3.0		3.0
EGGN315	DYNAMICS	3.0		3
EGGN350	MULTIDISCIPLINARY ENGINEERING LABORATORY II		4.5	1.5
EGGN491	SENIOR DESIGN I	2.0	3.0	3
EGCV ELECT	Civil Specialty Elective	3.0		3.0
				<b>16.5</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
LAIS/EBGN	H&SS Restricted Elective III	3.0		3.0
EGGN492	SENIOR DESIGN II	1.0	6.0	3
EGCV ELECT	Civil Specialty Elective	3.0		3.0
FREE	Free Elective	3.0		3.0
FREE	Free Elective	3.0		3.0

FREE	Free Elective	3.0		3.0
				<b>18.0</b>

Total Hours: 138.5

### Electrical Specialty

<b>Freshman</b>				
<b>Fall</b>				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
PAGN101	PHYSICAL EDUCATION			0.5
LAIS100	NATURE AND HUMAN VALUES			4
CHGN121	PRINCIPLES OF CHEMISTRY I			4
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4
CSCI101	INTRODUCTION TO COMPUTER SCIENCE, BELS 101, or SYGN 101			3
				<b>16.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
PAGN102	PHYSICAL EDUCATION			0.5
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4
PHGN100	PHYSICS I - MECHANICS			4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4
EPIC151	DESIGN (EPICS) I			3
				<b>16.0</b>
<b>Sophomore</b>				
<b>Fall</b>				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
DCGN241	DIST CORE - STATICS	3.0		3
SYGN200	HUMAN SYSTEMS			3
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.0	2.5	4.5
CSCI261	PROGRAMMING CONCEPTS	3.0		3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>18.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH225	DIFFERENTIAL EQUATIONS	3.0		3
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3
EGGN320	MECHANICS OF MATERIALS	3.0		3
EGGN250	MULTIDISCIPLINARY ENGINEERING LABORATORY		4.5	1.5
EGGN281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER			3
EPIC25X	Design II	3.0	1.0	3.0
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>17.0</b>





<b>Junior</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
<b>Fall</b>					
LAIS/EBGN	H&SS Restricted Elective I	3.0			3.0
MATH348	ADVANCED ENGINEERING MATHEMATICS	3.0			3
EGGN315	DYNAMICS	3.0			3
EGGN351	FLUID MECHANICS	3.0			3
EGGN353	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I	3.0			3
FREE	Free Elective	3.0			3.0
					<b>18.0</b>
<b>Spring</b>					
MATH323	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0			3
EGGN350	MULTIDISCIPLINARY ENGINEERING LABORATORY II		4.5	1.5	
EGGN354	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II	3.0			3
EGGN371	THERMODYNAMICS I	3.0			3
EGEV ELECT	Environmental Specialty Elective	3.0			3.0
FREE	Free Elective	3.0			3.0
					<b>16.5</b>
<b>Summer</b>					
EGGN335	ENGINEERING FIELD SESSION, ENVIRONMENTAL SPECIALTY		3.0		3
					<b>3.0</b>
<b>Senior</b>					
<b>Fall</b>					
LAIS/EBGN	H&SS Restricted Elective II	3.0			3.0
EGGN491	SENIOR DESIGN I	2.0	3.0		3
EGGN413	COMPUTER AIDED ENGINEERING	3.0			3
EGEV ELECT	Environmental Specialty Elective	3.0			3.0
EGEV ELECT	Environmental Specialty Elective	3.0			3.0
					<b>15.0</b>
<b>Spring</b>					
LAIS/EBGN	H&SS Restricted Elective III	3.0			3.0
EGGN492	SENIOR DESIGN II	1.0	6.0		3
EGEV ELECT	Environmental Specialty Elective	3.0			3.0
EGEV ELECT	Environmental Specialty Elective	3.0			3.0
FREE	Free Elective	3.0			3.0
FREE	Free Elective	3.0			3.0
					<b>18.0</b>

Total Hours: 137.5

### Mechanical Specialty

<b>Freshman</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
<b>Fall</b>					
PAGN101	PHYSICAL EDUCATION				0.5
LAIS100	NATURE AND HUMAN VALUES				4
CHGN121	PRINCIPLES OF CHEMISTRY I				4
CSM101	FRESHMAN SUCCESS SEMINAR				0.5
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I				4
CSCI101	INTRODUCTION TO COMPUTER SCIENCE, BELS 101, or SYGN 101				3
					<b>16.0</b>
<b>Spring</b>					
PAGN102	PHYSICAL EDUCATION				0.5
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)				4
PHGN100	PHYSICS I - MECHANICS				4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II				4
EPIC151	DESIGN (EPICS) I				3
					<b>16.0</b>
<b>Sophomore</b>					
<b>Fall</b>					
DCGN241	DIST CORE - STATICS	3.0			3
SYGN200	HUMAN SYSTEMS	3.0			3
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0			4
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.0	3.0		4.5
CSCI261	PROGRAMMING CONCEPTS or EGGN 205	3.0			3
PAGN2XX	PHYSICAL EDUCATION				0.5
					<b>18.0</b>
<b>Spring</b>					
MATH225	DIFFERENTIAL EQUATIONS	3.0			3
MTGN202	ENGINEERED MATERIALS	3.0			3
EGGN320	MECHANICS OF MATERIALS	3.0			3
EGGN250	MULTIDISCIPLINARY ENGINEERING LABORATORY		4.5	1.5	
EGGN281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER				3
EPIC25X	Design II	3.0	1.0		3.0
PAGN2XX	PHYSICAL EDUCATION				0.5
					<b>17.0</b>
<b>Summer</b>					
EGGN235	ENGINEERING FIELD SESSION, MECHANICAL SPECIALTY		3.0		3

**3.0**

<b>Junior</b>			
<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>
MATH323	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0	3
MATH348	ADVANCED ENGINEERING MATHEMATICS	3.0	3
LAIS/EBGN	H&SS Restricted Elective I	3.0	3.0
EGGN315	DYNAMICS	3.0	3
EGGN371	THERMODYNAMICS I	3.0	3
EGGN388	INFORMATION SYSTEMS SCIENCE	0.0	4
			<b>19.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
EBGN201	PRINCIPLES OF ECONOMICS	3.0	3
EGGN351	FLUID MECHANICS	3.0	3
EGGN350	MULTIDISCIPLINARY ENGINEERING LABORATORY II		4.5 1.5
EGGN307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0	3
EGGN413	COMPUTER AIDED ENGINEERING	3.0	3
EGMC ELECT	Mechanical Specialty Elective	3.0	3.0
			<b>16.5</b>
<b>Senior</b>			
<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>
EGGN450	MULTIDISCIPLINARY ENGINEERING LABORATORY III		3.0 1
EGGN491	SENIOR DESIGN I	2.0	3.0 3
LAIS/EBGN	H&SS Restricted Elective II	3.0	3.0
EGGN471	HEAT TRANSFER	3.0	3
EGGN411	MACHINE DESIGN	3.0	3.0 4
FREE	Free Elective	3.0	3.0
			<b>17.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
LAIS/EBGN	H&SS Restricted Elective III	3.0	3.0
EGGN492	SENIOR DESIGN II	1.0	6.0 3
EGMC ELECT	Mechanical Specialty Elective	3.0	3.0
EGMC ELECT	Mechanical Specialty Elective	3.0	3.0
FREE	Free Elective	3.0	3.0
FREE	Free Elective	3.0	3.0
			<b>18.0</b>

Total Hours: 140.5

## Engineering Specialty Electives

### Civil Specialty

Civil specialty students are required to take three Civil Elective courses from the following list. The electives have been grouped by themes for

convenience only. When choosing their three courses, students can elect for breadth across themes or depth within a theme.

Students must take at least two courses marked (A).

#### Environmental

EGGN353	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I (A)	3
EGGN354	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II (A)	3
EGGN453	WASTEWATER ENGINEERING (A)	3
EGGN454	WATER SUPPLY ENGINEERING (A)	3
EGGN455	SOLID AND HAZARDOUS WASTE ENGINEERING (A)	3
EGGN456	SCIENTIFIC BASIS OF ENVIRONMENTAL REGULATIONS (A)	3
EGGN457	SITE REMEDIATION ENGINEERING (A)	3

#### General

EGGN307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS (A)	3
EBGN321	ENGINEERING ECONOMICS (A)	3
EGGN460	NUMERICAL METHODS FOR ENGINEERS (A)	3
EGGN433	SURVEYING II (A)	3
EGGN490	SUSTAINABLE ENGINEERING DESIGN (B)	3
EBGN553	PROJECT MANAGEMENT (B)	3

#### Geotechnical

EGGN465	UNSATURATED SOIL MECHANICS (A)	3
EGGN448	ADVANCED SOIL MECHANICS (A)	3
EGGN534	SOIL BEHAVIOR (A)	3
EGGN531	SOIL DYNAMICS (A)	3
MNGN321	INTRODUCTION TO ROCK MECHANICS (A)	3
MNGN404	TUNNELING (B)	3
MNGN405	ROCK MECHANICS IN MINING (B)	3
MNGN406	DESIGN AND SUPPORT OF UNDERGROUND EXCAVATIONS (B)	3
GEGN466	GROUNDWATER ENGINEERING (B)	3
GEGN468	ENGINEERING GEOLOGY AND GEOTECHNICS (B)	4
GEGN473	GEOLOGICAL ENGINEERING SITE INVESTIGATION (B)	3

#### Mechanics

EGGN422	ADVANCED MECHANICS OF MATERIALS (A)	3
EGGN442	FINITE ELEMENT METHODS FOR ENGINEERS (A)	3
EGGN473	FLUID MECHANICS II (A)	3
EGGN478	ENGINEERING VIBRATION (A)	3

#### Structural

EGGN441	ADVANCED STRUCTURAL ANALYSIS (A)	3
EGGN444/445	DESIGN OF STEEL STRUCTURES (A) *	3
EGGN447/547	TIMBER AND MASONRY DESIGN (A)	3
EGGN549	ADVANCED DESIGN OF STEEL STRUCTURES (A)	3
EGGN556	DESIGN OF REINFORCED CONCRETE STRUCTURES (A)	3

\* To count as elective credit, the companion course must be taken as part of the Civil Specialty degree requirements.

Graduate courses in EG and elsewhere may occasionally be approved as civil electives on an ad hoc basis. In order for a course that is not listed here to be considered, the student should submit a written request in advance to their faculty advisor enclosing a copy of the course syllabus.

## Electrical Specialty

Electrical specialty students are required to take three courses from the following list of electrical technical electives:\*

EGGN325	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3
EGGN400	INTRODUCTION TO ROBOTICS	3
EGGN417	MODERN CONTROL DESIGN	3
EGGN460	NUMERICAL METHODS FOR ENGINEERS	3
EGGN481	DIGITAL SIGNAL PROCESSING	3
EGGN483	ANALOG & DIGITAL COMMUNICATION SYSTEMS	4
EGGN484	POWER SYSTEMS ANALYSIS	3
EGGN485	INTRODUCTION TO HIGH POWER ELECTRONICS	3
EGGN486	PRACTICAL DESIGN OF SMALL RENEWABLE ENERGY SYSTEMS	3
EGGN487	ANALYSIS AND DESIGN OF ADVANCED ENERGY SYSTEMS	3
CSCI341	COMPUTER ORGANIZATION	3
CSCI/MATH440	PARALLEL COMPUTING FOR SCIENTISTS AND ENGINEERS	3
MATH334	INTRODUCTION TO PROBABILITY	3
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3
PHGN300	PHYSICS III-MODERN PHYSICS I	3
PHGN320	MODERN PHYSICS II: BASICS OF QUANTUM MECHANICS	4
PHGN435	INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY	3
PHGN440	SOLID STATE PHYSICS	3
PHGN441	SOLID STATE PHYSICS APPLICATIONS AND PHENOMENA	3
PHGN462	ELECTROMAGNETIC WAVES AND OPTICAL PHYSICS	3

\* Additional courses are advisor and Division Director approved special topics with a number of EGGN398/EGGN498 and all graduate courses taught in the Electrical Engineering specialty area. Students should consult their faculty advisor for guidance.

## Environmental Specialty

All students pursuing the Environmental Specialty are required to take EGGN353/ESGN353 and EGGN354/ESGN354. These courses are prerequisites for many 400 level Environmental Specialty courses. In addition students are required to take five courses from the following list:

ESGN401	FUNDAMENTALS OF ECOLOGY	3
ESGN440	ENVIRONMENTAL POLLUTION: SOURCES, CHARACTERISTICS, TRANSPORT AND FATE	3

EGGN/ ESGN453	WASTEWATER ENGINEERING	3
EGGN/ ESGN454	WATER SUPPLY ENGINEERING	3
EGGN/ ESGN456	SCIENTIFIC BASIS OF ENVIRONMENTAL REGULATIONS	3
EGGN/ ESGN457	SITE REMEDIATION ENGINEERING	3
ESGN355	ENVIRONMENTAL ENGINEERING LABORATORY	3
ESGN460	ONSITE WATER RECLAMATION AND REUSE	3
ESGN462	SOLID WASTE MINIMIZATION AND RECYCLING	3
ESGN463	POLLUTION PREVENTION: FUNDAMENTALS AND PRACTICE	3
EGGN466	GROUNDWATER ENGINEERING	3

Students completing the Engineering degree with an environmental specialty may not also complete a minor or ASI in Environmental Science.

**Students should consult their faculty advisor for guidance on course substitutions.**

## Mechanical Specialty

The list of approved Mechanical Engineering electives appears below. Students are required to take three of these courses and at least one must be from List A. In addition to these courses, any graduate course taught by a member of the Mechanical Engineering faculty will also be counted as a Mechanical Elective. Students are welcome to petition to have a course approved, and the petition form is provided on the Mechanical Engineering web site. Courses are occasionally added to this list with the most updated version maintained on the Mechanical Engineering web site.

### List A

EGGN403	THERMODYNAMICS II	3
EGGN422	ADVANCED MECHANICS OF MATERIALS	3
EGGN473	FLUID MECHANICS II	3
EGGN478	ENGINEERING VIBRATION	3

### List B

EGGN325	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3
EGGN389	FUNDAMENTALS OF ELECTRIC MACHINERY	4
EGGN400	INTRODUCTION TO ROBOTICS	3
EGGN417	MODERN CONTROL DESIGN	3
EGGN425	MUSCULOSKELETAL BIOMECHANICS	3
EGGN442	FINITE ELEMENT METHODS FOR ENGINEERS	3
EGGN444	DESIGN OF STEEL STRUCTURES	3
EGGN460	NUMERICAL METHODS FOR ENGINEERS	3
EBGN321	ENGINEERING ECONOMICS	3
ESGN527	WATERSHED SYSTEMS ANALYSIS	3
MTGN445	MECHANICAL PROPERTIES OF MATERIALS	4
EGGN390	MATERIALS AND MANUFACTURING PROCESSES	3
MTGN450	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS	3
MTGN464	FORGING AND FORMING	3

MTGN475/477	METALLURGY OF WELDING	2
MLGN/ MTGN570	BIOCOMPATIBILITY OF MATERIALS	3
MNGN444	EXPLOSIVES ENGINEERING II	3
PEGN311	DRILLING ENGINEERING	4
PEGN361	COMPLETION ENGINEERING	3
PEGN419	WELL LOG ANALYSIS AND FORMATION EVALUATION	3
PEGN515	RESERVOIR ENGINEERING PRINCIPLES	3
PHGN300	PHYSICS III-MODERN PHYSICS I	3
PHGN350	INTERMEDIATE MECHANICS	4
PHGN435	INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY	3
PHGN440	SOLID STATE PHYSICS	3

General CSM Minor/ASI requirements can be found here (p. 195).

## College of Engineering & Computational Sciences Areas of Special Interest and Minor Programs

### General Requirements

A **Minor Program** of study consists of a minimum of 18 credit hours of a logical sequence of courses. With the exception of the McBride Honors minor, only three of these hours may be taken in the student's degree-granting department and no more than three of these hours may be at the 100- or 200- level. A Minor Program may not be completed in the same department as the major.

An **Area of Special Interest (ASI)** consists of a minimum of 12 credit hours of a logical sequence of courses. Only three of these hours may be taken at the 100- or 200- level and no more than three of these hours may be specifically required for the degree program in which the student is graduating. An ASI may be completed within the same major department.

A **Minor Program / Area of Special Interest** declaration (available in the Registrar's Office) should be submitted for approval prior to the student's completion of half of the hours proposed to constitute the program. Approvals are required from the Minor program Department Head, the student's advisor, and the Department Head or Division Director in the department or division in which the student is enrolled.

### Programs in the College of Engineering & Computational Sciences

CECS offers minor and ASI programs to meet two sets of audiences: (1) students that are not pursuing an engineering degree and (2) students that are pursuing an engineering degree in another department. For the first audience, a minor or ASI is available in Engineering. This program offers the foundational coursework in engineering which is compatible with many of the topics in the Fundamentals of Engineering examination. For the second audience, there is a program in engineering specialties. This program recognizes that many majors will have completed the fundamental engineering courses that are prerequisites to upper division engineering courses. Since these students complete the fundamental coursework as a part of their degree, they can pursue a minor or ASI in the four engineering specialties (civil, electrical, environmental, mechanical) as long as they are outside of their major department.

The requirements for a minor do not allow CECS engineering students to acquire a minor as a part of the Engineering Specialties program (for

instance, a student that is an Engineering-civil-specialty student cannot get a minor in Engineering-mechanical specialty). However, the ASI program in Engineering Specialties is available to all CECS students with the note that an ASI in the students declared major area is not allowed (for instance, Engineering-mechanical-specialty students cannot acquire an ASI in Engineering-mechanical specialty). Students earning one of the new engineering Bachelors degrees, however, (i.e. B.S. Mechanical) can complete a CECS minor as long as it is outside of their home department.

Students wishing to enroll in either program must satisfy all prerequisite requirements for each course in a chosen sequence. Students in the sciences or mathematics will therefore be better positioned to satisfy prerequisite requirements in the General Engineering program, while students in engineering disciplines will be better positioned to meet the prerequisite requirements for courses in the Engineering Specialties.

Students majoring in Engineering with an Environmental Specialty may not also complete a minor or ASI in Environmental Science and Engineering.

The courses listed below, constituting each program and the specialty variations, are offered as guidelines for selecting a logical sequence. In cases where students have unique backgrounds or interests, these sequences may be adapted accordingly through consultation with faculty in the college.

### Engineering Program

A twelve (ASI) or eighteen hour (minor) sequence must be selected from:

DCGN241	DIST CORE - STATICS	3
EGGN320	MECHANICS OF MATERIALS	3
EGGN351	FLUID MECHANICS	3
EGGN371	THERMODYNAMICS I	3
EGGN315	DYNAMICS	3
EGGN281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER	3
EBGN321	ENGINEERING ECONOMICS	3
Total Hours		21.0

Note: Multidisciplinary Engineering Laboratories I, II and III (EGGN250, EGGN350 and EGGN450, respectively) may be taken as laboratory supplements to EGGN281, EGGN351 and EGGN320.

### Engineering Specialties Program Civil Minor and ASI

A twelve (ASI) or eighteen hour (minor) sequence must be selected from:

EGGN342	STRUCTURAL THEORY	3
EGGN353	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I	3
EGGN354	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II	3
EGGN361	SOIL MECHANICS	3
EGGN363	SOIL MECHANICS LABORATORY	1
EGGN383	MICROCOMPUTER ARCHITECTURE AND INTERFACING	4
EGGN422	ADVANCED MECHANICS OF MATERIALS	3
EGGN441	ADVANCED STRUCTURAL ANALYSIS	3
EGGN442	FINITE ELEMENT METHODS FOR ENGINEERS	3
EGGN433	SURVEYING II	3
EGGN444	DESIGN OF STEEL STRUCTURES	3

EGGN445	DESIGN OF REINFORCED CONCRETE STRUCTURES	3
EGGN448	ADVANCED SOIL MECHANICS	3
EGGN451	HYDRAULIC PROBLEMS	3
EGGN453	WASTEWATER ENGINEERING	3
EGGN454	WATER SUPPLY ENGINEERING	3
EGGN460	NUMERICAL METHODS FOR ENGINEERS	3
EGGN464	FOUNDATIONS	3
EGGN465	UNSATURATED SOIL MECHANICS	3
EGGN478	ENGINEERING VIBRATION	3
EGGN499	INDEPENDENT STUDY	3.0
GEGN467	GROUNDWATER ENGINEERING	4
GEGN468	ENGINEERING GEOLOGY AND GEOTECHNICS	4
MNGN321	INTRODUCTION TO ROCK MECHANICS	3

### Engineering Specialties Program Electrical Minor and ASI

A twelve (ASI) or eighteen hour (minor) sequence must be selected from a basic electrical program comprising:\*

EGGN382	ENGINEERING CIRCUIT ANALYSIS	3
EGGN281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER	3

Additional courses are to be selected from:

EGGN307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3
EGGN334	ENGINEERING FIELD SESSION, ELECTRICAL SPECIALTY	3
EGGN385	ELECTRONIC DEVICES AND CIRCUITS	4
EGGN386	FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS	3
EGGN388	INFORMATION SYSTEMS SCIENCE	3
EGGN389	FUNDAMENTALS OF ELECTRIC MACHINERY	4
EGGN417	MODERN CONTROL DESIGN	3
EGGN481	DIGITAL SIGNAL PROCESSING	3
EGGN483	ANALOG & DIGITAL COMMUNICATION SYSTEMS	4
EGGN484	POWER SYSTEMS ANALYSIS	3
EGGN485	INTRODUCTION TO HIGH POWER ELECTRONICS	3

\* Additional courses are approved special topics with a number EGGN398/EGGN498 and all graduate courses taught in the Electrical Engineering specialty area. Students should consult their faculty advisor for guidance

### Engineering specialties program Environmental Minor and ASI

All students pursuing the Environmental Minor or ASI are required to take ESGN353/EGGN353 and ESGN354/EGGN354. Additional courses for the ASI or Minor sequence must be selected from:

ESGN401	FUNDAMENTALS OF ECOLOGY	3
ESGN440	ENVIRONMENTAL POLLUTION: SOURCES, CHARACTERISTICS, TRANSPORT AND FATE	3.0
ESGN/EGGN453	WASTEWATER ENGINEERING	3

ESGN/EGGN454	WATER SUPPLY ENGINEERING	3
ESGN/EGGN456	SCIENTIFIC BASIS OF ENVIRONMENTAL REGULATIONS	3
ESGN/EGGN457	SITE REMEDIATION ENGINEERING	3
ESGN460	ONSITE WATER RECLAMATION AND REUSE	3
ESGN462	SOLID WASTE MINIMIZATION AND RECYCLING	3
ESGN463	POLLUTION PREVENTION: FUNDAMENTALS AND PRACTICE	3
ESGN490	ENVIRONMENTAL LAW	3

### Engineering specialties program Mechanical Minor and ASI

A twelve (ASI) or eighteen hour (minor) sequence must be selected from:

EGGN307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3
EGGN351	FLUID MECHANICS	3
EGGN403	THERMODYNAMICS II	3
EGGN400	INTRODUCTION TO ROBOTICS	3
EGGN411	MACHINE DESIGN	4
EGGN413	COMPUTER AIDED ENGINEERING	3
EGGN422	ADVANCED MECHANICS OF MATERIALS	3
EGGN471	HEAT TRANSFER	3
EGGN473	FLUID MECHANICS II	3

### Courses

#### EGGN250. MULTIDISCIPLINARY ENGINEERING LABORATORY. 1.5 Hour.

(I, II) (WI) Laboratory experiments integrating instrumentation, circuits and power with computer data acquisitions and sensors. Sensor data is used to transition between science and engineering science. Engineering Science issues like stress, strains, thermal conductivity, pressure and flow are investigated using fundamentals of equilibrium, continuity, and conservation. Prerequisite: DCGN381 or concurrent enrollment. 4.5 hours lab; 1.5 semester hour.

#### EGGN350. MULTIDISCIPLINARY ENGINEERING LABORATORY II. 1.5 Hour.

(I, II) (WI) Laboratory experiments integrating electrical circuits, fluid mechanics, stress analysis, and other engineering fundamentals using computer data acquisition and transducers. Fluid mechanics issues like compressible and incompressible fluid flow (mass and volumetric), pressure losses, pump characteristics, pipe networks, turbulent and laminar flow, cavitation, drag, and others are covered. Experimental stress analysis issues like compression and tensile testing, strain gage installation, Young's Modulus, stress vs. strain diagrams, and others are covered. Experimental stress analysis and fluid mechanics are integrated in experiments which merge fluid power of the testing machine with applied stress and displacement of material specimen. Prerequisite: EGGN250. Prerequisite or concurrent enrollment: EGGN351, EGGN320. 4.5 hours lab; 1.5 semester hour.

**EGGN408. INTRODUCTION TO SPACE EXPLORATION. 1.0 Hour.**

(I) Overview of extraterrestrial applications of science and engineering by covering all facets of human and robotic space exploration, including its history, current status, and future opportunities in the aerospace and planetary science fields. Subtopics include: the space environment, space transportation systems, destinations (Low-Earth orbit, Moon, Mars, asteroids, other planets), current research, missions, and projects, the international and commercial perspectives, and discussion of potential career opportunities. This seminar-style class is taught by CSM faculty, engineers and scientists from space agencies and research organizations, aerospace industry experts, and visionaries and entrepreneurs of the private space commerce sector. Prerequisites: None; 1 hour lecture; 1 semester hour.

**EGGN450. MULTIDISCIPLINARY ENGINEERING LABORATORY III. 1.0 Hour.**

(I, II) Laboratory experiments integrating electrical circuits, fluid mechanics, stress analysis, and other engineering fundamentals using computer data acquisition and transducers. Students will design experiments to gather data for solving engineering problems. Examples are recommending design improvements to a refrigerator, diagnosing and predicting failures in refrigerators, computer control of a hydraulic fluid power circuit in a fatigue test, analysis of structural failures in an off-road vehicle and redesign, diagnosis and prediction of failures in a motor/generator system. Prerequisites: EGGN320, EGGN351, either EGGN350 or EGGN382; Corequisite: EGGN307. 3 hours lab; 1 semester hour.

**EGGN490. SUSTAINABLE ENGINEERING DESIGN. 3.0 Hours.**

(I) This course is a comprehensive introduction into concept of sustainability and sustainable development from an engineering point of view. It involves the integration of engineering and statistical analysis through a Life Cycle Assessment tool, allowing a quantitative, broad-based consideration any process or product design and their respective impacts on environment, human health and the resource base. The requirements for considering social implications are also discussed. Prerequisites: Senior or graduate standing, or consent of instructor.; 3 hours lecture, 3 semester hours.

**EGGN491. SENIOR DESIGN I. 4.0 Hours.**

(I, II) (WI) This course is the first of a two-semester capstone course sequence giving the student experience in the engineering design process. Realistic open-ended design problems are addressed for real world clients at the conceptual, engineering analysis, and the synthesis stages and include economic and ethical considerations necessary to arrive at a final design. Students are assigned to interdisciplinary teams and exposed to processes in the areas of design methodology, project management, communications, and work place issues. Strong emphasis is placed on this being a process course versus a project course. This is a writing-across-the-curriculum course where students' written and oral communication skills are strengthened. The design projects are chosen to develop student creativity, use of design methodology and application of prior course work paralleled by individual study and research. Prerequisite: Field session appropriate to the student's specialty and EPIC251. For Mechanical Specialty students, concurrent enrollment or completion of EGGN 411. 1-2 hour lecture; 6 hours lab; 3 semester hours.

**EGGN492. SENIOR DESIGN II. 3.0 Hours.**

(I, II) (WI) This course is the second of a two-semester sequence to give the student experience in the engineering design process. Design integrity and performance are to be demonstrated by building a prototype or model, or producing a complete drawing and specification package, and performing pre-planned experimental tests, wherever feasible, to verify design compliance with client requirements. Prerequisite: EGGN491. 1 hour lecture; 6 hours lab; 3 semester hours.

**EGGN497X. SPECIAL SUMMER COURSE. 6.0 Hours.**

# Mechanical Engineering

<http://mechanical.mines.edu>

## Program Description

The Mechanical Engineering Department offers a design-oriented undergraduate program in mechanical engineering. The program emphasizes fundamental engineering principles and requires in-depth understanding of mechanical engineering. Graduates are in a position to take advantage of a broad variety of professional opportunities, and are well-prepared for a mechanical engineering career in a world of rapid technological change. This department also supports the legacy Bachelor of Science degree with a specialty in Mechanical Engineering offered by the College of Engineering & Computational Sciences. Please see the Engineering section of the bulletin for information about that degree.

The legacy B.S. in Engineering degree is accredited by ABET. The B.S. degree in Mechanical Engineering is new as of the 2012-2013 school year and is therefore not yet accredited. Accreditation for this new degree will be sought during the 2013-2014 school year.

## Program Educational Objectives (Bachelor of Science in Mechanical Engineering)

The Mechanical Engineering program contributes to the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria. In addition, the Mechanical Engineering Program at CSM has established the following program educational objectives: within three years of attaining the BS degree in Mechanical Engineering:

- Graduates will be situated in growing careers in their chosen mechanical engineering fields or will be successfully pursuing a graduate degree.
- Graduates will be advancing in their professional standing, generating new knowledge and/or exercising leadership in their mechanical engineering field.
- Graduates will be contributing to the needs of society through professional practice, research, and/or service.

## Curriculum

During the first two years at CSM, students complete a set of core courses that include mathematics, basic sciences, and engineering sciences. coursework in mathematics is an essential part of the curriculum which gives mechanical engineering students essential tools for modeling, analyzing, and predicting physical phenomena. The basic sciences are represented by physics and chemistry which provide an appropriate foundation in the physical sciences. Engineering sciences build upon the basic sciences and are focused on mechanical engineering applications.

The first two years also includes engineering design coursework within the Engineering Practice Introductory Course Sequence (EPICS I and II). This experience teaches design methodology and stresses the creative and synthesis aspects of the mechanical engineering profession. Finally, the first two years includes systems-oriented courses with humanities and social sciences content; these courses explore the linkages within the environment, human society, and engineered devices.

In the final two years, students complete an advanced core that includes fluid mechanics, engineering mechanics, advanced mathematics, thermodynamics, heat transfer, engineering design, economics and additional studies in liberal arts international topics. The program contains

free electives (9 credits), at the student's discretion, that can be used to either satisfy a student's personal interest in a topic or they can be used as coursework as part of an "area of special interest" of at least 12 semester hours or a minor of at least 18 semester hours in another department.

All students must complete a capstone design course which is focused on an in-depth mechanical engineering related project. The projects are generated by customer demand, and include experimental verification to ensure a realistic design experience.

Prospective students should note that this is a design-oriented mechanical engineering program. Engineering analysis and design is emphasized with applications in mechanical engineering design, manufacturing and processes. Classroom education is augmented with extensive practical laboratory experiences.

The Mechanical Engineering junior and senior level courses provide depth in material mechanics and the thermal sciences with emphases in computational methods and engineering design. Topics such as computational engineering, machine design, control theory, fluid mechanics, heat transfer and biomechanics are an important part of the mechanical engineering program. The Mechanical Engineering Department has close ties to the metallurgical and materials engineering, engineering physics, chemical engineering and biological life sciences communities on campus, and undergraduates are encouraged to become involved in one of the large number of research programs conducted by the Mechanical Engineering faculty. Many students go on to graduate school.

Students in mechanical engineering will spend considerable time in laboratories and use a variety of computer-based analysis techniques. The department is well equipped with basic laboratory equipment, such as PC-based instrumentation systems, a 3D printer rapid prototyping facility and several computational laboratory classrooms. Several advanced experimental facilities are also available within the department and include: the robotics and automation laboratory, a biomechanics laboratory, an IC engines laboratory and the CSM fuel cell technology center.

Students are encouraged to become involved in research that is being conducted within the Department of Mechanical Engineering. These research areas include: biomechanics, solid mechanics and materials, thermal science and engineering, and robotics, automation, and design.

The Mechanical Engineering Department is housed in the west wing of the George R. Brown Hall. Emphasis on hands-on education is reflected in the department's teaching and research laboratories. All students are encouraged to take the Fundamental of Engineering examination before graduation.

**Mechanical Engineering** complements the core curriculum with courses that provide depth in material mechanics and the thermal sciences with emphases in computational methods and engineering design. Topics such as computational engineering, machine design, control theory, fluid mechanics, and heat transfer are an important part of the mechanical engineering program. The Mechanical Engineering program has close ties to the metallurgical and materials engineering, physics, chemical engineering and biological life sciences communities on campus, and undergraduates are encouraged to get involved in one of the large number of research programs conducted by the Mechanical Engineering faculty. Many students go on to graduate school.

## Bachelor of Science in Mechanical Engineering Degree Requirements:

<b>Freshman</b>				<b>Junior</b>					
<b>Fall</b>				<b>Fall</b>					
		lec	lab	sem.hrs			lec	lab	sem.hrs
PAGN101	PHYSICAL EDUCATION			0.5	MATH323	PROBABILITY AND STATISTICS FOR ENGINEERS			3
LAIS100	NATURE AND HUMAN VALUES			4	MATH398	APPLIED NUMERICAL METHODS			3.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4	LAIS/EBGN	H&SS Restricted Elective I			3.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5	EGGN315	DYNAMICS			3
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4	EGGN371	THERMODYNAMICS I			3
CSCI101	INTRODUCTION TO COMPUTER SCIENCE, BELS 101, or SYGN 101			3					<b>15.0</b>
				<b>16.0</b>	<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	EBGN201	PRINCIPLES OF ECONOMICS			3
PAGN102	PHYSICAL EDUCATION			0.5	EGGN351	FLUID MECHANICS			3
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4	EGGN350	MULTIDISCIPLINARY ENGINEERING LABORATORY II			1.5
PHGN100	PHYSICS I - MECHANICS			4.5	EGGN307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS			3
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4	EGGN413	COMPUTER AIDED ENGINEERING			3
EPIC151	DESIGN (EPICS) I			3	EGMC	Mechanical Engineering Elective *			3.0
				<b>16.0</b>	ELECT				<b>16.5</b>
<b>Sophomore</b>									
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	<b>Senior</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
DCGN241	DIST CORE - STATICS			3	<b>Fall</b>				
SYGN200	HUMAN SYSTEMS			3	EGGN450	MULTIDISCIPLINARY ENGINEERING LABORATORY III			1
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4	EGGN491	SENIOR DESIGN I			3
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS			4.5	LAIS/EBGN	H&SS Restricted Elective II			3.0
CSCI261	PROGRAMMING CONCEPTS			3	EGGN471	HEAT TRANSFER			3
PAGN2XX	PHYSICAL EDUCATION			0.5	EGGN411	MACHINE DESIGN			4
				<b>18.0</b>	FREE	Free Elective			3.0
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>					<b>17.0</b>
MATH225	DIFFERENTIAL EQUATIONS			3	<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MTGN202	ENGINEERED MATERIALS			3	EGGN492	SENIOR DESIGN II			3
EGGN320	MECHANICS OF MATERIALS			3	LAIS/EBGN	H&SS Restricted Elective III			3.0
EGGN281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER			3	EGMC	Mechanical Engineering Elective *			3.0
EGGN250	MULTIDISCIPLINARY ENGINEERING LABORATORY			1.5	EGMC	Mechanical Engineering Elective *			3.0
EPIC251	DESIGN (EPICS) II			3	ELECT				3.0
PAGN2XX	PHYSICAL EDUCATION			0.5	FREE	Free Elective			3.0
				<b>17.0</b>	FREE	Free Elective			<b>18.0</b>
				<b>17.0</b>					

Total Hours: 136.5

\* Mechanical Engineering students are required to take three Mechanical Engineering elective courses. At least one of these courses must be



from List A, the remaining must be from List B. List A electives can be found below. For a complete listing of List B electives, please consult the Mechanical Engineering website here: <http://mechanical.mines.edu/>

## Mechanical Engineering List A Electives:

EGGN403	THERMODYNAMICS II	3
EGGN422	ADVANCED MECHANICS OF MATERIALS	3
EGGN473	FLUID MECHANICS II	3
EGGN478	ENGINEERING VIBRATION	3

## Combined Mechanical Engineering Baccalaureate and Masters Degrees

Mechanical Engineering offers a five year combined program in which students have the opportunity to obtain specific engineering skills supplemented with graduate coursework in mechanical engineering. Upon completion of the program, students receive two degrees, the Bachelor of Science in Mechanical Engineering and the Master of Science in Mechanical Engineering.

Students must apply to enter this program by the beginning of their Senior year and must have a minimum GPA of 3.0. To complete the undergraduate portion of the program, students must successfully complete all Mechanical Engineering undergraduate curriculum. At the beginning of the Senior year, a pro forma graduate school application is submitted and as long as the undergraduate portion of the program is successfully completed, the student is admitted to the Mechanical Engineering graduate program.

Students are required to take an additional thirty credit hours for the M.S. degree. Up to nine of the 30 credit hours beyond the undergraduate degree requirements can be 400-level courses. The remainder of the courses will be at the graduate level (500-level and above). The Mechanical Engineering Graduate Bulletin provides details for the graduate program and includes specific instructions regarding required and elective courses. Students may switch from the combined program, which includes a non-thesis Master of Science degree to a M.S. degree with a thesis option; however, if students change degree programs they must satisfy all degree requirements for the M.S. with thesis degree.

General CSM Minor/ASI requirements can be found here (p. 195).

## Mechanical Engineering Areas of Special Interest and Minor Programs

### General Requirements

A Minor Program of study consists of a minimum of 18 credit hours of a logical sequence of courses. With the exception of the McBride Honors minor, only three of these hours may be taken in the student's degree-granting department and no more than three of these hours may be at the 100- or 200- level. A Minor Program may not be completed in the same department as the major.

An Area of Special Interest (ASI) consists of a minimum of 12 credit hours of a logical sequence of courses. Only three of these hours may be taken at the 100- or 200-level and no more than three of these hours may be specifically required for the degree program in which the student is graduating. An ASI may be completed within the same major department.

A Minor Program / Area of Special Interest declaration (available in the Registrar's Office) should be submitted for approval upon application to graduate. Approvals are required from the Mechanical Engineering Department Head, the student's advisor, and the Department Head or

Division Director in the department or division in which the student is enrolled.

The Mechanical Engineering Department offers minor and ASI programs. Students wishing to enroll in the ASI or minor program must satisfy all prerequisite requirements for each course in a chosen sequence. Students in the sciences or mathematics must be prepared to satisfy prerequisite requirements in fundamental engineering and engineering science courses, while students in engineering disciplines will be better positioned to meet the prerequisite requirements for courses in the minor and ASI Mechanical Engineering program. No specific course sequences are suggested for students wishing to include Mechanical minors or areas of special interest in their programs. Rather, those students should consult with the ME department head (or designated faculty member) to design appropriate sequences.

## Courses

### BELS426. MODELING AND SIMULATION OF HUMAN MOVEMENT.

#### 3.0 Hours.

(II) Introduction to modeling and simulation in biomechanics. The course includes a synthesis of musculoskeletal properties and interactions with the environment to construct detailed computer models and simulations. The course will culminate in individual class projects related to each student's individual interests. Prerequisites: EGGN315 and EGGN325/ BELS325, or consent of the instructor. 3 hours lecture; 3 semester hours.

### EGGN205. PROGRAMMING CONCEPTS AND ENGINEERING ANALYSIS. 3.0 Hours.

(I,II) This course provides an introduction to techniques of scientific computation that are utilized for engineering analysis, with the software package MATLAB as the primary computational platform. The course focuses on methods data analysis and programming, along with numerical solutions to algebraic and differential equations. Engineering applications are used as examples throughout the course. Prerequisite: MATH112 or MATH113 or MATH122 or consent of instructor. 3 hours lecture; 3 semester hours.

### EGGN235. ENGINEERING FIELD SESSION, MECHANICAL SPECIALTY. 3.0 Hours.

(S) This course provides the student with hands-on experience in the use of modern engineering tools as part of the design process including modeling, fabrication, and testing of components and systems. Student use engineering, mathematics and computers to conceptualize, model, create, test, and evaluate components and systems of their creation. Teamwork is emphasized by having students work in teams. Prerequisites: PHGN200, CSCI261 or EGGN205, and EPIC251/ EPIC262. Three weeks in summer field session; 3 semester hours.

### EGGN315. DYNAMICS. 3.0 Hours.

(I, II, S) Absolute and relative motions. Kinetics, work-energy, impulse-momentum, vibrations. Prerequisite: DCGN241 and MATH225. 3 hours lecture; 3 semester hours.

**EGGN325. INTRODUCTION TO BIOMECHANICAL ENGINEERING. 3.0 Hours.**

(I) The application of mechanical engineering principles and techniques to the human body presents many unique challenges. The discipline of Biomedical Engineering (more specifically, Biomechanical Engineering) has evolved over the past 50 years to address these challenges. Biomechanical Engineering includes such areas as biomechanics, biomaterials, bioinstrumentation, medical imaging, and rehabilitation. This course is intended to provide an introduction to, and overview of, Biomechanical Engineering and to prepare the student for more advanced Biomechanical coursework. At the end of the semester, students should have a working knowledge of the special considerations necessary to apply various mechanical engineering principles to the human body. Prerequisites: EGGN320, PHGN200. Co-requisites: EGGN315. 3 hours lecture; 3 semester hours.

**EGGN351. FLUID MECHANICS. 3.0 Hours.**

(I, II, S) Fluid properties, fluid statics, control-volume analysis, Bernoulli equation, differential analysis and Navier-Stokes equations, dimensional analysis, internal flow, external flow, open-channel flow, turbomachinery. Prerequisite: DCGN241 or MNGN317. 3 hours lecture; 3 semester hours.

**EGGN371. THERMODYNAMICS I. 3.0 Hours.**

(I, II, S) A comprehensive treatment of thermodynamics from a mechanical engineering point of view. Thermodynamic properties of substances inclusive of phase diagrams, equations of state, internal energy, enthalpy, entropy, and ideal gases. Principles of conservation of mass and energy for steady-state and transient analyses. First and Second Law of thermodynamics, heat engines, and thermodynamic efficiencies. Application of fundamental principles with an emphasis on refrigeration and power cycles. Prerequisite: MATH213/MATH223. 3 hours lecture; 3 semester hours.

**EGGN390. MATERIALS AND MANUFACTURING PROCESSES. 3.0 Hours.**

This course focuses on available engineering materials and the manufacturing processes used in their conversion into a product or structure as critical considerations in design. Properties, characteristics, typical selection criteria, and applications are reviewed for ferrous and nonferrous metals, plastics and composites. The nature, features, and economics of basic shaping operations are addressed with regard to their limitations and applications and the types of processing equipment available. Related technology such as measurement and inspection procedures, numerical control systems and automated operations are introduced throughout the course. Prerequisite: EGGN320, SYGN202. 3 hours lecture; 3 semester hours. Taught on demand.

**EGGN398M. SPECIAL TOPICS IN ENGINEERING. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**EGGN400. INTRODUCTION TO ROBOTICS. 3.0 Hours.**

(I, II) Overview and introduction to the science and engineering of intelligent mobile robotics and robotic manipulators. Covers guidance and force sensing, perception of the environment around a mobile vehicle, reasoning about the environment to identify obstacles and guidance path features and adaptively controlling and monitoring the vehicle health. A lesser emphasis is placed on robot manipulator kinematics, dynamics, and force and tactile sensing. Surveys manipulator and intelligent mobile robotics research and development. Introduces principles and concepts of guidance, position, and force sensing; vision data processing; basic path and trajectory planning algorithms; and force and position control. Prerequisite: CSCI261 and DCGN381. 2 hours lecture; 1 hour lab; 3 semester hours.

**EGGN403. THERMODYNAMICS II. 3.0 Hours.**

(I) This course includes the study of thermodynamic relations, Clapeyron equation, mixtures and solutions, Gibbs function, combustion processes, first and second law applied to reacting systems, third law of thermodynamics, real combustion processes, equilibrium of multicomponent systems, simultaneous chemical reactions of real combustion processes, ionization, overview of the major characteristics of spark-ignition and compression-ignition engines, define parameters used to describe engine operation, develop the necessary thermodynamic and combustion theory required for a quantitative analysis of engine behavior, develop an integrated treatment of the various methods of analyzing idealized models of internal combustion engine cycles, and finally summarize how operating characteristics of spark-ignition and compression-ignition engine depend on the major engine design and operating variables. Prerequisite: EGGN351, EGGN371. 3 hours lecture; 3 semester hours.

**EGGN410. MECHANICAL DESIGN USING GD&T. 3.0 Hours.**

(II) The mechanical design process can be broadly grouped into three phases: requirements and concept, design and analysis, details and drawing package. In this class students will learn concepts and techniques for the details and drawing package phase of the design process. The details of a design are critical to the success of a design project. The details include selection and implementation of a variety of mechanical components such as fasteners (threaded, keys, retaining rings), bearing and bushings. Fits and tolerances will also be covered. Statistical tolerance analysis will be used to verify that an assembly will fit together and to optimize the design. Mechanical drawings have become sophisticated communication tools that are used throughout the processes of design, manufacturing, and inspection. Mechanical drawings are interpreted either by the ANSI or ISO standard which includes Geometric Dimensioning and Tolerancing (GD&T). In this course the student will learn to create mechanical drawings that communicate all of the necessary information to manufacture the part, inspect the part, and allow the parts to be assembled successfully. Prerequisite: EGGN235. 3 hours lecture, 3 semester hours.

**EGGN411. MACHINE DESIGN. 4.0 Hours.**

(I, II) This course is an introduction to the principles of mechanical design. Methods for determining static, fatigue and surface failure are presented. Analysis and selection of machine components such as shafts, keys, couplings, bearings, gears, springs, power screws, and fasteners is covered. Prerequisites: EPIC251; EGGN315 or PHGN350; EGGN320; and EGGN413. 3 hours lecture, 3 hours lab; 4 semester hours.

**EGGN413. COMPUTER AIDED ENGINEERING. 3.0 Hours.**

(I, II) This course introduces the student to the concept of computer-aided engineering. The major objective is to provide the student with the necessary background to use the computer as a tool for engineering analysis and design. The Finite Element Analysis (FEA) method and associated computational engineering software have become significant tools in engineering analysis and design. This course is directed to learning the concepts of FEA and its application to civil and mechanical engineering analysis and design. Note that critical evaluation of the results of a FEA using classical methods (from statics and mechanics of materials) and engineering judgment is employed throughout the course. Prerequisite: EGGN320. 3 hours lecture; 3 semester hours.

**EGGN422. ADVANCED MECHANICS OF MATERIALS. 3.0 Hours.**

(I, II) General theories of stress and strain; stress and strain transformations, principal stresses and strains, octahedral shear stresses, Hooke's law for isotropic material, and failure criteria. Introduction to elasticity and to energy methods. Torsion of noncircular and thin-walled members. Unsymmetrical bending and shear-center, curved beams, and beams on elastic foundations. Introduction to plate theory. Thick-walled cylinders and contact stresses. Prerequisite: EGGN320, EGGN413. 3 hours lecture; 3 semester hours.

**EGGN425. MUSCULOSKELETAL BIOMECHANICS. 3.0 Hours.**

(II) This course is intended to provide mechanical engineering students with a second course in musculoskeletal biomechanics. At the end of the semester, students should have in-depth knowledge and understanding necessary to apply mechanical engineering principles such as statics, dynamics, and mechanics of materials to the human body. The course will focus on the biomechanics of injury since understanding injury will require developing an understanding of normal biomechanics. Prerequisite: EGGN315, EGGN320, EGGN325/BELS325, or instructor permission. 3 hours lecture; 3 semester hours.

**EGGN426. MODELING AND SIMULATION OF HUMAN MOVEMENT. 3.0 Hours.**

(II) Introduction to modeling and simulation in biomechanics. The course includes a synthesis of musculoskeletal properties and interactions with the environment to construct detailed computer models and simulations. The course will culminate in individual class projects related to each student's individual interests. Prerequisites: EGGN315 and EGGN325/BELS325, or consent of the instructor. 3 hours lecture; 3 semester hours.

**EGGN428. COMPUTATIONAL BIOMECHANICS. 3.0 Hours.**

Computational Biomechanics provides an introduction to the application of computer simulation to solve some fundamental problems in biomechanics and bioengineering. Musculoskeletal mechanics, medical image reconstruction, hard and soft tissue modeling, joint mechanics, and inter-subject variability will be considered. An emphasis will be placed on understanding the limitations of the computer model as a predictive tool and the need for rigorous verification and validation of computational techniques. Clinical application of biomechanical modeling tools is highlighted and impact on patient quality of life is demonstrated. Prerequisites: EGGN413, EGGN325. 3 hours lecture, 3 semester hours. Fall odd years.

**EGGN469. FUEL CELL SCIENCE AND TECHNOLOGY. 3.0 Hours.**

(I) Investigate fundamentals of fuel-cell operation and electrochemistry from a chemical-thermodynamics and materials- science perspective. Review types of fuel cells, fuel-processing requirements and approaches, and fuel-cell system integration. Examine current topics in fuel-cell science and technology. Fabricate and test operational fuel cells in the Colorado Fuel Cell Center. Prerequisites: EGGN371 or ChEN357 or MTGN351, or consent of instructor. 3 hours lecture; 3 semester hours.

**EGGN471. HEAT TRANSFER. 3.0 Hours.**

(I, II) Engineering approach to conduction, convection, and radiation, including steady-state conduction, nonsteady-state conduction, internal heat generation conduction in one, two, and three dimensions, and combined conduction and convection. Free and forced convection including laminar and turbulent flow, internal and external flow. Radiation of black and grey surfaces, shape factors and electrical equivalence. Prerequisite: MATH225; EGGN351; EGGN371 or PHGN341. 3 hours lecture; 3 semester hours.

**EGGN473. FLUID MECHANICS II. 3.0 Hours.**

(II) Review of elementary fluid mechanics and engineering, two-dimensional external flows, boundary layers, flow separation; Compressible flow, isentropic flow, normal and oblique shocks, Prandtl-Meyer expansion fans, Fanno and Rayleigh flow; Introduction to flow instabilities (e.g., Kelvin-Helmholtz instability, Raleigh Benard convection). Prerequisite: EGGN351 or consent of instructor. 3 hours lecture; 3 semester hours.

**EGGN478. ENGINEERING VIBRATION. 3.0 Hours.**

(II) Theory of mechanical vibrations as applied to single- and multi-degree-of-freedom systems. Analysis of free and forced vibrations to different types of loading - harmonic, impulse, periodic and general transient loading. Derive model systems using D'Alembert's principle, Lagrange's equations and Hamilton's principle. Analysis of natural frequencies and mode shapes. Role of damping in machines and structures. Analysis and effects of resonance. Use of the modal superposition method and the transient Duhamel integral method. Prerequisite: EGGN315. 3 hours lecture; 3 semester hours.

**EGGN493. ENGINEERING DESIGN OPTIMIZATION. 3.0 Hours.**

(II) The application of gradient, stochastic and heuristic optimization algorithms to linear and nonlinear optimization problems in constrained and unconstrained design spaces. Students will consider problems with continuous, integer and mixed-integer variables, problems with single or multiple objectives and the task modeling design spaces and constraints. Design optimization methods are becoming of increasing importance in engineering design and offer the potential to reduce design cycle times while improving design quality by leveraging simulation and historical design data. Prerequisites: MATH213 and MATH225 (Required), CSCI260 or CSCI261 or other experience with computer programming languages (Suggested). 3 hours lecture; 3 semester hours.

**EGGN499M. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

## Economics and Business

### Program Description

The economy is becoming increasingly global and dependent on advanced technology. In such a world, private companies and public organizations need leaders and managers who understand economics and business, as well as science and technology.

Programs in the Division of Economics and Business are designed to bridge the gap that often exists between economists and managers, on the one hand, and engineers and scientists, on the other. All Mines undergraduate students are introduced to economic principles in a required course, and many pursue additional course work in minor programs or elective courses. The courses introduce undergraduate students to economic and business principles so that they will understand the economic and business environments, both national and global, in which they will work and live.

In keeping with the mission of the Colorado School of Mines, the Division of Economics and Business offers a Bachelor of Science in Economics. Most economics degrees at other universities are awarded as a Bachelor of Arts, with a strong liberal arts component. Our degree is grounded in mathematics, engineering and the sciences. We graduate technologically literate economists with quantitative economics and business skills that give them a competitive advantage in today's economy.

Economics majors have a range of career options following their undergraduate studies. Some pursue graduate degrees in economics, business, or law. Others begin careers as managers, economic advisors, and financial officers in business or government, often in organizations that deal with engineering, applied science, and advanced technology.

### Program Educational Objectives (Bachelor of Science in Economics)

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria, the educational objectives of the undergraduate program in economics and business are:

1. To provide students with a strong foundation in economic theory and analytical techniques, taking advantage of the mathematical and quantitative abilities of CSM undergraduate students; and
2. To prepare students for the work force, especially in organizations in CSM's areas of traditional strength (engineering, applied science, mathematics and computer science), and for graduate school, especially in economics, business, and law.

### Curriculum

All economics majors take forty-five percent of their courses in math, science, and engineering, including the same core required of all CSM undergraduates. Students take another forty percent of their courses in economics and business. The remaining fifteen percent of the course work can come from any field. Many students complete minor programs in a technical field, such as computer science, engineering, geology or environmental science. A number of students pursue double majors.

To complete the economics major, students must take 45 hours of 300 and 400 level economics and business courses. Of these, 18 hours must be at the 400 level. At least 30 of the required 45 hours must be taken in residence in the home department. For students participating in an approved foreign study program, up to 19 hours of the 30 hours in residence requirement may be taken abroad.

### Degree Requirements in Economics

		lec	lab	sem.hrs
<b>Freshman</b>				
CORE	Common Core			33.0
				<b>33.0</b>
<b>Sophomore</b>				
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3
DIST SCI	Distributed Science III*	3.0		3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4
SYGN200	HUMAN SYSTEMS			3
PAGN2XX	PHYSICAL EDUCATION			0.5
FREE	Free Elective	3.0		3.0
				<b>16.5</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
EBGN301	INTERMEDIATE MICROECONOMICS	3.0		3
MATH323	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0		3
MATH225	DIFFERENTIAL EQUATIONS	3.0		3
PAGN2XX	PHYSICAL EDUCATION			0.5
FREE	Free Elective			3.0
EBGN	EBGN Elective I**	3.0		3.0
				<b>15.5</b>
<b>Junior</b>				
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
EBGN302	INTERMEDIATE MACROECONOMICS	3.0		3
EBGN325	OPERATIONS RESEARCH	3.0		3
EBGN	EBGN Elective II**	3.0		3.0
LAIS/EBGN	H&SS GenEd Restricted Elective I	3.0		3.0
FREE	Free Elective	3.0		3.0
				<b>15.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
EBGN303	ECONOMETRICS	3.0		3
EBGN321	ENGINEERING ECONOMICS	3.0		3
EBGN409	MATHEMATICAL ECONOMICS***	3.0		3
	or EBGN Elective III**			
LAIS/EBGN	H&SS GenEd Restricted Elective II	3.0		3.0
FREE	Free Elective	3.0		3.0
				<b>15.0</b>
<b>Summer</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
EBGN403	FIELD SESSION	3.0		3
				<b>3.0</b>

**Senior**

		lec	lab	sem.hrs
<b>Fall</b>				
EBGN401	ADVANCED TOPICS IN ECONOMICS	3.0		3
EBGN455	LINEAR PROGRAMMING*** or EBGN Elective III**	3.0		3
LAIS/EBGN	H&SS GenEd Restricted Elective III	3.0		3.0
EBGN	EBGN Elective IV**	3.0		3.0
FREE	Free Elective	3.0		3.0
				<b>15.0</b>
<b>Spring</b>				
EBGN	EBGN Elective V**	3.0		3.0
EBGN	EBGN Elective VI**	3.0		3.0
EBGN	EBGN Elective VII**	3.0		3.0
FREE	Free Electives	6.0		6.0
				<b>15.0</b>

Total Hours: 128.0

\* Students in all degree options (majors) are required to complete a minimum of three out of five courses from the list of Distributed Science Requirements. For Economics Majors, students have a choice of three of the following: BELS101, SYGN101, PHGN200, CHGN122, and CSC1101. A total of 12.5 credit hours must be completed for the DSR requirement. If the DSR courses chosen do not equal 12.5 credit hours, additional free elective credit will be required to meet the program total.

\*\* At least 2 EBGN elective courses must be at the 400-level or above.

\*\*\* Students must take either EBGN409 or EBGN455.

General CSM Minor/ASI requirements can be found here (p. 195).

## Minor Program in Economics and Business

The minor in Economics requires that students complete 6 economics courses, for a total of 18 credit hours. Minors are required to take Principles of Economics (EBGN201) and either Intermediate Microeconomics (EBGN301) or Intermediate Macroeconomics (EBGN302). Students must complete 4 additional courses from the lists below. Students may choose courses from either the economics focus or the business focus list (or both). Regardless of their course selection, the minor remains "Economics and Business." Economics courses taken as part of the Humanities and Social Sciences electives can be counted toward the minor.

### Area of Special Interest in Economics and Business

The area of special interest in Economics and Business requires that students complete Principles of Economics (EBGN201) and 3 other courses in economics and business chosen from the lists below, for a total of 12 credit hours. Except for Principles of Economics (EBGN201) Economics courses taken to complete any other graduation requirement may not be counted toward the area of special interest.

### Area of Special Interest in Entrepreneurship

The objective of the Area of Special Interest in Entrepreneurship is to supplement an engineering or applied science education with tools and processes to recognize and evaluate entrepreneurial opportunities.

These tools include financial forecasting, business models and the interrelationships of business functions including accounting, marketing, finance, human resources and operations. The processes include developing feasibility studies and business plans.

The area of Special Interest in Entrepreneurship requires that students complete Principles of Economics (EBGN201), Business Principles for Entrepreneurs (EBGN361), Introduction to Entrepreneurship (EBGN360) and Business Plan Development (EBGN460), for a total of 12 credit hours.

### Economics Focus

EBGN301	INTERMEDIATE MICROECONOMICS	3
EBGN302	INTERMEDIATE MACROECONOMICS	3
EBGN303	ECONOMETRICS	3
EBGN310	ENVIRONMENTAL AND RESOURCE ECONOMICS	3
EBGN315	BUSINESS STRATEGY	3
EBGN320	ECONOMICS AND TECHNOLOGY	3
EBGN330	ENERGY ECONOMICS	3
EBGN340	ENERGY AND ENVIRONMENTAL POLICY	3
EBGN342	ECONOMIC DEVELOPMENT	3
EBGN401	ADVANCED TOPICS IN ECONOMICS	3
EBGN409	MATHEMATICAL ECONOMICS	3
EBGN437	REGIONAL ECONOMICS	3
EBGN441	INTERNATIONAL ECONOMICS	3
EBGN443	PUBLIC ECONOMICS	3
EBGN470	ENVIRONMENTAL ECONOMICS	3
EBGN495	ECONOMIC FORECASTING	3

### Business Focus

EBGN304	PERSONAL FINANCE	3
EBGN305	FINANCIAL ACCOUNTING	3
EBGN306	MANAGERIAL ACCOUNTING	3
EBGN314	PRINCIPLES OF MANAGEMENT	3
EBGN321	ENGINEERING ECONOMICS	3
EBGN325	OPERATIONS RESEARCH	3
EBGN345	PRINCIPLES OF CORPORATE FINANCE	3
EBGN360	INTRODUCTION TO ENTREPRENEURSHIP	3
EBGN361	BUSINESS PRINCIPLES FOR ENTREPRENEURS	3
EBGN452	NONLINEAR PROGRAMMING	3
EBGN455	LINEAR PROGRAMMING	3
EBGN456	NETWORK MODELS	3
EBGN457	INTEGER PROGRAMMING	3
EBGN459	SUPPLY CHAIN MANAGEMENT	3
EBGN460	BUSINESS PLAN DEVELOPMENT	3
EBGN461	STOCHASTIC MODELS IN MANAGEMENT SCIENCE	3
EBGN474	INVENTING, PATENTING AND LICENSING	3.0

### Minor Program in Operations Research (OR)

The Operations Research minor consists of a minimum of 18 credit hours of a logical sequence of courses. Only three of these hours may be taken in the student's degree-granting department. Three of these hours must consist of a deterministic modeling course, three must consist of a

stochastic modeling course, and no more than three must draw from a survey course (combining both stochastic and deterministic modeling).

The objectives of the minor are to supplement an engineering or applied science background with a formal approach to mathematical modeling that includes assessing and/or improving the performance of a system. Such a system could be naturally occurring or man-made. Examples of such systems are manufacturing lines, mines, wind farms, mechanical systems such as turbines and generators (or a collection of such objects), waste water treatment facilities, and chemical processes. The formal approach includes optimization, (e.g., linear programming, nonlinear programming, integer programming), decision analysis, stochastic modeling, and simulation.

### Deterministic Modeling (minimum of one)

CSCI262	DATA STRUCTURES	3
CSCI406	ALGORITHMS	3
MATH406	ALGORITHMS	3
CSCI404	ARTIFICIAL INTELLIGENCE	3
EBGN452	NONLINEAR PROGRAMMING	3
EBGN455	LINEAR PROGRAMMING	3
EBGN456	NETWORK MODELS	3
EBGN457	INTEGER PROGRAMMING	3
EGGN307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3
MATH332	LINEAR ALGEBRA	3
EGGN417	MODERN CONTROL DESIGN	3
EGGN502	ADVANCED ENGINEERING ANALYSIS	4

### Stochastic Modeling (minimum of one)

EBGN459	SUPPLY CHAIN MANAGEMENT	3
EBGN461	STOCHASTIC MODELS IN MANAGEMENT SCIENCE	3
EBGN528	INDUSTRIAL SYSTEMS SIMULATION	3
EBGN560	DECISION ANALYSIS	3
MATH424	INTRODUCTION TO APPLIED STATISTICS	3
MATH438	STOCHASTIC MODELS	3
MNGN438	GEOSTATISTICS	3
PEGN438	GEOSTATISTICS	3
MTGN450	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS	3

### Survey Course (Maximum of one)

EBGN325	OPERATIONS RESEARCH	3
MNGN433	MINE SYSTEMS ANALYSIS I	3

## Courses

### EBGN198. SPECIAL TOPICS IN ECONOMICS AND BUSINESS. 1-6 Hour.

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### EBGN199. INDEPENDENT STUDY. 0.5-6 Hour.

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

### EBGN201. PRINCIPLES OF ECONOMICS. 3.0 Hours.

(I,II,S) Introduction to microeconomics and macroeconomics. This course focuses on applying the economic way of thinking and basic tools of economic analysis. Economic effects of public policies. Analysis of markets for goods, services and resources. Tools of cost-benefit analysis. Measures of overall economic activity. Determinants of economic growth. Monetary and fiscal policy. Prerequisites: None. 3 hours lecture; 3 semester hours.

### EBGN298. SPECIAL TOPICS IN ECONOMICS AND BUSINESS. 1-6 Hour.

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### EBGN299. INDEPENDENT STUDY. 1-6 Hour.

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

### EBGN301. INTERMEDIATE MICROECONOMICS. 3.0 Hours.

(I,II) This course introduces the theoretical and analytical foundations of microeconomics and applies these models to the decisions and interactions of consumers, producers and governments. Develops and applies models of consumer choice and production with a focus on general equilibrium results for competitive markets. Examines the effects of market power and market failures on prices, allocation of resources and social welfare. Prerequisites: EBGN201 and MATH213. 3 hours lecture; 3 semester hours.

### EBGN302. INTERMEDIATE MACROECONOMICS. 3.0 Hours.

(I,II) Intermediate macroeconomics provides a foundation for analyzing both short-run and long-run economic performance across countries and over time. The course discusses macroeconomic data analysis (including national income and balance of payments accounting), economic fluctuations and the potentially stabilizing roles of monetary, fiscal and exchange rates policies, the role of expectations and intertemporal considerations, and the determinants of long-run growth. The effects of external and internal shocks (such as oil price shocks, resource booms and busts) are analyzed. Prerequisites: EBGN201 and MATH213. 3 hours lecture; 3 semester hours.

### EBGN303. ECONOMETRICS. 3.0 Hours.

(II) (WI) Introduction to econometrics, including ordinary least-squares and single- equation models; two-stage least-squares and multiple-equation models; specification error, serial correlation, heteroskedasticity, and other problems; distributive-lag models and other extensions, hypothesis testing and forecasting applications. Prerequisites: EBGN201 and MATH323. 3 hours lecture; 3 semester hours.

**EBGN304. PERSONAL FINANCE. 3.0 Hours.**

(S) The management of household and personal finances. Overview of financial concepts with special emphasis on their application to issues faced by individuals and households: budget management, taxes, savings, housing and other major acquisitions, borrowing, insurance, investments, meeting retirement goals, and estate planning. Survey of principles and techniques for the management of a household's assets and liabilities. Study of financial institutions and their relationship to households, along with a discussion of financial instruments commonly held by individuals and families. 3 hours lecture; 3 semester hours.

**EBGN305. FINANCIAL ACCOUNTING. 3.0 Hours.**

(I, II) Survey and evaluation of balance sheets and income and expense statements, origin and purpose. Evaluation of depreciation, depletion, and reserve methods for tax and internal management purposes. Cash flow analysis in relation to planning and -decision making. Inventory methods and cost controls related to dynamics of production and processing. Prerequisite: EBGN201. 3 hours lecture; 3 semester hours.

**EBGN306. MANAGERIAL ACCOUNTING. 3.0 Hours.**

(II) Introduction to cost concepts and principles of management accounting including cost accounting. The course focuses on activities that create value for customers and owners of a company and demonstrates how to generate cost-accounting information to be used in management decision making. Prerequisite: EBGN201, EBGN305. 3 hours lecture; 3 semester hours.

**EBGN310. ENVIRONMENTAL AND RESOURCE ECONOMICS. 3.0 Hours.**

(I) (WI) Application of microeconomic theory to topics in environmental and resource economics. Topics include analysis of pollution control, benefit/cost analysis in decision-making and the associated problems of measuring benefits and costs, non-renewable resource extraction, measures of resource scarcity, renewable resource management, environmental justice, sustainability, and the analysis of environmental regulations and resource policies. Prerequisite: EBGN201. 3 hours lecture; 3 semester hours.

**EBGN314. PRINCIPLES OF MANAGEMENT. 3.0 Hours.**

(II) Introduction of underlying principles, fundamentals, and knowledge required of the manager in a complex, modern organization. Prerequisite: EBGN201. 3 hours lecture; 3 semester hours.

**EBGN315. BUSINESS STRATEGY. 3.0 Hours.**

(II) An introduction to game theory and industrial organization (IO) principles at a practical and applied level. Topics include economies of scale and scope, the economics of the make-versus-buy decision, market structure and entry, dynamic pricing rivalry, strategic positioning, and the economics of organizational design. Prerequisite: EBGN201. 3 hours lecture; 3 semester hours.

**EBGN320. ECONOMICS AND TECHNOLOGY. 3.0 Hours.**

(II) The theoretical, empirical and policy aspects of the economics of technology and technological change. Topics include the economics of research and development, inventions and patenting, the Internet, e-commerce, and incentives for efficient implementation of technology. Prerequisite: EBGN201. 3 hours lecture; 3 semester hours.

**EBGN321. ENGINEERING ECONOMICS. 3.0 Hours.**

(II) Time value of money concepts of present worth, future worth, annual worth, rate of return and break-even analysis applied to after-tax economic analysis of mineral, petroleum and general investments. Related topics on proper handling of (1) inflation and escalation, (2) leverage (borrowed money), (3) risk adjustment of analysis using expected value concepts, (4) mutually exclusive alternative analysis and service producing alternatives. Prerequisite: EBGN201. 3 hours lecture; 3 semester hours.

**EBGN325. OPERATIONS RESEARCH. 3.0 Hours.**

(I) This survey course introduces fundamental operations research techniques in the optimization areas of linear programming, network models (i.e., maximum flow, shortest path, and minimum cost flow), integer programming, and nonlinear programming. Stochastic (probabilistic) topics include queuing theory and simulation. Inventory models are discussed as time permits. The emphasis in this applications course is on problem formulation and obtaining solutions using Excel Software. Prerequisite: Junior Standing, EBGN201, MATH112. 3 hours lecture; 3 semester hours.

**EBGN330. ENERGY ECONOMICS. 3.0 Hours.**

(I) Study of economic theories of optimal resource extraction, market power, market failure, regulation, deregulation, technological change and resource scarcity. Economic tools used to analyze OPEC, energy mergers, natural gas price controls and deregulation, electric utility restructuring, energy taxes, environmental impacts of energy use, government R&D programs, and other energy topics. Prerequisite: EBGN201. 3 hours lecture; 3 semester hours.

**EBGN340. ENERGY AND ENVIRONMENTAL POLICY. 3.0 Hours.**

This course considers the intersection of energy and environmental policy from an economic perspective. Policy issues addressed include climate change, renewable resources, externalities of energy use, transportation, and economic development and sustainability. Prerequisites: EBGN201. 3 hours lecture; 3 semester hours.

**EBGN342. ECONOMIC DEVELOPMENT. 3.0 Hours.**

(II) (WI) Theories of development and underdevelopment. Sectoral development policies and industrialization. The special problems and opportunities created by an extensive mineral endowment, including the Dutch disease and the resource-curse argument. The effect of value-added processing and export diversification on development. Prerequisite: EBGN201. 3 lecture hours; 3 semester hours. Offered alternate years.

**EBGN345. PRINCIPLES OF CORPORATE FINANCE. 3.0 Hours.**

(II) Introduction to corporate finance, financial management, and financial markets. Time value of money and discounted cash flow valuation, risk and returns, interest rates, bond and stock valuation, capital budgeting and financing decisions. Introduction to financial engineering and financial risk management, derivatives, and hedging with derivatives. Prerequisite: EBGN201, EBGN305. 3 hours lecture; 3 semester hours.

**EBGN360. INTRODUCTION TO ENTREPRENEURSHIP. 3.0 Hours.**

(I) This course introduces students to the entrepreneurial process, focusing on the concepts, practices, and tools of the entrepreneurial world. This will be accomplished through a combination of readings, cases, speakers, and projects designed to convey the unique environment of entrepreneurship and new ventures. The mastery of concepts covered in this course will lead to an initial evaluation of new venture ideas. In this course students will interact with entrepreneurs, participate in class discussion, and be active participants in the teaching/learning process. Prerequisite: EBGN201. Corequisite: EBGN361. 3 hours lecture; 3 semester hours.

**EBGN361. BUSINESS PRINCIPLES FOR ENTREPRENEURS. 3.0 Hours.**

(I) Students will be introduced to each of the functional areas of an entrepreneurial business, including marketing, accounting, finance, operations, human resources management, and business operations. The course is designed to help students appreciate the interrelationship of these business functions and, understand how they operate in an entrepreneurial start-up business. In this course students are expected to participate in class discussion, and be active participants in the teaching/learning process. The class will be highly interactive and your engaged participation and presence will be required. Prerequisite: EBGN201. 3 hours lecture; 3 semester hours.

**EBGN398. SPECIAL TOPICS IN ECONOMICS AND BUSINESS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**EBGN399. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**EBGN401. ADVANCED TOPICS IN ECONOMICS. 3.0 Hours.**

(I) Application of economic theory to microeconomic and macroeconomic problems. This course will involve both theoretical and empirical modeling. Specific topics will vary by semester depending on faculty and student interest. Topics may include general equilibrium modeling, computational economics, game theory, the economics of information, intertemporal allocations, economic growth, microfoundations of macroeconomic models and policy simulation. Prerequisites: EBGN301, EBGN302 and EBGN303. 3 hours lecture; 3 semester hours.

**EBGN403. FIELD SESSION. 3.0 Hours.**

(S) (WI) An applied course for students majoring in economics. The field session may consist of either participation in a computer simulation or an independent research project under the supervision of a faculty member. In the computer simulation, students work as part of the senior executive team of a company and are responsible for developing and executing a strategy for their company with on-going decisions on everything from new product development, to marketing, to finance and accounting. Prerequisites: EBGN301, EBGN302, EBGN303; or permission of the instructor. 3 semester hours.

**EBGN404. ADVANCED TOPICS IN MICROECONOMICS. 3.0 Hours.**

(I) Application of economic theory to microeconomic problems. This course will involve both theoretical and empirical modeling of consumers, producers and markets. Topics may include game theory, risk and uncertainty, the economics of information, intertemporal allocations and general equilibrium modeling. Prerequisites: EBGN301, EBGN302 and EBGN303. 3 hours lecture; 3 semester hours.

**EBGN405. ADVANCED TOPICS IN MACROECONOMICS. 3.0 Hours.**

(I) This course is a sequel to Intermediate Macroeconomics. The course will cover (i) modern economic growth theory and empirics; (ii) microfoundations and econometric estimation of macroeconomic relationships, such as consumption, gross fixed investment, inventory behavior and the sustainability of fiscal deficits; and (iii) multi-sectoral models of international trade and finance. Other topics may include real business cycle models, macroeconomic policy simulation, macroeconomic policy efficacy in globally integrated economies, foreign repercussions effects, empirical relationships between interest rates and exchange rates, and interactions between resource industries and the rest of the economy. Prerequisites: EBGN301, ENGN302, EBGN303. 3 hours lecture; 3 semester hours.

**EBGN409. MATHEMATICAL ECONOMICS. 3.0 Hours.**

(II) Application of mathematical tools to economic problems. Coverage of mathematics needed to read published economic literature and to do graduate study in economics. Topics from differential and integral calculus, matrix algebra, differential equations, and dynamic programming. Applications are taken from mineral, energy, and environmental issues, requiring both analytical and computer solutions using programs such as GAMS and MATHEMATICA. Prerequisites: MATH213, EBGN301, EBGN302; or permission of the instructor. 3 hours lecture; 3 semester hours.

**EBGN437. REGIONAL ECONOMICS. 3.0 Hours.**

(I) (WI) Analysis of the spatial dimension of economies and economic decisions. Interregional capital and labor mobility. Location decisions of firms and households. Agglomeration economies. Models of regional economic growth. Measuring and forecasting economic impact and regional growth. Local and regional economic development policy. Urban and regional spatial structure. Emphasis on application of tools and techniques of regional analysis. Prerequisite: EBGN301. 3 hours lecture; 3 semester hours.

**EBGN441. INTERNATIONAL ECONOMICS. 3.0 Hours.**

(II) (WI) Theories and determinants of international trade, including static and dynamic comparative advantage and the gains from trade. The history of arguments for and against free trade. The political economy of trade policy in both developing and developed countries. Prerequisite: EBGN301. 3 hours lecture; 3 semester hours.



**EBGN443. PUBLIC ECONOMICS. 3.0 Hours.**

(I) (WI) This course covers public-sector economics, including the fundamental institutions and relationships between the government and private decision makers. It covers the fundamental general equilibrium welfare theorems and their interaction with government policy instruments that affect efficiency and distribution. Normative topics include an intensive study of the causes and consequences of, and policy prescriptions for, market failure due to public goods, or other problems associated with externalities and income distribution. Positive analysis focuses on policy formation in the context of political economy and public choice theories. Prerequisite: EBG301. 3 hours lecture; 3 semester hours.

**EBGN452. NONLINEAR PROGRAMMING. 3.0 Hours.**

(II) As an advanced course in optimization, this course will address both unconstrained and constrained nonlinear model formulation and corresponding algorithms, e.g., gradient search and Newton's method, Lagrange multiplier methods and reduced gradient algorithms. Applications of state-of-the-art hardware and software will emphasize solving real-world problems in areas such as mining, energy, transportation and the military. Prerequisite: EBG455 or permission of instructor. 3 hours lecture; 3 semester hours.

**EBGN455. LINEAR PROGRAMMING. 3.0 Hours.**

(I) This course addresses the formulation of linear programming models, examines linear programs in two dimensions, covers standard form and other basics essential to understanding the Simplex method, the Simplex method itself, duality theory, complementary slackness conditions, and sensitivity analysis. As time permits, multi-objective programming, an introduction to linear integer programming, and the interior point method are introduced. Applications of linear programming models discussed in this course include, but are not limited to, the areas of manufacturing, finance, energy, mining, transportation and logistics, and the military. Prerequisites: MATH332 or MATH348 or EBG409 or permission of instructor. 3 hours lecture; 3 semester hours.

**EBGN456. NETWORK MODELS. 3.0 Hours.**

(II) Network models are linear programming problems that possess special mathematical structures. This course examines a variety of network models, specifically, spanning tree problems, shortest path problems, maximum flow problems, minimum cost flow problems, and transportation and assignment problems. For each class of problem, we present applications in areas such as manufacturing, finance, energy, mining, transportation and logistics, and the military. We also discuss an algorithm or two applicable to each problem class. As time permits, we explore combinatorial problems that can be depicted on graphs, e.g., the traveling salesman problem and the Chinese postman problem, and discuss the tractability issues associated with these problems in contrast to "pure" network models. Prerequisites: MATH111; EBG325 or EBG455; or permission of the instructor.

**EBGN457. INTEGER PROGRAMMING. 3.0 Hours.**

(II) As an advanced course in optimization, this course will address computational performance of linear and linear-integer optimization problems, and, using state-of-the-art hardware and software, will introduce solution techniques for "difficult" optimization problems. We will discuss such methodologies applied to the monolith, e.g., branch-and-bound and its variations, cutting planes, strong formulations, as well as decomposition and reformulation techniques, e.g., Lagrangian relaxation, Benders decomposition, column generation. Additional special topics may be introduced as time permits. Prerequisite: EBG455 or permission of instructor. 3 hours lecture; 3 semester hours.

**EBGN459. SUPPLY CHAIN MANAGEMENT. 3.0 Hours.**

(II) As a quantitative managerial course, the course will explore how firms can better organize their operations so that they more effectively align their supply with the demand for their products and services. Supply Chain Management (SCM) is concerned with the efficient integration of suppliers, factories, warehouses and retail-stores (or other forms of distribution channels) so that products are provided to customers in the right quantity and at the right time. Topics include managing economies of scale for functional products, managing market-mediation costs for innovative products, make-to-order versus make-to-stock systems, quick response strategies, risk pooling strategies, supply-chain contracts and revenue management. Additional "special topics" will also be introduced, such as reverse logistics issues in the supply-chain or contemporary operational and financial hedging strategies. Prerequisite: permission of the instructor. 3 hours lecture; 3 semester hours.

**EBGN460. BUSINESS PLAN DEVELOPMENT. 3.0 Hours.**

(II) This course leads students through the process of developing a detailed business plan for a start-up company. The creation of a business plan can be challenging, frustrating, fascinating and will lead to a more in-depth understanding of how businesses start and operate. Most new ventures are started by teams, with complementary skills and experience sets. In this class, therefore, students will work in teams to develop and write a business plan. This class is also about identifying a new product or service with a viable market and potential to develop into a profitable enterprise by expanding the feasibility study work from EBG360. This course is the hands-on work of developing a business plan, and as such is intense and demanding. Additionally, this course will integrate previous entrepreneurship, business and economics classes. In this course students are expected to participate in class discussion, and be active participants in the teaching/learning process. The class will be highly interactive and engaged participation and presence will be required. Prerequisites: EBG360, EBG361; 3 hours lecture; 3 semester hours.

**EBGN461. STOCHASTIC MODELS IN MANAGEMENT SCIENCE. 3.0 Hours.**

(II) As a quantitative managerial course, the course is an introduction to the use of probability models for analyzing risks and economic decisions and doing performance analysis for dynamic systems. The difficulties of making decisions under uncertainty are familiar to everyone. We will learn models that help us quantitatively analyze uncertainty and how to use related software packages for managerial decision-making and to do optimization under uncertainty. Illustrative examples will be drawn from many fields including marketing, finance, production, logistics and distribution, energy and mining. The main focus of the course is to see methodologies that help to quantify the dynamic relationships of sequences of "random" events that evolve over time. Prerequisite: permission of the instructor. 3 hours lecture; 3 semester hours.

**EBGN470. ENVIRONMENTAL ECONOMICS. 3.0 Hours.**

(II) (WI) This course considers the role of markets as they relate to the environment. Topics discussed include environmental policy and economic incentives, market and non-market approaches to pollution regulation, property rights and the environment, the use of benefit/cost analysis in environmental policy decisions, and methods for measuring environmental and nonmarket values. Prerequisite: EBGN301. 3 hours lecture; 3 semester hours.

**EBGN474. INVENTING, PATENTING AND LICENSING. 3.0 Hours.**

(S) (WI) This course provides an introduction to the legal framework of inventing and patenting and addresses practical issues facing inventors. The course examines patent law, inventing and patenting in the corporate environment, patent infringement and litigation, licensing, and the economic impact of patents. Methods and resources for market evaluation, searching prior art, documentation and disclosure of invention, and preparing patent applications are presented. Prerequisite: Permission of instructor. 3 hours lecture; 3 semester hours.

**EBGN495. ECONOMIC FORECASTING. 3.0 Hours.**

(II) An introduction to the methods employed in business and econometric forecasting. Topics include time series modeling, Box-Jenkins models, vector autoregression, cointegration, exponential smoothing and seasonal adjustments. Covers data collection methods, graphing, model building, model interpretation, and presentation of results. Topics include demand and sales forecasting, the use of anticipations data, leading indicators and scenario analysis, business cycle forecasting, GNP, stock market prices and commodity market prices. Includes discussion of links between economic forecasting and government policy. Prerequisites: EBGN301, EBGN302, EBGN303. 3 hours lecture; 3 semester hours.

**EBGN497. SUMMER PROGRAMS. 6.0 Hours.****EBGN498. SPECIAL TOPICS IN ECONOMICS AND BUSINESS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**EBGN499. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

# Geology and Geological Engineering

## Program Description

A Bachelor of Science degree in Geological Engineering is the basis for careers concentrating on the interaction of humans and the earth. Geological Engineers deal with a wide variety of the resource and environmental problems that come with accommodating more and more people on a finite planet. Geologic hazards and conditions must be recognized and considered in the location and design of foundations for buildings, roads and other structures; waste disposal facilities must be properly located, designed and constructed; contaminated sites and ground water must be accurately characterized before cleanup can be accomplished; water supplies must be located, developed and protected; and new mineral and energy resources must be located and developed in an environmentally sound manner. Geological Engineers are the professionals trained to meet these challenges.

The Geological Engineering curriculum provides a strong foundation in the basic sciences, mathematics, geological science and basic engineering along with specialized upper level instruction in integrated applications to real problems. Engineering design is integrated throughout the four year program, beginning in Design I (Freshman year) and ending with the capstone design courses in the senior year. The program is accredited by the:

Engineering Accreditation Commission of Accreditation Inc  
111 Market Place, Suite 1050  
Baltimore, MD 21202-4012  
Telephone: (410) 347-7700.

Students have the background to take the Fundamentals of Engineering Exam, the first step in becoming a registered Professional Engineer.

Graduates follow five general career paths:

**Engineering Geology and Geotechnics.** Careers in site investigation, design and stabilization of foundations and slopes; site characterization, design, construction and remediation of waste disposal sites or contaminated sites; and assessment of geologic hazards for civil, mining or environmental engineering projects.

**Ground-Water Engineering.** Careers in assessment and remediation of ground-water contamination, design of ground-water control facilities for geotechnical projects and exploration for and development of ground-water supplies.

**Petroleum Exploration and Development Engineering.** Careers in search for and development of oil and gas and their efficient extraction.

**Mineral Exploration and Development Engineering.** Careers in search for and development of natural deposits of metals, industrial materials and rock aggregate.

**Geological Science.** Students are also well prepared to pursue careers in basic geoscience. Graduates have become experts in fields as divergent as global climate change, the early history of the Earth, planetary science, fractal representation of ground-water flow and simulation of sedimentary rock sequences, to name a few. Careers are available in research and education.

The curriculum may be followed along two concentration paths with slightly different upper division requirements. Both concentrations are identical in the first two years as students study basic science, mathematics, engineering science, and geological science. In the junior year those students pursuing careers in ground-water engineering,

engineering geology and geotechnics, or geoenvironmental engineering applications follow the Environmental, Engineering Geology and Geotechnics, and Ground-Water Engineering Concentration. Students anticipating careers in resource exploration and development or who expect to pursue graduate studies in geological sciences follow the Mineral and Petroleum Exploration Engineering Concentration.

At all levels the Geological Engineering Program emphasizes laboratory and field experience. All courses have a laboratory session, and after the junior year students participate in a field course, which is six weeks of geologic and engineering mapping and direct observation. The course involves considerable time outdoors in the mountains and canyons of Utah and southwestern Colorado.

At the senior level, students begin to focus on a career path by taking course sequences in at least two areas of geological engineering specialization. The course sequences begin with a 4 unit course in the fundamentals of a field of geological engineering which is followed by a 3 unit design-oriented course that emphasizes experience in direct application of principles through design projects.

## Combined Undergraduate/Graduate Programs

Several degree programs offer CSM undergraduate students the opportunity to begin work on a Graduate Certificate, Professional Degree, or Master Degree while completing the requirements for their Bachelor Degree. These programs can give students a head start on graduate education. An overview of these combined programs and description of the admission process and requirements are found in the Graduate Degrees and Requirements section of the Graduate Bulletin.

## Program Educational Objectives (Bachelor of Science in Geological Engineering)

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria, the Geological Engineering Program at CSM has established the following program educational objectives:

### Objective 1. Demonstrate a high level of technical competence. Outcomes. Graduates of the program will:

- Successfully complete a required course curriculum
- Participate in senior year design experiences
- Complete two capstone design courses
- Be encouraged to gain practical work experience
- Advance to careers or graduate school programs related to geological engineering

### Objective 2. Demonstrate prowess in written, oral, and graphical communication. Outcomes. Graduates of the program will

- Have quality role models for effective communication
- Be capable of producing concise and professional technical documents
- Be capable of giving specialized technical presentations using computer software

- Demonstrate computer literacy, including skills at writing computer programs, retrieving information on the internet, and applying computer software to solve problems

**Objective 3. Experience progressive leadership roles and good teamwork practices. Outcomes. Graduates of the program will:**

- Demonstrate leadership and teamwork by completing team projects while contributing in a variety of roles
- Gain appreciation for leadership and teamwork by participating in student organizations

**Objective 4. Demonstrate professional growth through life-long learning experiences. Outcomes. Graduates of the program will:**

- Develop an awareness of how world events relate to their profession
- Complete internships (33% of each class), independent study or special topics (10%), and advance to graduate or professional school (33%)

**Objective 5. Practice ethical behavior and integrity in professional activities. Outcomes. Graduates of the program will:**

- Understand what constitutes ethical behavior, as it applies to their profession, the engineering workplace, in professional societies, and when completing class projects and taking examinations

**Program Requirements**

In order to achieve the program goals listed above, every student working toward the Bachelor of Science Degree in Geological Engineering must complete the following requirements:

**Degree Requirements (Geological Engineering)**

**Sophomore**

Fall		lec	lab	sem.hrs
GEGN203	ENGINEERING TERRAIN ANALYSIS	2.0		2
GEGN204	GEOLOGIC PRINCIPLES AND PROCESSES	2.0		2
GEGN205	ADVANCED PHYSICAL GEOLOGY LABORATORY		3.0	1
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4
DCGN241	DIST CORE - STATICS	3.0		3
SYGN200	HUMAN SYSTEMS	3.0		3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>15.5</b>

**Spring**

		lec	lab	sem.hrs
EPIC264	EPICS II: GEOLOGY GIS	2.0	3.0	3
GEGN206	EARTH MATERIALS	2.0	3.0	3
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5

MATH222	INTRODUCTION TO DIFFERENTIAL EQUATIONS FOR GEOLOGISTS & GEOLOGICAL ENGINEERS*		2
EGGN320	MECHANICS OF MATERIALS	3.0	3
PAGN2XX	PHYSICAL EDUCATION		0.5
			<b>16.0</b>

Total Hours: 31.5

\* Only one of MATH222 and MATH225 can be counted toward graduation in GE. Any student who completes MATH222 and then changes majors out of Geology and Geological Engineering will be expected to complete MATH225 to meet graduation requirements. (In this case, MATH222 cannot be counted toward graduation in any manner - even as a free elective.)

Following the sophomore year, Geological Engineering students choose from one of two concentrations:

1. Minerals and Petroleum Exploration Engineering
2. Environmental, Engineering Geology and Geotechnics, and Ground-water Engineering

**Minerals and Petroleum Exploration Engineering Concentration**

*Recommended for students intending careers in exploration and development of mineral and fuels resources, or intending careers in geoscience research and education.*

**Freshman**

		lec	lab	sem.hrs
CORE	Common Core			33.0
				<b>33.0</b>

**Sophomore**

		lec	lab	sem.hrs
CORE	Sophomore Year			31.5
				<b>31.5</b>

**Junior**

Fall		lec	lab	sem.hrs
GEOL309	STRUCTURAL GEOLOGY AND TECTONICS	3.0	3.0	4
GEOL321	MINERALOGY AND MINERAL CHARACTERIZATION	2.0	3.0	3
DCGN209	DIST CORE THERMO	3.0		3
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3
EGGN361	SOIL MECHANICS or MNGN 321*	3.0		3
				<b>16.0</b>

**Spring**

		lec	lab	sem.hrs
GEGN307	PETROLOGY	2.0	3.0	3
GEGN317	GEOLOGIC FIELD METHODS	1.0	8.0	2
GEOL314	STRATIGRAPHY	3.0	3.0	4
GEGN351	GEOLOGICAL FLUID MECHANICS	3.0		3
LAIS/EBGN	H&SS GenEd Restricted Elective I	3.0		3.0

TECH ELECT	Tech Elective II*	3.0		3.0	
				<b>18.0</b>	
<b>Summer</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	
GEGN316	FIELD GEOLOGY		6.0	6	
				<b>6.0</b>	
<b>Senior</b>					
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	
GEGN ELECT	GEGN4xx Option Elective	3.0	3.0	4.0	
GEGN ELECT	GEGN4xx Option Elective	3.0	3.0	4.0	
GEGN432	GEOLOGICAL DATA MANAGEMENT	1.0	6.0	3	
LAIS/EBGN	H&SS GenEd Restricted Elective II	3.0		3.0	
FREE	Free Elective			3.0	
				<b>17.0</b>	
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	
GEGN ELECT	GEGN4xx Design Elective	2.0	3.0	3.0	
GEGN ELECT	GEGN 4xx Design Elective	2.0	3.0	3.0	
LAIS/EBGN	H&SS GenEd Restricted Elective III	3.0		3.0	
FREE	Free Elective			3.0	
FREE	Free Elective			3.0	
				<b>15.0</b>	

Total Hours: 136.5

\* Technical Electives I & II: Either MNGN321 or EGGN361 is required as ONE of the technical electives. An additional technical elective must be selected from a department list of approved courses. The technical elective credits must total a minimum of 6 hours of engineering topics with a minimum of 3 credit hours of engineering design.

**Option Electives**

Student must take TWO of the following four courses:	8.0
GEGN401 MINERAL DEPOSITS	
GEGN438 PETROLEUM GEOLOGY	
GEGN467 GROUNDWATER ENGINEERING	
GEGN468 ENGINEERING GEOLOGY AND GEOTECHNICS	

**Design Electives**

Students must take TWO of the following design courses, corresponding in subject area to the Option Elective:	6.0
GEGN403 MINERAL EXPLORATION DESIGN	
GEGN439 MULTIDISCIPLINARY PETROLEUM DESIGN	
GEGN469 ENGINEERING GEOLOGY DESIGN	
GEGN470 GROUND-WATER ENGINEERING DESIGN	

**Environmental, Engineering Geology and Geotechnics, and Ground-Water Engineering Concentration**

Recommended for students intending careers in geotechnical engineering, hydrogeology, or other environmental engineering careers.

<b>Freshman</b>					
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	
CORE	Common Core				33.0
					<b>33.0</b>
<b>Sophomore</b>					
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	
CORE	Sophomore Year				31.5
					<b>31.5</b>
<b>Junior</b>					
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	
GEGN212	PETROGRAPHY FOR GEOLOGICAL ENGINEERS	1.0	3.0	2	
GEOL309	STRUCTURAL GEOLOGY AND TECTONICS	3.0	3.0	4	
DCGN209	DIST CORE THERMO or EGGN 371	3.0		3	
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3	
EGGN361	SOIL MECHANICS	3.0		3	
EGGN363	SOIL MECHANICS LABORATORY		1.0	1	
					<b>16.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	
GEGN317	GEOLOGIC FIELD METHODS	1.0	8.0	2	
GEGN473	GEOLOGICAL ENGINEERING SITE INVESTIGATION	3.0		3	
GEOL314	STRATIGRAPHY	3.0	3.0	4	
GEGN351	GEOLOGICAL FLUID MECHANICS	3.0		3	
LAIS/EBGN	H&SS GenEd Restricted Elective I	3.0		3.0	
MNGN321	INTRODUCTION TO ROCK MECHANICS	2.0	3.0	3	
					<b>18.0</b>
<b>Summer</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	
GEGN316	FIELD GEOLOGY		6.0	6	
					<b>6.0</b>
<b>Senior</b>					
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	
GEGN468	ENGINEERING GEOLOGY AND GEOTECHNICS	3.0	3.0	4	
GEGN467	GROUNDWATER ENGINEERING	3.0	3.0	4	
GEGN432	GEOLOGICAL DATA MANAGEMENT	1.0	6.0	3	
LAIS/EBGN	H&SS GenEd Restricted Elective II	3.0		3.0	
FREE	Free Elective	3.0		3.0	
					<b>17.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>	
GEGN469	ENGINEERING GEOLOGY DESIGN	3.0		3	
GEGN470	GROUND-WATER ENGINEERING DESIGN	3.0		3	

LAIS/EBGN	H&SS GenEd Restricted Elective III	3.0	3.0
FREE	Free Elective	3.0	3.0
FREE	Free Elective	3.0	3.0
			<b>15.0</b>

Total Hours: 136.5

Students in the Environmental, Engineering Geology and Geotechnics, and Ground-Water Engineering Concentration may further specialize by utilizing their free elective courses to emphasize a specific specialty. Suggested courses are presented below and should be selected in consultation with the student's advisor. The emphasis area is an informal designation only and it will not appear on the transcript.

### Engineering Geology and Geotechnics Emphasis

EGGN464	FOUNDATIONS	3.0	
GEGN475	APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS	3.0	
EBGN321	ENGINEERING ECONOMICS	3.0	
EGGN465	UNSATURATED SOIL MECHANICS	3.0	
GEGN399	INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY	1-6	
GEGN499	INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY	1-6	
GEGN307	PETROLOGY	3.0	
GEOL321	MINERALOGY AND MINERAL CHARACTERIZATION	3.0	
CSCI261	PROGRAMMING CONCEPTS	3.0	
MNGN404	TUNNELING	3.0	
MNGN408	UNDERGROUND DESIGN AND CONSTRUCTION	2.0	
MNGN410	EXCAVATION PROJECT MANAGEMENT	2.0	
MNGN445/545	ROCK SLOPE ENGINEERING	3.0	

### Water Engineering Emphasis

EBGN321	ENGINEERING ECONOMICS	3.0	
EGGN/ ESGN353	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I	3	
EGGN/ ESGN354	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II	3	
EGGN465	UNSATURATED SOIL MECHANICS	3.0	
EGGN473	FLUID MECHANICS II	3.0	
EGGN/ ESGN453	WASTEWATER ENGINEERING	3	
EGGN/ ESGN454	WATER SUPPLY ENGINEERING	3	
ESGN401	FUNDAMENTALS OF ECOLOGY	3.0	
ESGN440	ENVIRONMENTAL POLLUTION: SOURCES, CHARACTERISTICS, TRANSPORT AND FATE	3.0	
ESGN/ EGGN455	SOLID AND HAZARDOUS WASTE ENGINEERING	3	
ESGN/ EGGN456	SCIENTIFIC BASIS OF ENVIRONMENTAL REGULATIONS	3	
ESGN/ EGGN457	SITE REMEDIATION ENGINEERING	3	

ESGN490	ENVIRONMENTAL LAW	3.0	
ESGN/ CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY	3	
GEGN499	INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY	1-6	
GEGN475	APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS	3.0	
GEGN481	ADVANCED HYDROGEOLOGY	3.0	
GEGN483	MATHEMATICAL MODELING OF GROUNDWATER SYSTEMS	3.0	
GEOL321	MINERALOGY AND MINERAL CHARACTERIZATION	3.0	
LAIS487	ENVIRONMENTAL POLITICS AND POLICY	3.0	
LAIS488	WATER POLITICS AND POLICY	3.0	
CSCI260	FORTRAN PROGRAMMING	2.0	
CSCI261	PROGRAMMING CONCEPTS	3.0	
MATH332	LINEAR ALGEBRA	3.0	

General CSM Minor/ASI requirements can be found [here](#).

### Geological Engineering Minor and Area of Special Interest

To receive a minor or ASI, a student must take at least 12 (ASI) or 18 (minor) hours of a logical sequence of courses. This may include SYGN101 (4 hours) and up to 4 hours at the 200-level.

### Courses

#### EGGN203. ENGINEERING TERRAIN ANALYSIS. 2.0 Hours.

(I) Analysis of landforms, geologic processes, principles of geomorphology, mapping, air photo and map interpretation, and engineering uses of geologic information. Geomorphology of glacial, volcanic, arid, karst, and complex geological landscapes. Introduction to weathering, soils, hillslopes, and drainage systems. Prerequisite: SYGN101. Must be taken concurrently with GEGN204 and GEGN205 for GE majors. 2 hours lecture, 2 semester hours.

#### EGGN204. GEOLOGIC PRINCIPLES AND PROCESSES. 2.0 Hours.

(I) Introduction to advanced concepts of physical and historical geology from a scientific perspective. Development of the geologic time scale, relative time, and geochronology. Chemical composition and cycling of elements in the Earth.

Plate tectonics and how tectonics influence sea-level history and sedimentation patterns. Evolution and the fossil record. Critical events in Earth history with a focus on North America and Colorado geology. Prerequisite: SYGN101. Must be taken concurrently with GEGN203 and GEGN205 for GE majors. 2 hours lecture, 2 semester hours.

**GEGN205. ADVANCED PHYSICAL GEOLOGY LABORATORY. 1.0 Hour.**

(I) Basic geologic mapping and data gathering skills, with special emphasis on air photos and topographic and geologic maps. Course will include fieldwork in geomorphic regions of Colorado, with analysis of landforms and geologic processes. Applications of geologic information to solve geologic engineering problems. Prerequisite: SYGN101. Must be taken concurrently with GEGN203 and GEGN204 for GE majors. 3 hours laboratory, 1 semester hour.

**GEGN206. EARTH MATERIALS. 3.0 Hours.**

(II) Introduction to Earth Materials, emphasizing the structure, composition, formation, and behavior of minerals. Laboratories emphasize the recognition, description, and engineering evaluation of earth materials. Prerequisite: SYGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN212. PETROGRAPHY FOR GEOLOGICAL ENGINEERS. 2.0 Hours.**

(I) Introduction to concepts of rock forming processes as a basis for rock classification. The course will teach practical skills allowing identification of common rock types in hand specimen and in outcrop. Subsurface and nearsurface alteration and weathering processes will be covered, emphasizing recognition of secondary mineral products and the changes to the physical properties of these minerals in the rock masses. Prerequisites: GEGN206 or equivalent. 1 hour lecture, 3 hours lab; 2 semester hours.

**GEGN299. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**GEGN307. PETROLOGY. 3.0 Hours.**

(II) An introduction to igneous, sedimentary and metamorphic processes, stressing the application of chemical and physical mechanisms to study the origin, occurrence, and association of rock types. Emphasis on the megascopic and microscopic classification, description, and interpretation of rocks. Analysis of the fabric and physical properties. Prerequisite: GEOL321, DCGN209. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN316. FIELD GEOLOGY. 6.0 Hours.**

(S) Six weeks of field work, stressing geology of the Southern Rocky Mountain Province. Measurement of stratigraphic sections. Mapping of igneous, metamorphic, and sedimentary terrain using air photos, topographic maps, plane table, and other methods. Diversified individual problems in petroleum geology, mining geology, engineering geology, structural geology, and stratigraphy. Formal reports submitted on several problems. Frequent evening lectures and discussion sessions. Field trips emphasize regional geology as well as mining, petroleum, and engineering projects. Prerequisite: GEGN203, GEGN204, GEGN205, GEGN206, GEGN212 or GEGN307, GEOL314, GEOL309, and GEGN317. 6 semester hours (Summer Term).

**GEGN317. GEOLOGIC FIELD METHODS. 2.0 Hours.**

(II) Methods and techniques of geologic field observations and interpretations. Lectures in field techniques and local geology. Laboratory and field project in diverse sedimentary, igneous, metamorphic, structural, and surficial terrains using aerial photographs, topographic maps and compass and pace methods. Geologic cross sections maps, and reports. Weekend exercises required. Prerequisite: GEGN203, GEGN204, GEGN205, GEOL309 or GEOL308. Completion or concurrent enrollment in GEGN307 and GEOL314. 1 hour lecture, 8 hours field; 2 semester hours.

**GEGN340. COOPERATIVE EDUCATION. 1-3 Hour.**

(I, II, S) Supervised, full-time, engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 1 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions. Repeatable.

**GEGN342. ENGINEERING GEOMORPHOLOGY. 3.0 Hours.**

(I) Study of interrelationships between internal and external earth processes, geologic materials, time, and resulting landforms on the Earth's surface. Influences of geomorphic processes on design of natural resource exploration programs and siting and design of geotechnical and geohydrologic projects. Laboratory analysis of geomorphic and geologic features utilizing maps, photo interpretation and field observations. Prerequisite: SYGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN351. GEOLOGICAL FLUID MECHANICS. 3.0 Hours.**

(II) Properties of fluids; Bernoulli's energy equation, the momentum and mass equations; laminar and turbulent flow in pipes, channels, machinery, and earth materials; subcritical and supercritical flow in channels; Darcy's Law; the Coriolis effect and geostrophic flow in the oceans and atmosphere; sediment transport. Prerequisite: DCGN241 or permission of instructor. 3 hours lecture; 3 semester hours.

**GEGN398. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**GEGN399. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**GEGN401. MINERAL DEPOSITS. 4.0 Hours.**

(I) Introductory presentation of magmatic, hydrothermal, and sedimentary metallic ore deposits. Chemical, petrologic, structural, and sedimentological processes that contribute to ore formation. Description of classic deposits representing individual deposit types. Review of exploration sequences. Laboratory consists of hand specimen study of host rock-ore mineral suites and mineral deposit evaluation problems. Prerequisite: DCGN209, GEGN307, GEGN316, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

**GEGN403. MINERAL EXPLORATION DESIGN. 3.0 Hours.**

(II) (WI) Exploration project design: commodity selection, target selection, genetic models, alternative exploration approaches and associated costs, exploration models, property acquisition, and preliminary economic evaluation. Lectures and laboratory exercises to simulate the entire exploration sequence from inception and planning through implementation to discovery, with initial ore reserve calculations and preliminary economic evaluation. Prerequisite: GEGN401 and EPIC251. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN404. ORE MICROSCOPY. 3.0 Hours.**

(II) Identification of ore minerals using reflected light microscopy, micro-hardness, and reflectivity techniques. Interpretation of common ore mineral textures, including those produced by magmatic segregation, open space filling, replacement, exsolution, and recrystallization. Guided research on the ore mineralogy and ore textures of classical ore deposits. Prerequisite: GEOL321, GEGN401, or consent of instructor. 6 hours lab; 3 semester hours.

**GEGN432. GEOLOGICAL DATA MANAGEMENT. 3.0 Hours.**

(I) Techniques for managing and analyzing geological data, including statistical analysis procedures and computer programming. Topics addressed include elementary probability, populations and distributions, estimation, hypothesis testing, analysis of data sequences, mapping, sampling and sample representativity, linear regression, and overview of univariate and multivariate statistical methods. Practical experience with principles of software programming and statistical analysis for geological applications via supplied software and data sets from geological case histories. Prerequisites: Senior standing in Geological Engineering or permission of instructor. 1 hour lecture, 6 hours lab; 3 semester hours.

**GEGN438. PETROLEUM GEOLOGY. 4.0 Hours.**

(I) Source rocks, reservoir rocks, types of traps, temperature and pressure conditions of the reservoir, theories of origin and accumulation of petroleum, geology of major petroleum fields and provinces of the world, and methods of exploration for petroleum. Term report required. Laboratory consists of study of well log analysis, stratigraphic correlation, production mapping, hydrodynamics and exploration exercises. Prerequisite: GEOL308 or GEOL309 and GEOL314 or GEOL315; and GEGN316 or GPGN486 or PEGN316. 3 hours lecture, 3 hours lab; 4 semester hours.

**GEGN439. MULTIDISCIPLINARY PETROLEUM DESIGN. 3.0 Hours.**

(II) (WI) This is a multi-disciplinary design course that integrates fundamentals and design concepts in geology, geophysics, and petroleum engineering. Students work in integrated teams consisting of students from each of the disciplines. Multiple open-ended design problems in oil and gas exploration and field development, including the development of a prospect in an exploration play and a detailed engineering field study are assigned. Several detailed written and oral presentations are made throughout the semester. Project economics including risk analysis are an integral part of the course. Prerequisites: GE Majors: GEOL309, GEOL314, GEGN438, and EPIC264; GP Majors: GPGN302, GPGN303, and EPIC268; PE Majors: GEOL308, PEGN316 and PEGN426. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN466. GROUNDWATER ENGINEERING. 3.0 Hours.**

(I) Theory of groundwater occurrence and flow. Relation of groundwater to surface; potential distribution and flow; theory of aquifer tests; water chemistry, water quality, and contaminant transport. Prerequisite: mathematics through calculus and MATH225, GEOL309, GEOL315, and GEGN351, or EGGN351 or consent of instructor. 3 hours lecture, 3 semester hours.

**GEGN467. GROUNDWATER ENGINEERING. 4.0 Hours.**

(I) Theory of groundwater occurrence and flow. Relation of groundwater to surface water; potential distribution and flow; theory of aquifer tests; water chemistry, water quality, and contaminant transport. Laboratory sessions on water budgets, water chemistry, properties of porous media, solutions to hydraulic flow problems, analytical and digital models, and hydrogeologic interpretation. Prerequisite: mathematics through calculus and MATH225, GEOL309, GEOL314 or GEOL315, and GEGN351, or EGGN351 or consent of instructor. For GE Majors only. 3 hours lecture, 3 hours lab; 4 semester hours.

**GEGN468. ENGINEERING GEOLOGY AND GEOTECHNICS. 4.0 Hours.**

(I) Application of geology to evaluation of construction, mining, and environmental projects such as dams, water ways, tunnels, highways, bridges, buildings, mine design, and land-based waste disposal facilities. Design projects including field, laboratory, and computer analysis are an important part of the course. Prerequisite: MNGN321 and concurrent enrollment in EGGN361/EGGN363 or consent of instructor. 3 hours lecture, 3 hours lab, 4 semester hours.

**GEGN469. ENGINEERING GEOLOGY DESIGN. 3.0 Hours.**

(II) (WI) This is a capstone design course that emphasizes realistic engineering geologic/geotechnics projects. Lecture time is used to introduce projects and discussions of methods and procedures for project work. Several major projects will be assigned and one to two field trips will be required. Students work as individual investigators and in teams. Final written design reports and oral presentations are required. Prerequisite: GEGN468 or equivalent and EPIC251. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN470. GROUND-WATER ENGINEERING DESIGN. 3.0 Hours.**

(II) (WI) Application of the principles of hydrogeology and ground-water engineering to water supply, geotechnical, or water quality problems involving the design of well fields, drilling programs, and/or pump tests. Engineering reports, complete with specifications, analysis, and results, will be required. Prerequisite: GEGN467 or equivalent or consent of instructor and EPIC264. 2 hours lecture, 3 hours lab; 3 semester hours.



**GEGN473. GEOLOGICAL ENGINEERING SITE INVESTIGATION. 3.0 Hours.**

(II) Methods of field investigation, testing, and monitoring for geotechnical and hazardous waste sites, including: drilling and sampling methods, sample logging, field testing methods, instrumentation, trench logging, foundation inspection, engineering stratigraphic column and engineering soils map construction. Projects will include technical writing for investigations (reports, memos, proposals, workplans). Class will culminate in practice conducting simulated investigations (using a computer simulator). 3 hours lecture; 3 semester hours.

**GEGN475. APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS. 3.0 Hours.**

(II) An introduction to Geographic Information Systems (GIS) and their applications to all areas of geology and geological engineering. Lecture topics include: principles of GIS, data structures, digital elevation models, data input and verification, data analysis and spatial modeling, data quality and error propagation, methods of GIS projects, as well as video presentations. Prerequisite: SYGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN481. ADVANCED HYDROGEOLOGY. 3.0 Hours.**

(I) Lectures, assigned readings, and discussions concerning the theory, measurement, and estimation of ground water parameters, fractured-rock flow, new or specialized methods of well hydraulics and pump tests, tracer methods, and well construction design. Design of well tests in variety of settings. Prerequisites: GEGN467 or consent of instructor. 3 hours lecture; 3 semester hours.

**GEGN483. MATHEMATICAL MODELING OF GROUNDWATER SYSTEMS. 3.0 Hours.**

(II) Lectures, assigned readings, and direct computer experience concerning the fundamentals and applications of analytical and finite-difference solutions to ground water flow problems as well as an introduction to inverse modeling. Design of computer models to solve ground water problems. Prerequisites: Familiarity with computers, mathematics through differential and integral calculus, and GEGN467. 3 hours lecture; 3 semester hours.

**GEGN497. SUMMER PROGRAMS. 15.0 Hours.****GEGN498. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**GEGN499. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**GEOC407. ATMOSPHERE, WEATHER AND CLIMATE. 3.0 Hours.**

(II) An introduction to the Earth's atmosphere and its role in weather patterns and long term climate. Provides basic understanding of origin and evolution of the atmosphere, Earth's heat budget, global atmospheric circulation and modern climatic zones. Long- and short-term climate change including paleoclimatology, the causes of glacial periods and global warming, and the depletion of the ozone layer. Causes and effects of volcanic eruptions on climate, El Nino, acid rain, severe thunderstorms, tornadoes, hurricanes, and avalanches are also discussed. Microclimates and weather patterns common in Colorado. Prerequisite: Completion of CSM freshman technical core, or equivalent. 3 hours lecture; 3 semester hours. Offered alternate years.

**GEOC408. INTRODUCTION TO OCEANOGRAPHY. 3.0 Hours.**

(II) An introduction to the scientific study of the oceans, including chemistry, physics, geology, biology, geophysics, and mineral resources of the marine environment. Lectures from pertinent disciplines are included. Recommended background: basic college courses in chemistry, geology, mathematics, and physics. 3 hours lecture; 3 semester hours. Offered alternate years.

**GEO102. INTRODUCTION TO GEOLOGICAL ENGINEERING. 1.0 Hour.**

(II) Presentations by faculty members and outside professionals of case studies to provide a comprehensive overview of the fields of Geology and Geological Engineering and the preparation necessary to pursue careers in those fields. A short paper on an academic professional path will be required. Prerequisite: SYGN101 or concurrent enrollment. 1 hour lecture; 1 semester hour.

**GEO198. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**GEO199. INDEPENDENT STUDY IN GEOLOGY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**GEO1308. INTRODUCTORY APPLIED STRUCTURAL GEOLOGY. 3.0 Hours.**

(II) Nature and origin of structural features of Earth's crust emphasizing oil entrapment and control of ore deposition. Structural patterns and associations are discussed in context of stress/strain and plate tectonic theories, using examples of North American deformed belts. Lab and field projects in structural geometry, map air photo and cross section interpretation, and structural analysis. Course required of all PEGN and MNGN students. Prerequisite: SYGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEOL309. STRUCTURAL GEOLOGY AND TECTONICS. 4.0 Hours.**

(I) (WI) Recognition, habitat, and origin of deformational structures related to stresses and strains (rock mechanics and microstructures) and modern tectonics. Structural development of the Appalachian and Cordilleran systems. Comprehensive laboratory projects use descriptive geometry, stereographic projection, structural contours, map and air photo interpretation, structural cross section and structural pattern analysis. Required of Geological and Geophysical Engineers. Prerequisite: SYGN101, GEGN203, GEGN204, GEGN205 and GEGN206 or GPGN200. 3 hours lecture, 3 hours lab; 4 semester hours.

**GEOL310. EARTH MATERIALS AND RESOURCES. 4.0 Hours.**

(I) Introduction to Earth Materials, emphasizing the structure, formation, distribution and engineering behavior of minerals, rocks and ores. Laboratories emphasize the recognition, description and engineering evaluation of natural materials. Lectures present the knowledge of natural materials, processes and resources necessary for mining engineering careers. Prerequisite: SYGN101. 3 hours lecture, 3 hours lab: 4 semester hours.

**GEOL311. STRUCTURAL GEOLOGY FOR MINING ENGINEERS. 2.0 Hours.**

(II) Nature and origin of structural features of Earth's crust emphasizing structural controls of ore deposits and analysis of structures related to rock engineering and mining. Structural features and processes are related to stress/strain theory and rock mechanics principles. Lab and field projects include deformation experiments, geologic map, cross section, and orientation data analysis of structural features including fractures, faults, folds, and rock cleavages. Prerequisite: SYGN101. 2 semester hours combined lecture and lab.

**GEOL314. STRATIGRAPHY. 4.0 Hours.**

(II) Lectures and laboratory and field exercises in concepts of stratigraphy and biostratigraphy, facies associations in various depositional environments, sedimentary rock sequences and geometries in sedimentary basins, and geohistory analysis of sedimentary basins. . Prerequisite: SYGN101, GEGN203, GEGN204, GEGN205. 3 hours lecture, 3 hours lab; 4 semester hours.

**GEOL315. SEDIMENTOLOGY AND STRATIGRAPHY. 3.0 Hours.**

(I) Integrated lecture, laboratory and field exercises on the genesis of sedimentary rocks as related to subsurface porosity and permeability development and distribution for non-geology majors. Emphasis is placed on siliciclastic systems of varying degrees of heterogeneity. Topics include diagenesis, facies analysis, correlation techniques, and sequence and seismic stratigraphy. Application to hydrocarbon exploitation stressed throughout the course. Required of all PEGN students. Prerequisite: SYGN101, PEGN308, or consent of instructor. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEOL321. MINERALOGY AND MINERAL CHARACTERIZATION. 3.0 Hours.**

(I) Principles of mineralogy and mineral characterization. Crystallography of naturally occurring materials. Principles of crystal chemistry. Interrelationships among mineral structure, external shape, chemical composition, and physical properties. Introduction to mineral stability. Laboratories emphasize analytical methods, including X-ray diffraction, scanning electron microscopy, and optical microscopy. Prerequisite: SYGN101, CHGN122, GEGN206. 2 hours lecture, 3 hours lab: 3 semester hours.

**GEOL399. INDEPENDENT STUDY IN GEOLOGY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**GEOL410. PLANETARY GEOLOGY. 2.0 Hours.**

(II) Geology of the terrestrial planets and moons, specifically the Moon and Mars. Emphasis will be placed on the geomorphology, planetary materials, geologic structure, geologic history, and natural resource potential of terrestrial planetary bodies. Lectures present the knowledge of materials, geomorphic processes, and geologic history. Prerequisite: SYGN101. 2 hours lecture: 2 semester hours.

**GEOL443. UNDERGRADUATE FIELD SEMINAR. 1-3 Hour.**

Special advanced classroom and field programs emphasizing detailed study of some aspects of the geology of an area or region. Field studies normally conducted away from the Golden campus. Classroom course content dependent on area of study. Consent of instructor and/or Department Head required. Fees assessed for field and living expenses and transportation. 1 to 3 semester hours; may be repeated for credit with consent of instructor.

**GEOL470. APPLICATIONS OF SATELLITE REMOTE SENSING. 3.0 Hours.**

(II) Students are introduced to geoscience applications of satellite remote sensing. Introductory lectures provide background on satellites, sensors, methodology, and diverse applications. One or more areas of application are presented from a systems perspective. Guest lecturers from academia, industry, and government agencies present case studies focusing on applications, which vary from semester to semester. Students do independent term projects, under the supervision of a faculty member or guest lecturer, that are presented both written and orally at the end of the term. Prerequisites: PHGN200 and MATH225 or consent of instructor. 3 hours lecture; 3 semester hours.

**GEOL497. SPECIAL SUMMER COURSE. 15.0 Hours.****GEOL498. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**GEOL499. INDEPENDENT STUDY IN GEOLOGY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**SYGN101. EARTH & ENV SYSTEMS. 4.0 Hours.**

(I, II, S) Fundamental concepts concerning the nature, composition and evolution of the lithosphere, hydrosphere, atmosphere and biosphere of the earth integrating the basic sciences of chemistry, physics, biology and mathematics. Understanding of anthropological interactions with the natural systems, and related discussions on cycling of energy and mass, global warming, natural hazards, land use, mitigation of environmental problems such as toxic waste disposal, exploitation and conservation of energy, mineral and agricultural resources, proper use of water resources, biodiversity and construction. 3 hours lecture, 3 hours lab; 4 semester hours.

**SYGN198. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

# Geophysics

<http://geophysics.mines.edu>

## Program Description

Founded in 1926, the Department of Geophysics at the Colorado School of Mines is recognized and respected around the world for its programs in applied geophysical research and education. With 20 active faculty and an average class size of 25, students receive individualized attention in a close-knit department. The mission of the geophysical engineering program is to educate undergraduates in the application of geophysics to help meet global needs for energy, water, food, minerals, and the mitigation of natural hazards by exploring and illuminating the dynamic processes of the earth, oceans, atmosphere and solar system.

Geophysicists study the Earth's interior through physical measurements collected at the Earth's surface, in boreholes, from aircraft, or from satellites. Using a combination of mathematics, physics, geology, chemistry, hydrology, and computer science, both geophysicists and geophysical engineers analyze these measurements to infer properties and processes within the Earth's complex interior. Non-invasive imaging beneath the surface of Earth and other planets by geophysicists is analogous to non-invasive imaging of the interior of the human body by medical specialists.

The Earth supplies all materials needed by our society, serves as the repository for used products, and provides a home to all its inhabitants. Geophysics and geophysical engineering have important roles to play in the solution of challenging problems facing the inhabitants of this planet, such as providing fresh water, food, and energy for Earth's growing population, evaluating sites for underground construction and containment of hazardous waste, monitoring non-invasively the aging infrastructures of developed nations, mitigating the threat of geohazards (earthquakes, volcanoes, landslides, avalanches) to populated areas, contributing to homeland security (including detection and removal of unexploded ordnance and land mines), evaluating changes in climate and managing humankind's response to them, and exploring other planets.

Energy companies and mining firms employ geophysicists to explore for hidden resources around the world. Engineering firms hire geophysical engineers to assess the Earth's near-surface properties when sites are chosen for large construction projects and waste-management operations. Environmental organizations use geophysics to conduct groundwater surveys and to track the flow of contaminants. On the global scale, geophysicists employed by universities and government agencies (such as the United States Geological Survey, NASA, and the National Oceanographic and Atmospheric Administration) try to understand such Earth processes as heat flow, gravitational, magnetic, electric, thermal, and stress fields within the Earth's interior. For the past decade, 100% of CSM's geophysics graduates have found employment in their chosen field, with about 70% choosing to pursue graduate studies.

## Bachelor of Science Program in Geophysical Engineering

The Colorado School of Mines offers one of only two undergraduate geophysical engineering programs in the entire United States accredited by:

the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology  
111 Market Place, Suite 1050

Baltimore, MD 21202-4012  
Telephone: (410) 347-7700

Geophysical Engineering undergraduates who may have an interest in professional registration as engineers are encouraged to take the Engineer in Training (EIT)/Fundamentals of Engineering (FE) exam as seniors. The Geophysical Engineering Program has the following objectives and associated outcomes:

**Program Objective 1:** Graduates will be competent geophysical engineers who are capable of independent and innovative problem solving.

**Program Objective 2:** Graduates can design and execute experiments effectively with appropriate treatment of the resulting data.

**Program Objective 3:** Graduates will be competent in scientific computing.

**Program Objective 4:** Graduates will be effective communicators, both orally and in writing.

**Program Objective 5:** Graduates will exhibit good team skills, be able to lead and to follow effectively.

### Student Outcomes (from ABET Criterion 3):

- a. An ability to apply knowledge of mathematics, science, and engineering.
- b. An ability to design and conduct experiments, as well as to analyze and interpret data.
- c. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health, safety, manufacturability, and sustainability.
- d. An ability to function on multidisciplinary teams.
- e. An ability to identify, formulate, and solve engineering problems.
- f. An understanding of professional and ethical responsibility.
- g. An ability to communicate effectively.
- h. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
- i. A recognition of the need for, and an ability to engage in life-long learning.
- j. A knowledge of contemporary issues.
- k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

### Program Specific Outcomes

1. Expanded perspective of applied geophysics as a result of participating in employment or research.
2. An ability to analyze, quantitatively, the errors, limitations, and uncertainties in data.

## Geophysics Field Camp

Each summer, a base of field operations is set up for four weeks, usually in the mountains of Colorado for students who have completed their junior year. Students prepare geological maps and cross sections and then use these as the basis for conducting seismic, gravimetric, magnetic, and electrical surveys. After acquiring these various geophysical data-sets, the students process the data and develop an

interpretation that is consistent with all the information. In addition to the required four-week program, students can also participate in other diverse field experiences. In recent years these have included cruises on seismic ships in the Gulf of Mexico, studies at an archeological site, investigations at an environmental site, a ground-penetrating radar survey on an active volcano in Hawaii, and a well-logging school offered by Baker Atlas.

## Study Abroad

The Department of Geophysics encourages its undergraduates to spend one or two semesters studying abroad. At some universities credits can be earned that substitute for course requirements in the geophysical engineering program at CSM. Information on universities that have established formal exchange programs with CSM can be obtained from either the Department of Geophysics or the Office of International Programs.

## Combined BS/MS Program

Undergraduate students in the Geophysical Engineering program who would like to continue directly into the Master of Science program in Geophysics or Geophysical Engineering are allowed to fulfill part of the requirements of their graduate degree by including up to six hours of specified course credits which also were used in fulfilling the requirements of their undergraduate degree. Students interested to take advantage of this option should meet with their advisor or department head as early as possible in their undergraduate program to determine which elective courses will be acceptable and advantageous for accelerating them through their combined BS/MS studies.

## Summer Jobs in Geophysics

In addition to the summer field camp experience, students are given opportunities every summer throughout their undergraduate career to work as summer interns within the industry, at CSM, or for government agencies. Students have recently worked outdoors with geophysics crews in various parts of the U.S., South America, and offshore in the Gulf of Mexico.

## Undergraduate Research

Students are encouraged to try their hand at research by working on a project with a faculty member either part-time during the semester or full-time during the summer.

## The Cecil H. and Ida Green Graduate and Professional Center

The lecture rooms, laboratories, and computer-aided instruction areas of the Department of Geophysics are located in the Green Center. The department maintains equipment for conducting geophysical field measurements, including magnetometers, gravity meters, ground-penetrating radar, and instruments for recording seismic waves. Students have access to the Department petrophysics laboratory for measuring properties of porous rocks.

## Curriculum

Geophysics is an applied and interdisciplinary science; students therefore must have a strong foundation in physics, mathematics, geology and computer sciences. Superimposed on this foundation is a comprehensive body of courses on the theory and practice of geophysical methods. As geophysics and geophysical engineering involve the study and exploration of the entire earth, our graduates have great opportunities to work anywhere on, and even off, the planet. Therefore, emphasis is placed on electives in the humanities that give students an understanding

of international issues and different cultures. To satisfy all these requirements, every student who obtains a Bachelor's Degree in Geophysical Engineering at CSM must complete the courses in the CSM Core Curriculum plus the following, for a total of 133.5 semester hours. We strongly recommend students download the Department curriculum flowchart on its webpage, [geophysics.mines.edu](http://geophysics.mines.edu).

## Degree Requirements (Geophysical Engineering)

		lec	lab	sem.hrs
<b>Freshman</b>				
CORE	Common Core			33.0
				<b>33.0</b>
<b>Sophomore</b>				
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
GEGN203	ENGINEERING TERRAIN ANALYSIS or 204 <sup>1</sup>	2.0	3.0	2.0
GEGN205	ADVANCED PHYSICAL GEOLOGY LABORATORY			1
GPGN200	INTRODUCTION TO GEOPHYSICS			3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>18.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
GPGN221	THEORY OF FIELDS I: STATIC FIELDS	3.0		3
CSCI261	PROGRAMMING CONCEPTS <sup>2</sup>	3.0		3
EPIC268	EPIC II: FOR GEOPHYSICS	3.0		3
MATH225	DIFFERENTIAL EQUATIONS	3.0		3
SYGN200	HUMAN SYSTEMS	3.0		3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>15.5</b>
<b>Junior</b>				
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
GPGN303	INTRODUCTION TO GRAVITY, MAGNETIC AND ELECTRICAL METHODS	3.0	3.0	4
GPGN322	THEORY OF FIELDS II: TIME-VARYING FIELDS	3.0		3
GPGN315	SUPPORTING GEOPHYSICAL FIELD INVESTIGATIONS		6.0	2
MATH348	ADVANCED ENGINEERING MATHEMATICS or PHGN 311 <sup>3</sup>	3.0		3
ELECT	Electives <sup>4</sup>	6.0		6.0
				<b>18.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
GEOL308	INTRODUCTORY APPLIED STRUCTURAL GEOLOGY <sup>5</sup>	2.0	3.0	3

GPGN320	ELEMENTS OF CONTINUUM MECHANICS AND WAVE PROPAGATION	3.0		3
GPGN302	INTRODUCTION TO ELECTROMAGNETIC AND SEISMIC METHODS	3.0	3.0	4
ELECT	Electives <sup>4</sup>	6.0		6.0
				<b>16.0</b>
<b>Summer</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
GPGN486	GEOPHYSICS FIELD CAMP		4.0	4
				<b>4.0</b>
<b>Senior</b>				
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
GPGN404	DIGITAL SIGNAL ANALYSIS	3.0		3
GP ELECT	GPGN Advanced Elective <sup>6</sup>	3.0	3.0	4.0
GP ELECT	GPGN Advanced Elective <sup>6</sup>	3.0	3.0	4.0
GPGN438	GEOPHYSICS PROJECT DESIGN or 439 (in Spring Semester) <sup>7</sup>			3.0
ELECT	Electives <sup>4</sup>	3.0		3.0
				<b>17.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
GPGN409	INVERSION	3.0		3
GP ELECT	GPGN Advanced Elective <sup>6</sup>	3.0		3.0
GEOL314	STRATIGRAPHY <sup>5</sup>	3.0	3.0	4
ELECT	Electives <sup>4</sup>	3.0		3.0
				<b>13.0</b>

Total Hours: 134.5

- Students must take GEGN205 (1 credit hour) with either GEGN203 or GEGN204 (2 credit hours).
- Students should enroll in the Java section of CSCI261, although C++ is accepted.
- Students should enroll in the special section of MATH348 for Geophysics majors.
- Electives must include at least 9 hours that meet LAIS core requirements. The Department of Geophysics encourages its students to consider organizing their electives to form a Minor or an Area of Special Interest (ASI). A guide suggesting various Minor and ASI programs can be obtained from the Department office.
- Students must take either GEOL308 or GEOL309, and either GEOL314 or GEOL315.
- Students must take 11 credits of advanced GPGN elective courses at the 400- or 500-level.
- Students can take either GPGN438 or GPGN439 to satisfy the senior design requirement. The multidisciplinary design course GPGN439, a 3 credit hour course offered only in Spring semester, is strongly recommended for students interested in petroleum exploration and production. Students interested in non-petroleum applications of geophysics take GPGN438 for 3 credit hours, either by enrolling for all 3 credit hours in one semester (Fall or Spring) or by enrolling for a portion of the 3 hours in Fall and the remainder in Spring.

General CSM Minor/ASI requirements can be found [here](#).

## Minor in Geophysics/Geophysical Engineering

Geophysics plays an important role in many aspects of civil engineering, petroleum engineering, mechanical engineering, and mining engineering, as well as mathematics, physics, geology, chemistry, hydrology, and computer science. Given the natural connections between these various fields and geophysics, it may be of interest for students in other majors to consider choosing to minor in geophysics, or to choose geophysics as an area of specialization. The core of courses taken to satisfy the minor requirement typically includes some of the following geophysics methods courses.

GPGN200	INTRODUCTION TO GEOPHYSICS	4
GPGN302	INTRODUCTION TO ELECTROMAGNETIC AND SEISMIC METHODS	4
GPGN303	INTRODUCTION TO GRAVITY, MAGNETIC AND ELECTRICAL METHODS	4
GPGN404	DIGITAL SIGNAL ANALYSIS	3
GPGN409	INVERSION	3
GPGN432	FORMATION EVALUATION	4
GPGN470	APPLICATIONS OF SATELLITE REMOTE SENSING	3

The remaining hours can be satisfied by a combination of other geophysics courses, as well as courses in geology, mathematics, and computer science depending on the student's major. Students must consult with the Department of Geophysics to have their sequence of courses approved before embarking on a minor program.

## Courses

### GPGN200. INTRODUCTION TO GEOPHYSICS. 3.0 Hours.

(I) (WI) This is a discovery course designed to introduce sophomores to the science of geophysics in the context of the whole-earth system. Students will explore the fundamental observations from which physical and mathematical inferences can be made regarding the Earth's origin, structure, and processes. Examples of such observations are earthquake records; geodetic and gravitational data, such as those recorded by satellites; magnetic measurements; and greenhouse gases in the atmosphere. Learning will take place through the examination of selected topics that may vary from one semester to the next. Examples of such topics are: earthquake seismology, geomagnetism, geodynamics, and climate change. 3 hours, lecture, 3 semester hours.

### GPGN221. THEORY OF FIELDS I: STATIC FIELDS. 3.0 Hours.

(II) Introduction to the theory of gravitational, magnetic, and electrical fields encountered in geophysics. Emphasis on the mathematical and physical foundations of the various phenomena and the similarities and differences in the various field properties. Physical laws governing the behavior of the gravitational, electric, and magnetic fields. Systems of equations of these fields. Boundary value problems. Uniqueness theorem. Influence of a medium on field behavior. Prerequisites: PHGN200, MATH213, and concurrent enrollment in MATH225, or consent of instructor. 3 hours lecture; 3 semester hours.

**GPGN302. INTRODUCTION TO ELECTROMAGNETIC AND SEISMIC METHODS. 4.0 Hours.**

(II) (WI) This is an introductory study of electromagnetic and seismic methods for imaging the Earth's subsurface. The course begins with the connection between geophysical measurements and subsurface materials. It introduces basic concepts, mathematics, and physics of electromagnetic and seismic wave propagation, emphasizing similarities with the equations and physics that underlie all geophysical methods. These methods are employed in geotechnical and environmental engineering and resources exploration for base and precious metals, industrial minerals, geothermal and hydrocarbons. The discussion of each method includes the principles, instrumentation, procedures of data acquisition, analysis, and interpretation. Prerequisites: PHGN200, MATH213, MATH225, and MATH348 or PHGN311, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

**GPGN303. INTRODUCTION TO GRAVITY, MAGNETIC AND ELECTRICAL METHODS. 4.0 Hours.**

(I) This is an introductory study of gravity, magnetic and electrical methods for imaging the earth's subsurface. The course begins with the connection between geophysical measurements and subsurface materials. It introduces basic concepts, mathematics, and physics of gravity, magnetic and electrical fields, emphasizing similarities with the equations and physics that underlie all geophysical methods. These methods are employed in geotechnical and environmental engineering and resources exploration for base and precious metals, industrial minerals, geothermal and hydrocarbons. The discussion of each method includes the principles, instrumentation, and procedures of data acquisition, analysis, and interpretation. Prerequisites: PHGN200, MATH213, MATH225, and concurrent enrollment in MATH348 or PHGN311, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

**GPGN315. SUPPORTING GEOPHYSICAL FIELD INVESTIGATIONS. 2.0 Hours.**

(I) Prior to conducting a geophysical investigation, geophysicists often need input from related specialists such as geologists, surveyors, and land-men. Students are introduced to the issues that each of these specialists must address so that they may understand how each affects the design and outcome of geophysical investigations. Students learn to use and understand the range of applicability of a variety of surveying methods, learn the tools and techniques used in geological field mapping and interpretation, and explore the logistical and permitting issues directly related to geophysical field investigations. 6 hours lab, 2 semester hours.

**GPGN320. ELEMENTS OF CONTINUUM MECHANICS AND WAVE PROPAGATION. 3.0 Hours.**

(II) Introduction to continuum mechanics and elastic wave propagation with an emphasis on principles and results important in seismology and earth sciences in general. Topics include a brief overview of elementary mechanics, stress and strain, Hooke's law, notions of geostatic pressure and isostasy, fluid flow and Navier-stokes equation. Basic discussion of the wave equation for elastic media, plane wave and their reflection/transmission at interfaces. Prerequisites: MATH213, PHGN200. 3 hours lecture; 3 semester hours.

**GPGN322. THEORY OF FIELDS II: TIME-VARYING FIELDS. 3.0 Hours.**

(I) Constant electric field. Coulomb's law. System of equations of the constant electric field. Stationary electric field and the direct current in a conducting medium. Ohm's law. Principle of charge conservation. Sources of electric field in a conducting medium. Electromotive force. Resistance. System of equations of the stationary electric field. The magnetic field, caused by constant currents. Biot-Savart law. The electromagnetic induction. Faraday's law. Prerequisite: GPGN221, or consent of instructor. 3 hours lecture; 3 semester hours.

**GPGN340. COOPERATIVE EDUCATION. 1-3 Hour.**

(I, II, S) Supervised, full-time, engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions.

**GPGN399. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**GPGN404. DIGITAL SIGNAL ANALYSIS. 3.0 Hours.**

(I) The fundamentals of one-dimensional digital signal processing as applied to geophysical investigations are studied. Students explore the mathematical background and practical consequences of the sampling theorem, convolution, deconvolution, the Z and Fourier transforms, windows, and filters. Emphasis is placed on applying the knowledge gained in lecture to exploring practical signal processing issues. This is done through homework and in-class practicum assignments requiring the programming and testing of algorithms discussed in lecture. Prerequisites: MATH213, MATH225, and MATH348 or PHGN311, or consent of instructor. Knowledge of a computer programming language is assumed. 2 hours lecture; 2 hours lab, 3 semester hours.

**GPGN409. INVERSION. 3.0 Hours.**

(II) The fundamentals of inverse problem theory as applied to geophysical investigation are studied. Students explore the fundamental concepts of inversion in a Bayesian framework as well as practical methods for solving discrete inverse problems. Topics studied include Monte Carlo methods, optimization criteria, convex optimization methods, and error and resolution analysis. Weekly homework assignments addressing either theoretical or numerical problems through programming assignments illustrate the concepts discussed in class. Prerequisites: MATH213, MATH225, GPGN404 and MATH348 or PHGN311, or consent of instructor. Knowledge of a programming language is assumed. 3 hours lecture, 3 semester hours.

**GPGN411. ADVANCED GRAVITY AND MAGNETIC METHODS. 4.0 Hours.**

(I) Instrumentation for land surface, borehole, sea floor, sea surface, and airborne operations. Reduction of observed gravity and magnetic values. Theory of potential field effects of geologic distributions. Methods and limitations of interpretation. Prerequisite: GPGN303, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

**GPGN419. WELL LOG ANALYSIS AND FORMATION EVALUATION. 3.0 Hours.**

(I) The basics of core analysis and the principles of all common borehole instruments are reviewed. The course shows (computer) interpretation methods

that combine the measurements of various borehole instruments to determine rock properties such as porosity, permeability, hydrocarbon saturation, water salinity, ore grade, ash content, mechanical strength, and acoustic velocity. The impact of these parameters on reserves estimates of hydrocarbon reservoirs and mineral accumulations are demonstrated. In spring semesters, vertical seismic profiling, single well and cross-well seismic are reviewed. In the fall semester, topics like formation testing, and cased hole logging are covered. Prerequisites: MATH225, MATH348 or PHGN311, GPGN302 and GPGN303. 3 hours lecture, 2 hours lab; 3 semester hours.

**GPGN420. ADVANCED ELECTRICAL AND ELECTROMAGNETIC METHODS. 4.0 Hours.**

(I) In-depth study of the application of electrical and electromagnetic methods to crustal studies, minerals exploration, oil and gas exploration, and groundwater. Laboratory work with scale and mathematical models coupled with field work over areas of known geology. Prerequisite: GPGN302 and GPGN303, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

**GPGN432. FORMATION EVALUATION. 4.0 Hours.**

(II) The basics of core analysis and the principles of all common borehole instruments are reviewed. The course teaches interpretation methods that combine the measurements of various borehole instruments to determine rock properties such as porosity, permeability, hydrocarbon saturation, water salinity, ore grade and ash content. The impact of these parameters on reserve estimates of hydrocarbon reservoirs and mineral accumulations is demonstrated. Geophysical topics such as vertical seismic profiling, single well and cross-well seismic are emphasized in this course, while formation testing, and cased hole logging are covered in GPGN419/PEGN419 presented in the fall. The laboratory provides on-line course material and hands-on computer log evaluation exercises. Prerequisites: MATH225, MATH348 or PHGN311, GPGN302, and GPGN303. 3 hours lecture, 3 hours lab; 4 semester hours. Only one of the two courses GPGN432 and GPGN419/PEGN419 can be taken for credit.

**GPGN438. GEOPHYSICS PROJECT DESIGN. 1-3 Hour.**

(I, II) (WI) Complementary design course for geophysics restricted elective course(s). Application of engineering design principles to geophysics through advanced work, individual in character, leading to an engineering report or senior thesis and oral presentation thereof. Choice of design project is to be arranged between student and individual faculty member who will serve as an advisor, subject to department head approval. Prerequisites: GPGN302 and GPGN303 and completion of or concurrent enrollment in geophysics method courses in the general topic area of the project design. Credit variable, 1 to 3 hours. Repeatable for credit up to a maximum of 3 hours.

**GPGN439. GEOPHYSICS PROJECT DESIGN / MULTIDISCIPLINARY PETROLEUM DESIGN. 3.0 Hours.**

(II) (WI) This is a multi-disciplinary design course that integrates fundamentals and design concepts in geology, geophysics, and petroleum engineering. Students work in integrated teams consisting of students from each of the disciplines. Multiple open-ended design problems in oil and gas exploration and field development, including the development of a prospect in an exploration play and a detailed engineering field study are assigned. Several detailed written and oral presentations are made throughout the semester. Project economics including risk analysis are an integral part of the course. Prerequisites: GE Majors: GEOL309, GEOL314, GEGN438, and EPIC264; GP Majors: GPGN302, GPGN303, and EPIC268; PE Majors: GEOL308, PEGN316 and PEGN426. 2 hours lecture, 3 hours lab; 3 semester hours.

**GPGN461. SEISMIC DATA PROCESSING I. 4.0 Hours.**

(I) This course covers the basic processing steps required to create images of the earth using 2-D and 3-D reflection seismic data. Topics include data organization and domains, signal processing to enhance temporal and spatial resolution, identification and suppression techniques of incoherent and coherent noises, velocity analysis, velocity conversion, near-surface statics, datuming, common-midpoint stacking, imaging principles and methods used for post-stack and prestack time and depth imaging, migration-velocity analysis and post-imaging enhancement techniques. Examples from field data are extensively used. A three-hour lab introduces the student to hands-on seismic data processing using Seismic Unix. The final exam consists of a presentation of the data processing a 2-D seismic line. Prerequisites: GPGN302 and GEOL308. Co-requisites: GPGN404. 3 hour lecture, 3 hour lab; 4 semester hours.

**GPGN470. APPLICATIONS OF SATELLITE REMOTE SENSING. 3.0 Hours.**

(II) An introduction to geoscience applications of satellite remote sensing of the Earth and planets. The lectures provide background on satellites, sensors, methodology, and diverse applications. Topics include visible, near infrared, and thermal infrared passive sensing, active microwave and radio sensing, and geodetic remote sensing. Lectures and labs involve use of data from a variety of instruments, as several applications to problems in the Earth and planetary sciences are presented. Students will complete independent term projects that are presented both written and orally at the end of the term. Prerequisites: PHGN200 and MATH225 or consent of instructor. 2 hours lecture, 2 hours lab; 3 semester hours.

**GPGN475. PLANETARY GEOPHYSICS. 3.0 Hours.**

(I) Of the solid planets and moons in our Solar System, no two bodies are exactly alike. This class will provide an overview of the observed properties of the planets and moons, cover the basic physical processes that govern their evolution, and then investigate how the planets differ and why. The overarching goals are to develop a quantitative understanding of the processes that drive the evolution of planetary surfaces and interiors, and to develop a deeper understanding of the Earth by placing it in the broader context of the Solar System. Prerequisites: PHGN100, MATH225, and GEGN205 or GEOL410. Senior or graduate standing recommended. 3 hours lecture; 3 semester hours.



**GPGN486. GEOPHYSICS FIELD CAMP. 4-6 Hour.**

(S) Introduction to geological and geophysical field methods. The program

includes exercises in geological surveying, stratigraphic section measurements, geological mapping, and interpretation of geological observations. Students conduct geophysical surveys related to the acquisition of seismic, gravity, magnetic, and electrical observations. Students participate in designing the appropriate geophysical surveys, acquiring the observations, reducing the observations, and interpreting these observations in the context of the geological model defined from the geological surveys. Prerequisites: GEOL308 or GEOL309, GPGN302, GPGN303, and GPGN315 or consent of instructor. Repeatable to a maximum of 6 hours.

**GPGN498. SPECIAL TOPICS IN GEOPHYSICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**GPGN499. GEOPHYSICAL INVESTIGATION. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

# Liberal Arts and International Studies

<http://lais.mines.edu/>

## Program Description

As the 21st century unfolds, individuals, communities, and nations face major challenges in energy, natural resources, and the environment. While these challenges demand practical ingenuity from engineers and applied scientists, solutions must also take into account social, political, economic, cultural, ethical, and global contexts. CSM students, as citizens and future professionals, confront a rapidly changing society that demands core technical skills complemented by flexible intelligence, original thought, and cultural sensitivity.

Courses in Liberal Arts and International Studies (LAIS) expand students' professional and personal capacities by providing opportunities to explore the humanities, social sciences, and fine arts. Our curricula encourage the development of critical thinking skills that will help students make more informed choices as national and world citizens - promoting more complex understandings of justice, equality, culture, history, development, and sustainability. Students study ethical reasoning, compare and contrast different economies and cultures, develop arguments from data, and interrogate globalization. LAIS courses also foster creativity by offering opportunities for self-discovery. Students conduct literary analyses, improve communication skills, play music, learn media theory, and write poetry. These experiences foster intellectual agility, personal maturity, and respect for the complexity of our world.

## Required Undergraduate Core Courses

Two of three required undergraduate core courses in the Humanities and Social Sciences are delivered by LAIS, namely, LAIS100, Nature and Human Values; and SYGN200, Human Systems. The third HSS core course, EBGN201, Principles of Economics, is delivered by the Division of Economics & Business.

## Undergraduate Distributed Humanities and Social Sciences Requirement

Beyond the core, LAIS offers the majority of the courses that meet the 9 credit-hour Distributed Humanities and Social Science (DHSS) requirement. The Division of Economic and Business also offers courses that may be used to meet the DHSS requirement.

### Freshman

		lec	lab	sem.hrs
Fall				
LAIS100	NATURE AND HUMAN VALUES			4
				4.0

		lec	lab	sem.hrs
Spring				
EBGN201	PRINCIPLES OF ECONOMICS			3
				3.0

### Sophomore

		lec	lab	sem.hrs
SYGN200	HUMAN SYSTEMS			3
				3.0

### Junior

		lec	lab	sem.hrs
Fall				
LAIS2xx or 3xx	200- or 300-level Restricted H&SS Elective			3.0
				3.0

### Spring

		lec	lab	sem.hrs
LAIS2xx or 3xx	200- or 300-level Restricted H&SS Elective			3.0
				3.0

### Senior

		lec	lab	sem.hrs
Fall				
LAIS 4xx	400-level Restricted H&SS Elective			3.0
				3.0

Total Hours: 19.0

## Undergraduate Minors

At the undergraduate level, LAIS offers minors in Literature, Society, and the Environment; International Political Economy; Science, Technology, Engineering, and Policy; Humanitarian Studies; and an Individualized Undergraduate minor. See below for details. LAIS also is the home for the minor in the McBride Honors Program in Public Affairs.

## Graduate Degree and Programs

At the graduate level, LAIS offers a 36-hour degree, a Master of International Political Economy of Resources (MIPER). It also offers Graduate Certificates and Graduate minors in International Political Economy and Science and Technology Policy. See the Graduate Bulletin for details.

## Hennebach Program in the Humanities

The Hennebach Program in the Humanities, supported by a major endowment from Ralph Hennebach (CSM Class of 1941), sponsors a regular series of Visiting Professors and the general enhancement of the Humanities on campus. Recent visiting professors have included scholars in Classics, Creative Writing, Environmental Studies, Ethics, History, Literature, Philosophy, and Social Theory as well as the interdisciplinary fields of Environmental Policy, and Science, Technology, and Society Studies. The Program is dedicated to enriching the lives of both students and faculty through teaching and research, with visiting scholars offering courses, giving lectures, conducting workshops, and collaborating on projects. In addition, the Hennebach Program is exploring opportunities for meeting the needs of Undergraduate students who would especially benefit from more focused study in the Humanities that would appropriately complement technical degree curricula.

## Writing Center

The LAIS Division operates the LAIS Writing Center, which provides students with instruction tailored to their individual writing problems (including non-native speakers of English). It also provides faculty with support for courses associated with the Writing Across the Curriculum program. Faculty and staff are welcome to make use of the Writing Center's expertise for writing projects and problems. The Writing Center is located on the 3rd floor of Stratton Hall.

## Communication Center

The Communication Center, like the Writing Center, serves students and faculty by offering individual instruction in oral presentations.

## Program Educational Objectives

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria, the coursework in the Division of Liberal Arts and International Studies is designed to help CSM develop in students the ability to engage in life-long learning and recognize the value of doing so by acquiring the broad education necessary to:

1. Understand the impact of engineering solutions in contemporary, global, international, societal, political, and ethical contexts;
2. Understand the role of Humanities and Social Sciences in identifying, formulating, and solving engineering problems;
3. Prepare to live and work in a complex world;
4. Understand the meaning and implications of "stewardship of the Earth"; and
5. Communicate effectively in writing and orally.

## Curriculum

Key to courses offered by the LAIS Division:

Course Code	Course Title
LAIS	Humanities and Social Sciences
LIFL	Foreign Language
LIMU	Music
SYGN	Systems

CSM students in all majors must take 19 credit-hours in Humanities and Social Sciences, ranging from freshman through senior levels of coursework. These courses are housed in the Division of Liberal Arts and International Studies and in the Division of Economics and Business.

## Required Core Courses

1. All Undergraduate students are required to take the following two core courses from the Division of Liberal Arts & International Studies:
  - A. LAIS100 Nature and Human Values 4 semester hours
  - B. SYGN200 Human Systems 3 semester hours
2. All Undergraduate students are also required to take EBGN201 Principles of Economics (3 semester hours) from the Division of Economics and Business.
3. Students in the McBride Honors Program must take LAIS100, Nature and Human Values and EBGN201. Please see the McBride Honors Program web site for further information.

## Distributed Humanities and Social Sciences Requirement

Beyond the core, all Undergraduate students must take an additional three courses (9 semester hours) from the list below. The following restrictions apply to these three courses:

1. **At least one** of the three courses must be taken from the Division of Liberal Arts and International Studies.
2. **At least one of the three courses must be a 400-level course.** In any given semester, either LAIS or EB may offer 400-level Special Topics courses that will be numbered as either LAIS498 or EBGN498. Even though no Special Topics courses appear in the list below, these courses may be used to fulfill the H&SS General Education restricted electives requirement as follows:
  - A. All courses numbered LAIS498 will satisfy the requirement.

B. Some EBGN498 courses as determined on a case-by-case basis will satisfy the requirement. Consult EBGN in any given semester for EBGN498 courses that satisfy the requirement.

3. The other two courses may be midlevel courses, i.e., 200 or 300 level classes. The only exception to this rule are Foreign Language courses (see below).
4. A maximum of two Foreign Language courses (LIFL) may be applied toward satisfying the DHSS requirement. LIFL 498 or 499 may not be used to satisfy the 400-level course requirement.
5. Music (LIMU) courses **may not** be used to meet the DHSS requirement. They may be used for Free Elective credit only. **A maximum of 3 semester hours of concert band chorus, physical education, athletics, or other activity credit combined may be used toward free elective credit in a degree granting program.**
6. Single majors in Economics may not use Economics courses to meet the DHSS requirement. Economics majors must meet this requirement with courses from the Division of Liberal Arts and International Studies, as per the above restrictions and requirements. Students other than single majors in Economics may take up to 6 semester hours (2 courses) of approved EBGN courses, listed below, to satisfy the DHSS requirement.
7. During Pre-Registration each semester, only students with senior standing or instructor's permission are initially allowed to register for 400-level LAIS courses. If 400-level courses do not fill up during Pre-Registration or soon thereafter, the Division Director may elect to open course registration to sophomores and juniors who have met the LAIS100 pre-requisite and SYGN200 co-requisite for 400-level courses.
8. Except for foreign languages, **NO AP or IB credit can be used to meet the General Education Restricted Elective requirements.** AP/IB credits will be applied as free electives.

## List of LAIS and EB Courses Satisfying the DHSS Requirement

EBGN301	INTERMEDIATE MICROECONOMICS	3.0
EBGN302	INTERMEDIATE MACROECONOMICS	3.0
EBGN310	ENVIRONMENTAL AND RESOURCE ECONOMICS	3.0
EBGN320	ECONOMICS AND TECHNOLOGY	3.0
EBGN330	ENERGY ECONOMICS	3.0
EBGN340	ENERGY AND ENVIRONMENTAL POLICY	3.0
EBGN342	ECONOMIC DEVELOPMENT	3.0
EBGN437	REGIONAL ECONOMICS	3.0
EBGN441	INTERNATIONAL ECONOMICS	3.0
EBGN443	PUBLIC ECONOMICS	3.0
EBGN470	ENVIRONMENTAL ECONOMICS	3.0
LAIS220	INTRODUCTION TO PHILOSOPHY	3.0
LAIS221	INTRODUCTION TO RELIGIONS	3.0
LAIS286	INTRODUCTION TO GOVERNMENT AND POLITICS	3.0
LAIS298	SPECIAL TOPICS	1-6
LAIS300	CREATIVE WRITING: FICTION	3.0
LAIS301	CREATIVE WRITING: POETRY I	3.0
LAIS305	AMERICAN LITERATURE: COLONIAL PERIOD TO THE PRESENT	3.0

LAIS307	EXPLORATIONS IN COMPARATIVE LITERATURE	3.0	LAIS446	GLOBALIZATION	3.0
LAIS309	LITERATURE AND SOCIETY	3.0	LAIS448	GLOBAL ENVIRONMENTAL ISSUES	3.0
LAIS310	MODERN EUROPEAN LITERATURE	1-3	LAIS450	POLITICAL RISK ASSESSMENT	3.0
LAIS311	BRITISH LITERATURE: MEDIEVAL TO MODERN	3.0	LAIS452	CORRUPTION AND DEVELOPMENT	3.0
LAIS315	MUSICAL TRADITIONS OF THE WESTERN WORLD	3.0	LAIS453	ETHNIC CONFLICT IN GLOBAL PERSPECTIVE	3.0
LAIS320	ETHICS	3.0	LAIS456	POWER AND POLITICS IN EURASIA	3.0
LAIS322	LOGIC	3.0	LAIS457	INTRODUCTION TO CONFLICT MANAGEMENT	3.0
LAIS323	INTRODUCTION TO SCIENCE COMMUNICATION	3.0	LAIS460	GLOBAL GEOPOLITICS	3.0
LAIS325	CULTURAL ANTHROPOLOGY	3.0	LAIS475	ENGINEERING CULTURES IN THE DEVELOPING WORLD	3.0
LAIS335	INTERNATIONAL POLITICAL ECONOMY OF LATIN AMERICA	3.0	LAIS477	ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT	3.0
LAIS337	INTERNATIONAL POLITICAL ECONOMY OF ASIA	3.0	LAIS485	CONSTITUTIONAL LAW AND POLITICS	3.0
LAIS339	INTERNATIONAL POLITICAL ECONOMY OF THE MIDDLE EAST	3.0	LAIS486	SCIENCE AND TECHNOLOGY POLICY	3.0
LAIS341	INTERNATIONAL POLITICAL ECONOMY OF AFRICA	3.0	LAIS487	ENVIRONMENTAL POLITICS AND POLICY	3.0
LAIS344	INTERNATIONAL RELATIONS	3.0	LAIS488	WATER POLITICS AND POLICY	3.0
LAIS345	INTERNATIONAL POLITICAL ECONOMY	3.0	LAIS489	NUCLEAR POWER AND PUBLIC POLICY	3.0
LAIS365	HISTORY OF WAR	3.0	LAIS490	ENERGY AND SOCIETY	3.0
LAIS370	HISTORY OF SCIENCE	3.0	LAIS498	SPECIAL TOPICS	1-6
LAIS371	HISTORY OF TECHNOLOGY	3.0	LIFL113	SPANISH I	3.0
LAIS375	ENGINEERING CULTURES	3.0	LIFL123	SPANISH II	3.0
LAIS398	SPECIAL TOPICS	1-6	LIFL213	SPANISH III	3.0
LAIS401	CREATIVE WRITING: POETRY II	3.0	LIFL114	ARABIC I	3.0
LAIS402	WRITING PROPOSALS FOR A BETTER WORLD	3.0	LIFL124	ARABIC II	3.0
LAIS404	WOMEN, LITERATURE, AND SOCIETY	3.0	LIFL214	ARABIC III	3.0
LAIS406	THE LITERATURE OF WAR AND REMEMBRANCE	3.0	LIFL115	GERMAN I	3.0
LAIS407	SCIENCE IN LITERATURE	3.0	LIFL125	GERMAN II	3.0
LAIS408	LIFE STORIES	3.0	LIFL215	GERMAN III	3.0
LAIS409	SHAKESPEAREAN DRAMA	3.0	LIFLx98	Special Topics	
LAIS410	CRITICAL PERSPECTIVES ON 20TH CENTURY LITERATURE	3.0			
LAIS411	LITERATURES OF THE AFRICAN WORLD	3.0			
LAIS412	LITERATURE AND THE ENVIRONMENT	3.0			
LAIS415	MASS MEDIA STUDIES	3.0			
LAIS416	FILM STUDIES	3.0			
LAIS418	NARRATING THE NATION	3.0			
LAIS419	MEDIA AND THE ENVIRONMENT	3.0			
LAIS421	ENVIRONMENTAL PHILOSOPHY AND POLICY	3.0			
LAIS423	ADVANCED SCIENCE COMMUNICATION	3.0			
LAIS430	CORPORATE SOCIAL RESPONSIBILITY	3.0			
LAIS431	RELIGION & SECURITY	3.0			
LAIS435	LATIN AMERICAN DEVELOPMENT	3.0			
LAIS437	ASIAN DEVELOPMENT	3.0			
LAIS439	MIDDLE EAST DEVELOPMENT	3.0			
LAIS440	WAR AND PEACE IN THE MIDDLE EAST	3.0			
LAIS441	AFRICAN DEVELOPMENT	3.0			
LAIS442	NATURAL RESOURCES AND WAR IN AFRICA	3.0			

General CSM Minor/ASI requirements can be found [here](#).

## Minor Programs

The Division of Liberal Arts and International Studies offers several minor programs. Students who elect to pursue a minor **usually** will satisfy the DHSS requirements; however, the Music Technology ASI will not satisfy these requirements. Students will need to use their free elective hours to complete a minor.

A minor requires a minimum of 18 credit-hours; an area of special interest (ASI) requires a minimum of 12 credit-hours. No more than half the credits to be applied towards an LAIS minor or ASI may be transfer credits. The LAIS Undergraduate Advisor must approve all transfer credits that will be used for an LAIS minor or ASI.

Prior to the completion of the sophomore year, a student wishing to declare an LAIS Minor must fill out an LAIS Minor form (available in the LAIS Office) and obtain approval signatures from the appropriate minor advisor in LAIS and from the LAIS Director. The student must also fill out a Minor/Area of Special Interest Declaration (available in the Registrar's Office) and obtain approval signatures from the student's CSM advisor, from the Head or Director of the student's major department or division, and from the LAIS Director. Students should consult the listed advisors for the specific requirements of each minor.

The six minors or ASIs available and their advisors are:

## Literature, Society, and the Environment Minor and ASI

Program Advisors: Prof. Tina Gianquitto and Prof. Jay Straker. The Literature, Society, and the Environment Minor and ASI are designed for students with a passion for literature, and an interest in exploring relationships between literary traditions and the broader social and environmental processes that have helped inspire and shape them. The minor's inter-disciplinary emphasis creates unique opportunities for students to forge connections between literary studies and diverse fields of inquiry, spanning the humanities and qualitative and quantitative sciences. In the process of acquiring the minor, students will develop forms of intellectual creativity and sensitivity to social and environmental dynamics increasingly expected of twenty-first century scientists and engineers.

## International Political Economy Minor and ASI

Program Advisor: Prof. James Jesudason. This minor and ASI are ideal for students anticipating careers in the earth resources industries. The International Political Economy Program at CSM was the first such program in the U.S. designed with the engineering and applied science student in mind, and it remains one of the very few international engineering programs with this focus. International Political Economy is the study of the interplay among politics, the economy, and culture. In today's global economy, international engineering and applied science decisions are fundamentally political decisions made by sovereign nations. Therefore, International Political Economy theories and models are often used in evaluating and implementing engineering and science projects. Project evaluations and feasibilities now involve the application of such IPE methods as political risk assessment and mitigation. The IPE minor is also a gateway to the Graduate Program in International Political Economy.

## Science, Technology, Engineering, and Policy Minor and ASI

Program Advisor: Prof. Jason Delborne. The Science, Technology, Engineering, and Policy Minor and ASI focus on science, technology, and engineering in the societal and policy context: how STE influence society, politics, and policy, and how society, politics, and policy influence STE. Courses provide historical, social scientific, ethical, and policy approaches to issues that inevitably confront professional applied scientists, engineers, managers, and administrators in both public and private sectors. Such issues concern, for example, professional ethical responsibilities, intellectual property rights, regulatory regimes, assessments of societal impacts, science policy implementation, and the roles of technical innovation in economic development or international competitiveness. LAIS486 Science and Technology Policy is required. Students work with the STEP Advisor to tailor a sequence of other courses appropriate to their background and interests.

## Humanitarian Studies Minor and ASI

Program Advisor: Prof. Sandy Woodson. The Humanitarian Studies Minor and ASI focus on the intersection of science, technology, and engineering in humanitarian projects. Scientific, technological, and engineering oriented humanitarian projects are intended to help marginalized communities meet basic human needs (such as water, food, and shelter) when these are missing or inadequate. LAIS320 Ethics is required. Other HS courses are offered through LAIS along with selected technical electives by other academic units across campus. Students may also

wish to investigate the 28-credit minor in Humanitarian Engineering offered in cooperation with the Division of Engineering.

## Individualized Undergraduate Minor

Program Advisor: Prof. Sandy Woodson. Students declaring an Undergraduate Individual Minor in LAIS must choose 18 restricted elective hours in LAIS in accordance with a coherent rationale reflecting some explicit focus of study that the student wishes to pursue. A student desiring this minor must design it in consultation with a member of the LAIS faculty who approves the rationale and the choice of courses, eg., pre-law or pre-med courses.

## Area of Special Interest in Music Technology

Program Advisor: Prof. Bob Klimek. The Area of Special Interest in Music Technology is comprised of a sequence of courses that allows students to combine interests and abilities in both the science and theory of music production. Completion of this ASI will train students in the technical aspects of the music recording industry, including sound and video recording, sound effects, and software design.

## The Guy T. McBride, Jr. Honors Program in Public Affairs

Program Director: Prof. Kenneth Osgood. As of Fall 2011, the curriculum of the McBride Honors Program in Public Affairs has been modified for all incoming students. Continuing students will follow their existing curriculum. The new Program offers a 21 semester-hour honors minor consisting of seminars, courses, and off-campus activities that has the primary goal of providing a select number of students the opportunity to cross the boundaries of their technical expertise into the ethical, cultural, socio-political, and environmental dimensions of human life. Students will develop their skills in communication, critical thinking, and leadership through seminar style classes that explore diverse aspects of the human experience. Themes, approaches, and perspectives from the humanities and the social sciences are integrated with science and engineering perspectives to develop in students habits of thought necessary for a comprehensive understanding of societal and cultural issues that enhance critical thinking, social responsibility, and enlightened leadership. Please see the McBride Honors Program entry in the Bulletin or their website for further information.

## Courses

### LAIS100. NATURE AND HUMAN VALUES. 4.0 Hours.

Nature and Human Values will focus on diverse views and critical questions concerning traditional and contemporary issues linking the quality of human life and Nature, and their interdependence. The course will examine various disciplinary and interdisciplinary approaches regarding two major questions: 1) How has Nature affected the quality of human life and the formulation of human values and ethics? (2) How have human actions, values, and ethics affected Nature? These issues will use cases and examples taken from across time and cultures. Themes will include but are not limited to population, natural resources, stewardship of the Earth, and the future of human society. This is a writing-intensive course that will provide instruction and practice in expository writing, using the disciplines and perspectives of the Humanities and Social Sciences. 4 hours lecture/seminar; 4 semester hours.

**LAIS101. SHORT FORM NATURE AND HUMAN VALUES. 2.0 Hours.**

For transfer students with a minimum of six strong composition and related transfer credits, this course will, with LAIS undergraduate advisory permission, complete the LAIS100 Nature and Human and Value requirement. Prerequisite: two transfer college composition courses. 2 hours lecture/discussion; 2 semester hours.

**LAIS198. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LAIS199. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**LAIS220. INTRODUCTION TO PHILOSOPHY. 3.0 Hours.**

A general introduction to philosophy that explores historical and analytic traditions. Historical exploration may compare and contrast ancient and modern, rationalist and empiricist, European and Asian approaches to philosophy. Analytic exploration may consider such basic problems as the distinction between illusion and reality, the one and the many, the structure of knowledge, the existence of God, the nature of mind or self. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 credit hours.

**LAIS221. INTRODUCTION TO RELIGIONS. 3.0 Hours.**

This course has two focuses. We will look at selected religions emphasizing their popular, institutional, and contemplative forms; these will be four or five of the most common religions: Hinduism, Buddhism, Judaism, Christianity, and/or Islam. The second point of the course focuses on how the Humanities and Social Sciences work. We will use methods from various disciplines to study religion-history of religions and religious thought, sociology, anthropology and ethnography, art history, study of myth, philosophy, analysis of religious texts and artifacts (both contemporary and historical), analysis of material culture and the role it plays in religion, and other disciplines and methodologies. We will look at the question of objectivity; is it possible to be objective? We will approach this methodological question using the concept "standpoint." For selected readings, films, and your own writings, we will analyze what the "standpoint" is. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS286. INTRODUCTION TO GOVERNMENT AND POLITICS. 3.0 Hours.**

Introduction to Government and Politics is a beginning-level course intended to familiarize students with the study of politics across societies. The method is comparative in that it approaches the task of studying the world's different political systems by contrasting and comparing them along different dimensions, and by seeking generalizations about them. The class focuses on cases, topics, and methodologies in American and comparative politics. No background in political science is required or expected. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS298. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LAIS299. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**LAIS300. CREATIVE WRITING: FICTION. 3.0 Hours.**

Students will write weekly exercises and read their work for the pleasure and edification of the class. The midterm in this course will be the production of a short story. The final will consist of a completed, revised short story. The best of these works may be printed in a future collection. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS301. CREATIVE WRITING: POETRY I. 3.0 Hours.**

This course focuses on reading and writing poetry. Students will learn many different poetic forms to compliment prosody, craft, and technique. Aesthetic preferences will be developed as the class reads, discusses, and models some of the great American poets. Weekly exercises reflect specific poetic tools, encourage the writing of literary poetry, and stimulate the development of the student's craft. The purpose of the course is to experience the literature and its place in a multicultural society, while students "try on" various styles and contexts in order to develop their own voice. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS305. AMERICAN LITERATURE: COLONIAL PERIOD TO THE PRESENT. 3.0 Hours.**

This course offers an overview of American literature from the colonial period to the present. The texts of the class provide a context for examining the traditions that shape the American nation as a physical, cultural and historical space. As we read, we will focus on the relationships between community, landscape, history, and language in the American imagination. We will concentrate specifically on conceptions of the nation and national identity in relation to race, gender, and class difference. Authors may include: Rowlandson, Brown, Apess, Hawthorne, Douglass, Melville, Whitman, James, Stein, Eliot, Hemingway, Silko, and Auster. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS307. EXPLORATIONS IN COMPARATIVE LITERATURE. 3.0 Hours.**

This course examines major figures and themes in the modern literatures of Africa, the Caribbean, and Latin America. Reading, discussion and writing will focus on fiction and poetry representing Francophone, Arabic, and Hispanophone traditions within these world regions. Engaging these texts will foster understanding of some of the pivotal philosophical, political, and aesthetic debates that have informed cultural practices in diverse colonial territories and nation-states. Thematic and stylistic concerns will include imperialism, nationalism, existentialism, Orientalism, negritude, and social and magical realisms. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS309. LITERATURE AND SOCIETY. 3.0 Hours.**

Before the emergence of sociology as a distinct field of study, literary artists had long been investigating the seemingly infinite complexity of human societies, seeking to comprehend the forces shaping collective identities, socio-cultural transformations, technological innovations, and political conflicts. Designed to enrich recognition and understanding of the complex interplay of artistic creativity and social inquiry over time, this course compares influential literary and social-scientific responses to the Enlightenment, the Industrial Revolution, and other dynamic junctures integral to the forging of "modernity" and the volatile world we inhabit today. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS310. MODERN EUROPEAN LITERATURE. 1-3 Hour.**

This course will introduce students to some of the major figures and generative themes of post-Enlightenment European and British literature. Reading, discussion, and writing will focus on fiction, poetry, drama, and critical essays representing British, French, Germanic, Italian, Czech, and Russian cultural traditions. Engaging these texts will foster understanding of some of the pivotal philosophical, political, and aesthetic movements and debates that have shaped modern European society and culture. Thematic concerns will include the French Enlightenment and its legacies, imperialism within and beyond Europe, comparative totalitarianisms, the rise of psychoanalytic theory and existentialism, and modernist and postmodern perspectives on the arts. Prerequisite: LAIS100, prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS311. BRITISH LITERATURE: MEDIEVAL TO MODERN. 3.0 Hours.**

This course surveys British literature from the Middle Ages to early modernists in light of major developments in scientific thought. It considers topics such as medieval medicine and astrology in *The Canterbury Tales*, reflections of Copernicus' new astronomy in Shakespearean tragedy and John Donne's poetry, the tumultuous career of Newtonian physics across the Enlightenment and Romanticism, the struggle with Darwinian evolution in Victorian literature, and early 20th century reactions to anthropology and psychoanalysis. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS315. MUSICAL TRADITIONS OF THE WESTERN WORLD. 3.0 Hours.**

An introduction to music of the Western world from its beginnings to the present. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS320. ETHICS. 3.0 Hours.**

A general introduction to ethics that explores its analytic and historical traditions. Reference will commonly be made to one or more significant texts by such moral philosophers as Plato, Aristotle, Augustine, Thomas Aquinas, Kant, John Stuart Mill, and others. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS322. LOGIC. 3.0 Hours.**

A general introduction to logic that explores its analytic and historical traditions. Coverage will commonly consider informal and formal fallacies, syllogistic logic, sentential logic, and elementary quantification theory. Reference will commonly be made to the work of such logical theorists as Aristotle, Frege, Russell and Whitehead, Quine, and others. Prerequisite: LAIS100. Co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS323. INTRODUCTION TO SCIENCE COMMUNICATION. 3.0 Hours.**

This course will explore the relationship between science and the public through an examination of science writing and communication on current events. Students will study various forms of science communication, including essays, blogs, news segments, media clips, and radio programs in order to understand the ways in which science is communicated beyond the lab or university and into the public consciousness. Science writing often explores the human condition, reflects on hopes and worries about technology, and informs our collective knowledge about the world. Students will discuss the implications of this kind of communication, analyze breakdowns in communication through case studies, and write for peer and popular audiences, including turning a lab report into a short feature article and writing a science essay. Prerequisites: LAIS100 or LAIS101, and pre- or co-requisite of SYGN2003 hours lecture; 3 semester hours.

**LAIS324. AUDIO/ACOUSTICAL ENGINEERING AND SCIENCE. 3.0 Hours.**

(I) Audio/acoustical engineering and science teaches concepts surrounding the production, transmission, manipulation and reception of audible sound. These factors play a role in many diverse areas such as the design of modern music technology products, recording studios and loudspeakers, civil engineering and building design, and industrial safety. This course will explore and concepts of this field and the physics/mechanics that are involved, as well as aesthetic impacts related to the subject matter. Discussion of human anatomy and psychoacoustic phenomena are also presented. 3 hours lecture; 3 credit hours. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200.

**LAIS325. CULTURAL ANTHROPOLOGY. 3.0 Hours.**

A study of the social behavior and cultural development of humans. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS326. MUSIC THEORY. 3.0 Hours.**

(I) The course begins with the fundamentals of music theory and moves into more complex applications. Music of the common practice period (18th century) and beyond is considered. Aural and visual recognition of harmonic material is emphasized. 3 hours lecture; 3 credit hours. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200.

**LAIS327. MUSIC TECHNOLOGY. 3.0 Hours.**

(I, II) An introduction to the physics of music and sound. The history of music technology from wax tubes to synthesizers. Construction of instruments and studio. 3 hours lecture. 3 semester hours. Prerequisite: LAIS 100; Pre-or Co-requisite: SYGN200.

**LAIS328. BASIC MUSIC COMPOSITION AND ARRANGING. 1.0 Hour.**

(I) This course begins with the fundamentals of music composition and works towards basic vocal and instrumental arrangement skills. Upon completion of this course the student should: 1) Demonstrate basic knowledge of (music) compositional techniques; 2) Demonstrate primary concepts of vocal and instrumental ensemble arrangement; 3) Demonstrate an ability to use notational software and Midi station hardware. 1 semester hour; repeatable for credit. Pre-requisite: LAIS100; Pre-or Co-requisite: SYGN200.

**LAIS330. MUSIC TECHNOLOGY CAPSTONE. 3.0 Hours.**

(II) Project-based course designed to develop practical technological and communication skills for direct application to the music recording. 3 credit hours. Prerequisites: LAIS100, 324, 326, and 327. Prerequisite or corequisite: SYGN200.

**LAIS335. INTERNATIONAL POLITICAL ECONOMY OF LATIN AMERICA. 3.0 Hours.**

A broad survey of the interrelationship between the state and economy in Latin America as seen through an examination of critical contemporary and historical

issues that shape polity, economy, and society. Special emphasis will be given to the dynamics of interstate relationships between the developed North and the developing South. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS337. INTERNATIONAL POLITICAL ECONOMY OF ASIA. 3.0 Hours.**

A broad survey of the interrelationship between the state and economy in East and Southeast Asia as seen through an examination of critical contemporary and historical issues that shape polity, economy, and society. Special emphasis will be given to the dynamics of interstate relationships between the developed North and the developing South. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS339. INTERNATIONAL POLITICAL ECONOMY OF THE MIDDLE EAST. 3.0 Hours.**

A broad survey of the interrelationships between the state and market in the Middle East as seen through an examination of critical contemporary and historical

issues that shape polity, economy, and society. Special emphasis will be given to the dynamics between the developed North and the developing South. Prerequisite:

LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS341. INTERNATIONAL POLITICAL ECONOMY OF AFRICA. 3.0 Hours.**

A broad survey of the interrelationships between the state and market in Africa as seen through an examination of critical contemporary and historical issues that shape polity, economy, and society. Special emphasis will be given to the dynamics between the developed North and the developing South. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS344. INTERNATIONAL RELATIONS. 3.0 Hours.**

This course surveys major topics and theories of international relations. Students will evaluate diverse perspectives and examine a variety of topics including war and peace, economic globalization, human rights and international law, international environmental issues, and the role of the US as the current superpower. Prerequisite: LAIS 100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS345. INTERNATIONAL POLITICAL ECONOMY. 3.0 Hours.**

International Political Economy is a study of contentious and harmonious relationships between the state and the market on the nation-state level, between individual states and their markets on the regional level, and between region-states and region-markets on the global level. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS365. HISTORY OF WAR. 3.0 Hours.**

History of War looks at war primarily as a significant human activity in the history of the Western World since the times of Greece and Rome to the present. The causes, strategies, results, and costs of various wars will be covered, with considerable focus on important military and political leaders as well as on noted historians and theoreticians. The course is primarily a lecture course with possible group and individual presentations as class size permits. Tests will be both objective and essay types. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS370. HISTORY OF SCIENCE. 3.0 Hours.**

An introduction to the social history of science, exploring significant people, theories, and social practices in science, with special attention to the histories of physics, chemistry, earth sciences, ecology, and biology. Prerequisite: LAIS100. Prerequisite or co-requisite SYGN200. 3 hours lecture; 3 semester hours.

**LAIS371. HISTORY OF TECHNOLOGY. 3.0 Hours.**

A survey of the history of technology in the modern period (from roughly 1700 to the present), exploring the role technology has played in the political and social history of countries around the world. Prerequisite: LAIS100. Prerequisite or co-requisite SYGN200. 3 hours lecture; 3 semester hours.

**LAIS375. ENGINEERING CULTURES. 3.0 Hours.**

This course seeks to improve students' abilities to understand and assess engineering problem solving from different cultural, political, and historical perspectives. An exploration, by comparison and contrast, of engineering cultures in such settings as 20th century United States, Japan, former Soviet Union and presentday Russia, Europe, Southeast Asia, and Latin America. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS398. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LAIS399. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**LAIS401. CREATIVE WRITING: POETRY II. 3.0 Hours.**

This course is a continuation of LAIS301 for those interested in developing their poetry writing further. It focuses on reading and writing poetry. Students will learn many different poetic forms to compliment prosody, craft, and technique. Aesthetic preferences will be developed as the class reads, discusses, and models some of the great American poets. Weekly exercises reflect specific poetic tools, encourage the writing of literary poetry, and simulate the development of the student's craft. The purpose of the course is to experience the literature and its place in a multicultural society, while students "try on" various styles and contexts in order to develop their own voice. Prerequisite: LAIS100 and LAIS301. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.



**LAIS402. WRITING PROPOSALS FOR A BETTER WORLD. 3.0 Hours.**

This course develops the student's writing and higher-order thinking skills and helps meet the needs of underserved populations, particularly via funding proposals written for nonprofit organizations. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS404. WOMEN, LITERATURE, AND SOCIETY. 3.0 Hours.**

This reading and writing intensive course examines the role that women writers have played in a range of literary traditions. Far from residing in the margins of key national debates, women writers have actively contributed their voices to demands for social, racial, economic, and artistic equality. We will examine the writing produced by women from a diversity of racial, ethnic, and social backgrounds, as we examine the ways in which women writers respond to the various pressures placed on them as artists and activists. Prerequisite: LAIS100. Prerequisite or co-requisite SYGN200. 3 hours seminar; 3 semester hours.

**LAIS406. THE LITERATURE OF WAR AND REMEMBRANCE. 3.0 Hours.**

In "The Literature of War and Remembrance," students survey poetry, prose, and film ranging from classical to contemporary war literature. The course considers literary depictions of the individual and society in war and its aftermath. Critical reading and writing skills are demonstrated in creative presentations and analytical essays. Students will investigate war literature and commemorative art inspired by recent world conflicts, and place a contemporary work into the thematic structure of the course. Prerequisite: LAIS100. Co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS407. SCIENCE IN LITERATURE. 3.0 Hours.**

Science fiction often serves as a cautionary tale that deals with the darker side of humanity's desires in order to find a better understanding of who we are and what we hope to become. This class examines scientific and social progress as it is imagined by some of the greatest authors of the genre. We will examine the current events that may have influenced the writing and position our lens to the scientific and technological breakthroughs, as well as the social, cultural, and political state of the world at the time of our readings. This course focuses on classic science fiction from the late 1800's to the present which may include: Jules Verne, H.G. Wells, Sir Arthur Conan Doyle, Jack Williamson, Isaac Asimov, Robert Heinlein, Alfred Bester, Philip Jose Farmer, Marion Zimmer Bradley, Ray Bradbury, Philip K. Dick, William Gibson, Arthur C. Clarke, Ursula K. LeGuin and Mary Doria Russell, among others. Prerequisite: LAIS100, Co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS408. LIFE STORIES. 3.0 Hours.**

Using texts by published authors and members of the class, we will explore the pleasures and challenges of creating and interpreting narratives based on "real life." The class will consider critical theories about the relationship between the self and the stories we tell. Prerequisite: LAIS100. Pre-requisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS409. SHAKESPEAREAN DRAMA. 3.0 Hours.**

Shakespeare, the most well known writer in English and perhaps the world, deals with universal themes and the ultimate nature of what it is to be a human being. His plays are staged, filmed, and read around the globe, even after 400 years. This seminar will explore why Shakespeare's plays and characters have such lasting power and meaning to humanity. The seminar will combine class discussion, lecture, and video. Grades will be based on participation, response essays, and a final essay. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS410. CRITICAL PERSPECTIVES ON 20TH CENTURY LITERATURE. 3.0 Hours.**

This course introduces students to texts and cultural productions of the 20th Century literature. We will examine a diverse collection of materials, including novels and short stories, poems, plays, films, painting, and sculpture. Science, technology, violence, history, identity, language all come under the careful scrutiny of the authors we will discuss in this course, which may include Conrad, Fanon, Achebe, Eliot, Kafka, Barnes, Camus, Borges, and Marquez, among others. We will also screen films that comment upon the fragility of individual identity in the face of modern technology. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS411. LITERATURES OF THE AFRICAN WORLD. 3.0 Hours.**

This course examines wide-ranging writers' depictions of collective transformations and conflicts integral to the making and remaking of African and Afro-diasporic communities worldwide. Fiction, poetry, and essays representing diverse linguistic, aesthetic, and philosophical traditions will constitute the bulk of the reading. Alongside their intrinsic expressive values, these texts illuminate religious and popular cultural practices important to social groups throughout much of sub-Saharan Africa, the Caribbean, Latin America, and the United States. Primary socio-historical themes may include the slave trade, plantation cultures, generational consciousness, ethnicity, gender relations, urbanization, and collective violence. Prerequisite: LAIS 100. Prerequisite or co-requisite: SYGN 200. 3 hours seminar; 3 semester hours.

**LAIS412. LITERATURE AND THE ENVIRONMENT. 3.0 Hours.**

This reading and writing intensive course investigates the human connection to the environment in a broad range of literary materials. Discussions focus on the role of place - of landscape as physical, cultural, moral, historical space - and on the relationship between landscape and community, history, and language in the environmental imagination. Readings include texts that celebrate the natural world, those that indict the careless use of land and resources, and those that predict and depict the consequences of that carelessness. Additionally, we investigate philosophical, legal, and policy frameworks that shape approaches to environmental issues. Prerequisite: LAIS100. Prerequisite or co-requisite SYGN200. 3 hours seminar; 3 semester hours.

**LAIS415. MASS MEDIA STUDIES. 3.0 Hours.**

This introduction to mass media studies is designed to help students become more active interpreters of mass media messages, primarily those that emanate from television, radio, the Internet, sound recordings (music), and motion pictures (film, documentary, etc.). Taking a broad rhetorical and sociological perspective, the course examines a range of mass media topics and issues. Students should complete this course with enhanced rhetorical and sociological understandings of how media shapes individuals, societies, and cultures as well as how those groups shape the media. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS416. FILM STUDIES. 3.0 Hours.**

This course introduces students to the basics of film history, form, and criticism. Students will be exposed to a variety of film forms, including documentary, narrative, and formalist films, and will be encouraged to discuss and write about these forms using critical film language. Students will have an opportunity to work on their own film projects and to conduct research into the relationship between films and their historical, cultural, and ideological origins. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS418. NARRATING THE NATION. 3.0 Hours.**

The novel, nationalism, and the modern nation-state share the same eighteenth and nineteenth-century roots. Relationships between the works of novelists, local nationalisms, and state politics have, however, always been volatile. These tensions have assumed particularly dramatic expressive and political forms in Latin America and postcolonial South Asia and Africa. This course examines the inspirations, stakes, and ramifications of celebrated novelists' explorations of the conflicted and fragmentary character their own and/or neighboring nationstates. Beyond their intrinsic literary values, these texts illuminate distinctive religious, ritual, and popular cultural practices that have shaped collective imaginings of the nation, as well as oscillations in nationalist sentiment across specific regions and historical junctures. Studies in relevant visual media -films, paintings, and telenovelas - will further our comparative inquiry into the relationships between artistic narrative and critical perspectives on "the nation." Alongside the focal literary and visual texts, the course will address major historians' and social theorists' accounts of the origins, spread, and varied careers of nationalist thought and practice across our modern world. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS419. MEDIA AND THE ENVIRONMENT. 3.0 Hours.**

This course explores the ways that messages about the environment and environmentalism are communicated in the mass media, fine arts, and popular culture. The course will introduce students to key readings in environmental communication, media studies, and cultural studies in order to understand the many ways in which the images, messages, and politics of environmentalism and the natural world are constructed. Students will analyze their role as science communicators and will participate in the creation of communication projects related to environmental research on campus or beyond. Prerequisite: LAIS100. Prerequisite or co-requisite SYGN200. 3 hours seminar; 3 semester hours.

**LAIS421. ENVIRONMENTAL PHILOSOPHY AND POLICY. 3.0 Hours.**

A critical examination of environmental ethics and the philosophical theories on which they depend. Topics may include preservation/conservation, animal welfare, deep ecology, the land ethic, eco-feminism, environmental justice, sustainability, or non-western approaches. This class may also include analyses of select, contemporary environmental issues. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS423. ADVANCED SCIENCE COMMUNICATION. 3.0 Hours.**

This course will examine historical and contemporary case studies in which science communication (or miscommunication) played key roles in shaping policy outcomes and/or public perceptions. Examples of cases might include the recent controversies over hacked climate science emails, nuclear power plant siting controversies, or discussions of ethics in classic environmental cases, such as the Dioxin pollution case. Students will study, analyze, and write about science communication and policy theories related to scientific uncertainty; the role of the scientist as communicator; and media ethics. Students will also be exposed to a number of strategies for managing their encounters with the media, as well as tools for assessing their communication responsibilities and capacities. 3 hours seminar; 3 semester hours.

**LAIS424. RHETORIC, ENERGY AND PUBLIC POLICY. 3.0 Hours.**

(I) This course will examine the ways in which rhetoric shapes public policy debates on energy. Students will learn how contemporary rhetorical and public policy theory illuminates debates that can affect environmental, economic and/or socio-cultural aspects of energy use, transportation and production. 3 hour seminar; 3 credit hours. Prerequisite: LAIS 100; Pre-or Co-requisite: SYGN200.

**LAIS430. CORPORATE SOCIAL RESPONSIBILITY. 3.0 Hours.**

Businesses are largely responsible for creating the wealth upon which the well-being of society depends. As they create that wealth, their actions impact society, which is composed of a wide variety of stakeholders. In turn, society shapes the rules and expectations by which businesses must navigate their internal and external environments. This interaction between corporations and society (in its broadest sense) is the concern of Corporate Social Responsibility (CSR). This course explores the dimensions of that interaction from a multi-stakeholder perspective using case studies, guest speakers and field work. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS431. RELIGION & SECURITY. 3.0 Hours.**

This course introduces students to the central topics in religion and society. It defines civil society in 21st century contexts and connects this definition with leading debates about the relationship of religion and security. IT creates an understanding of diverse religious traditions from the perspective of how they view security. Prerequisite: LAIS 100. Prerequisite or corequisite: SYGN 200. 3 hours lecture and discussion; 3 semester hours.

**LAIS435. LATIN AMERICAN DEVELOPMENT. 3.0 Hours.**

A seminar designed to explore the political economy of current and recent past development strategies, models, efforts, and issues in Latin America, one of the most dynamic regions of the world today. Development is understood to be a nonlinear, complex set of processes involving political, economic, social, cultural, and environmental factors whose ultimate goal is to improve the quality of life for individuals. The role of both the state and the market in development processes will be examined. Topics to be covered will vary as changing realities dictate but will be drawn from such subjects as inequality of income distribution; the role of education and health care; region-markets; the impact of globalization, institution-building, corporate-community-state interfaces, neoliberalism, privatization, democracy, and public policy formulation as it relates to development goals. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS437. ASIAN DEVELOPMENT. 3.0 Hours.**

This international political economy seminar deals with the historical development of Asia Pacific from agrarian to post-industrial eras; its economic, political, and cultural transformation since World War II, contemporary security issues that both divide and unite the region; and globalization processes that encourage Asia Pacific to forge a single trading bloc. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS439. MIDDLE EAST DEVELOPMENT. 3.0 Hours.**

This international political economy seminar analyzes economic, political and social dynamics that affect the progress and direction of states, markets, and peoples of the region. It examines the development of the Middle East from agrarian to post-industrial societies; economic, political and cultural transformations since World War II; contemporary security issues that both divide and unite the region; and the effects of globalization processes on economies and societies in the Middle East. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS440. WAR AND PEACE IN THE MIDDLE EAST. 3.0 Hours.**

This course introduces students to theories of war and then discusses a select number of historical wars and contemporary ones. It also analyzes efforts at peace-making efforts and why some fail and others succeed. The global consequences of war and peace in the Middle East will be explored in terms of oil supply and of other geostrategic interests that America has in that region. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS441. AFRICAN DEVELOPMENT. 3.0 Hours.**

This course provides a broad overview of the political economy of Africa. Its goal is to give students an understanding of the possibilities of African development and the impediments that currently block its economic growth. Despite substantial natural resources, mineral reserves, and human capital, most African countries remain mired in poverty. The struggles that have arisen on the continent have fostered thinking about the curse of natural resources where countries with oil or diamonds are beset with political instability and warfare. Readings give first an introduction to the continent followed by a focus on the specific issues that confront African development today. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS442. NATURAL RESOURCES AND WAR IN AFRICA. 3.0 Hours.**

Africa possesses abundant natural resources yet suffers civil wars and international conflicts based on access to resource revenues. The course examines the distinctive history of Africa, the impact of the resource curse, mismanagement of government and corruption, and specific cases of unrest and war in Africa. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS446. GLOBALIZATION. 3.0 Hours.**

This international political economy seminar is an historical and contemporary analysis of globalization processes examined through selected issues of world affairs of political, economic, military, and diplomatic significance. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS448. GLOBAL ENVIRONMENTAL ISSUES. 3.0 Hours.**

Critical examination of interactions between development and the environment and the human dimensions of global change; social, political, economic, and cultural responses to the management and preservation of natural resources and ecosystems on a global scale. Exploration of the meaning and implications of "Stewardship of the Earth" and "Sustainable Development." Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS450. POLITICAL RISK ASSESSMENT. 3.0 Hours.**

This course will review the existing methodologies and techniques of risk assessment in both country-specific and global environments. It will also seek to design better ways of assessing and evaluating risk factors for business and public diplomacy in the increasingly globalized context of economy and politics wherein the role of the state is being challenged and redefined. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. Prerequisite: At least one IPE 300- or 400-level course and permission of instructor. 3 hours seminar; 3 semester hours.

**LAIS451. POLITICAL RISK ASSESSMENT RESEARCH SEMINAR. 1.0 Hour.**

This international political economy seminar must be taken concurrently with LAIS450, Political Risk Assessment. Its purpose is to acquaint the student with empirical research methods and sources appropriate to conducting a political risk assessment study, and to hone the students' analytical abilities. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. Concurrent enrollment in LAIS450. 1 hour seminar; 1 semester hour.

**LAIS452. CORRUPTION AND DEVELOPMENT. 3.0 Hours.**

This course addresses the problem of corruption and its impact on development. Readings are multi disciplinary and include policy studies, economics, and political science. Students will acquire an understanding of what constitutes corruption, how it negatively affects development, and what they, as engineers in a variety of professional circumstances, might do in circumstances in which bribe paying or bribe taking might occur. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS453. ETHNIC CONFLICT IN GLOBAL PERSPECTIVE. 3.0 Hours.**

Many scholars used to believe that with modernization, racial, religious, and cultural antagonisms would weaken as individuals developed more rational outlooks and gave primacy to their economic concerns. Yet, with the waning of global ideological conflict of the left-right nature, conflict based on cultural and "civilization" differences have come to the fore in both developing and developed countries. This course will examine ethnic conflict, broadly conceived, in a variety of contexts. Case studies will include the civil war in Yugoslavia, the LA riots, the antagonism between the Chinese and "indigenous" groups in Southeast, the so-called war between the West and Islam, and ethnic relations in the U.S. We will consider ethnic contention in both institutionalized, political processes, such as the politics of affirmative action, as well as in non-institutionalized, extra-legal settings, such as ethnic riots, pogroms, and genocide. We will end by asking what can be done to mitigate ethnic conflict and what might be the future of ethnic group identification. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS456. POWER AND POLITICS IN EURASIA. 3.0 Hours.**

This seminar covers the major internal and international issues confronting the fifteen states that once comprised the Soviet Union. After an overview of the USSR and its collapse in 1991, the course explores subsequent economic and security dilemmas facing the "new" nations of Eurasia. Special attention will be paid to oil, natural gas, and other energy sectors in the region. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS457. INTRODUCTION TO CONFLICT MANAGEMENT. 3.0 Hours.**

This course introduces students to central topics in conflict management. It assesses the causes of contemporary conflicts with an initial focus on weak states, armed insurgencies, and ethnic conflict. It then examines a range of peace-building efforts, and strategies for reconstructing post-conflict states. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS459. INTERNATIONAL FIELD PRACTICUM. 3.0 Hours.**

For students who go abroad for an on-site practicum involving their technical field as practiced in another country and culture; required course for students pursuing a certificate in International Political Economy; all arrangements for this course are to be supervised and approved by the advisor of the International Political Economy minor program. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS460. GLOBAL GEOPOLITICS. 3.0 Hours.**

This seminar examines geopolitical competition between great and aspiring powers for influence, control over land and natural resources, critical geo-strategic trade routes, or even infrastructure. Using empirical evidence from case studies, students develop a deeper understanding of the interconnections between the political, economic, social, cultural and geographic dimensions of foreign policies, as well as issues of war and peace. Prerequisite: LAIS100 or LAIS101. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 credit hours.

**LAIS475. ENGINEERING CULTURES IN THE DEVELOPING WORLD. 3.0 Hours.**

An investigation and assessment of engineering problem-solving in the developing world using historical and cultural cases. Countries to be included range across Africa, Asia, and Latin America. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS477. ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT. 3.0 Hours.**

This course is an introduction to the relationship between engineering and sustainable community development (SCD) from historical, political, ethical, cultural, and practical perspectives. Students will study and analyze different dimensions of sustainability, community, and "helping," and the role that engineering might play in them. Also students will critically explore strengths and limitations of dominant methods in engineering problem solving and design for working in SCD. Through case-studies, students will learn to analyze and evaluate projects in SCD and develop criteria for their evaluation. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN 200. 3 hours seminar; 3 semester hours.

**LAIS478. ENGINEERING AND SOCIAL JUSTICE. 3.0 Hours.**

(II) This course offers students the opportunity to explore the relationships between engineering and social justice. The course begins with students' exploration of their own social locations, alliances and resistances to social justice through critical engagement of interdisciplinary readings that challenge engineering mindsets. Then the course helps students to understand what constitutes social justice in different areas of social life and the role that engineers and engineering might play in these. Finally, the course gives students an understanding of why and how engineering has been aligned and/or divergent from social justice issues and causes. 3 hours lecture and discussion; 3 semester hours. Prerequisite: LAIS100; pre- or co-requisite: SYGN 200.

**LAIS485. CONSTITUTIONAL LAW AND POLITICS. 3.0 Hours.**

This course presents a comprehensive survey of the U.S. Constitution with special attention devoted to the first ten Amendments, also known as the Bill of Rights. Since the Constitution is primarily a legal document, the class will adopt a legal approach to constitutional interpretation. However, as the historical and political context of constitutional interpretation is inseparable from the legal analysis, these areas will also be covered. Significant current developments in constitutional jurisprudence will also be examined. The first part of the course deals with Articles I through III of the Constitution, which specify the division of national governmental power among the executive, legislative, and judicial branches of government. Additionally, the federal nature of the American governmental system, in which governmental authority is apportioned between the national government and the state governments, will be studied. The second part of the course examines the individual rights specifically protected by the amendments to the Constitution, principally the First, Fourth, Fifth, Sixth, Eighth, and Fourteenth Amendments. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS486. SCIENCE AND TECHNOLOGY POLICY. 3.0 Hours.**

An examination of current issues relating to science and technology policy in the United States and, as appropriate, in other countries. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS487. ENVIRONMENTAL POLITICS AND POLICY. 3.0 Hours.**

Seminar on environmental policies and the political and governmental processes that produce them. Group discussion and independent research on specific environmental issues. Primary but not exclusive focus on the U.S. Prerequisite:

LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS488. WATER POLITICS AND POLICY. 3.0 Hours.**

Seminar on water policies and the political and governmental processes that produce them, as an exemplar of natural resource politics and policy in general. Group discussion and independent research on specific politics and policy issues. Primary but not exclusive focus on the U.S.

Pre requisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS489. NUCLEAR POWER AND PUBLIC POLICY. 3.0 Hours.**

A general introduction to research and practice concerning policies and practices relevant to the development and management of nuclear power. Prerequisite: LAIS 100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

**LAIS490. ENERGY AND SOCIETY. 3.0 Hours.**

(I,II) An interdisciplinary capstone seminar that explores a spectrum of approaches

to the understanding, planning, and implementation of energy production and use, including those typical of diverse private and public (national and international) corporations, organizations, states, and agencies.

Aspects of global energy policy that may be considered include the historical, social, cultural, economic, ethical, political, and environmental aspects of energy together with comparative methodologies and assessments of diverse forms of energy development as these affect particular communities and societies. Prerequisite:

LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

**LAIS498. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LAIS499. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**LIFL113. SPANISH I. 3.0 Hours.**

Fundamentals of spoken and written Spanish with an emphasis on vocabulary, idiomatic expressions of daily conversation, and Spanish American culture. 3 semester hours.

**LIFL114. ARABIC I. 3.0 Hours.**

Fundamentals of spoken and written Arabic with an emphasis on vocabulary, idiomatic expressions of daily conversation, and culture of Arabic-speaking societies. 3 semester hours.

**LIFL115. GERMAN I. 3.0 Hours.**

Fundamentals of spoken and written German with an emphasis on vocabulary, idiomatic expressions of daily conversation, and German culture. 3 semester hours.

**LIFL123. SPANISH II. 3.0 Hours.**

Continuation of Spanish I with an emphasis on acquiring conversational skills as well as further study of grammar, vocabulary, and Spanish American culture.

3 semester hours.

**LIFL124. ARABIC II. 3.0 Hours.**

Continuation of Arabic I with an emphasis on acquiring conversational skills as well as further study of grammar, vocabulary, and culture of Arabic speaking societies. 3 semester hours.

**LIFL125. GERMAN II. 3.0 Hours.**

Continuation of German I with an emphasis on acquiring conversational skills as well as further study of grammar, vocabulary, and German culture. 3 semester hours.

**LIFL198. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIFL199. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**LIFL213. SPANISH III. 3.0 Hours.**

Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and Spanish American culture. 3 semester hours.

**LIFL214. ARABIC III. 3.0 Hours.**

Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and culture of Arabic-speaking societies. 3 semester hours.

**LIFL215. GERMAN III. 3.0 Hours.**

Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and German culture. 3 semester hours.

**LIFL299. INDEPENDENT STUDY. 6.0 Hours.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**LIFL398. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIFL399. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**LIFL499. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**LIMU101. BAND. 1.0 Hour.**

Study, rehearsal, and performance of concert, marching and stage repertory. Emphasis on fundamentals of rhythm, intonation, embouchure, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU102. BAND. 1.0 Hour.**

Study, rehearsal, and performance of concert, marching and stage repertory. Emphasis on fundamentals of rhythm, intonation, embouchure, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU111. CHORUS. 1.0 Hour.**

Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU112. CHORUS. 1.0 Hour.**

Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU189. INDIVIDUAL INSTRUMENTAL OR VOCAL MUSIC INSTRUCTION. 1.0 Hour.**

(I, II) The course affords the student an opportunity to study privately with CSM music faculty on a wide range of instruments including guitar, piano, bass guitar, voice, saxophone, flute, drums and world instruments. Students will be required to practice regularly and demonstrate proficiency on their instrument/voice. Topics of this class will include performance etiquette, musicianship, musical styles, stylistic vocabulary, foreign language and basic music theory. 1 credit hour.

**LIMU198. SPECIAL TOPICS. 6.0 Hours.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIMU201. BAND. 1.0 Hour.**

Study, rehearsal, and performance of concert, marching and stage repertory. Emphasis on fundamentals of rhythm, intonation, embouchure, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU202. BAND. 1.0 Hour.**

Study, rehearsal, and performance of concert, marching and stage repertory. Emphasis on fundamentals of rhythm, intonation, embouchure, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU211. CHORUS. 1.0 Hour.**

Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU212. CHORUS. 1.0 Hour.**

Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU299. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**LIMU301. BAND. 1.0 Hour.**

Study, rehearsal, and performance of concert, marching and stage repertory. Emphasis on fundamentals of rhythm, intonation, embouchure, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU302. BAND. 1.0 Hour.**

Study, rehearsal, and performance of concert, marching and stage repertory. Emphasis on fundamentals of rhythm, intonation, embouchure, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU311. CHORUS. 1.0 Hour.**

Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU312. CHORUS. 1.0 Hour.**

Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU340. MUSIC THEORY. 3.0 Hours.**

The course begins with the fundamentals of music theory and moves into their more complex applications. Music of the common practice period is considered. Aural and visual recognition of harmonic materials covered is emphasized. Prerequisite: LAIS315 or consent of instructor. 3 hours lecture; 3 semester hours.

**LIMU341. BASIC MUSIC COMPOSITION AND ARRANGING. 1.0 Hour.**

This course begins with the fundamentals of music composition and works towards basic vocal and instrumental arrangement skills. Upon completion of this course the student should: 1) demonstrate basic knowledge of (music\_ compositional techniques; 2) demonstrate primary concepts of vocal and instrumental ensemble arrangement; 3) demonstrate an ability to use notational software and Midi station hardware. Prerequisite: LIMU340 or permission of instructor. 1 hour lecture; 1 semester hour.

**LIMU350. MUSIC TECHNOLOGY. 3.0 Hours.**

An introduction to the physics of music and sound. The history of music technology from wax tubes to synthesizers. Construction of instruments and studio. 3 hours lecture; 3 semester hours.

**LIMU398. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIMU401. BAND. 1.0 Hour.**

Study, rehearsal, and performance of concert, marching and stage repertory. Emphasis on fundamentals of rhythm, intonation, embouchure, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU402. BAND. 1.0 Hour.**

Study, rehearsal, and performance of concert, marching and stage repertory. Emphasis on fundamentals of rhythm, intonation, embouchure, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU411. CHORUS. 1.0 Hour.**

Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU412. CHORUS. 1.0 Hour.**

Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

**LIMU421. JAZZ ENSEMBLE/PEP BAND - FALL. 1.0 Hour.**

FALL The Jazz Ensemble provides an opportunity for students to participate in a musical ensemble in the jazz big band format. Jazz music is a unique American art form. The big band jazz format is an exciting way for students to experience the power, grace and beauty of this art form and music in general. The class will consist of regular weekly rehearsals and one or more concert performance (s). 1 semester hour. Repeatable for credit. See rules limiting the number of hours applicable to a degree above.

**LIMU422. JAZZ ENSEMBLE/PEP BAND - SPRING. 1.0 Hour.**

SPRING The Jazz Ensemble provides an opportunity for students to participate in a musical ensemble in the jazz big band format. Jazz music is a unique American art form. The big band jazz format is an exciting way for students to experience the power, grace and beauty of this art form and music in general. The class will consist of regular weekly rehearsals and one or more concert performance(s). 1 semester hour. Repeatable for credit. See rules limiting the number of hours applicable to a degree above.

**LIMU423. JAZZ LAB. 1.0 Hour.**

The Jazz Lab provides an opportunity for students to participate in a musical ensemble in the jazz combo format. Jazz music is a unique American art form. The jazz combo format is an exciting way for students to experience the joy and sense of achievement of performing this great American music form. The class will consist of regular weekly rehearsals and one or more concert performance(s). 1 semester hour. Repeatable for credit. See rules limiting the number of hours applicable to a degree above.

**LIMU450. MUSIC TECHNOLOGY CAPSTONE COURSE. 3.0 Hours.**

Project-based course designed to develop practical technological and communication skills for direct application to the music recording. Prerequisite: LIMU340 and LIMU350. 3 hours seminar; 3 semester hours.

**LIMU498. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**SYGN200. HUMAN SYSTEMS. 3.0 Hours.**

(I, II) This course in the CSM core curriculum articulates with LAIS100: Nature and Human Values and with the other systems courses. Human Systems is an interdisciplinary historical examination of key systems created by humans - namely, political, economic, social, and cultural institutions - as they have evolved worldwide from the inception of the modern era (ca. 1500) to the present. This course embodies an elaboration of these human systems as introduced in their environmental context in Nature and Human Values and will reference themes and issues explored therein. It also demonstrates the cross-disciplinary applicability of the "systems" concept. Assignments will give students continued practice in writing. Prerequisite: LAIS100. 3 semester hours.



# Mining Engineering

## Program Description

Mining engineering is a broad profession, which embraces all required activities to facilitate the recovery of valuable minerals and products from the earth's crust for the benefit of humanity. It is one of the oldest engineering professions, which continues to grow in importance. It has often been said: "If it was not grown in the field or fished out of the water, then it must have been mined." An adequate supply of mineral products at competitive prices is the life-blood of the continuing growth of industrialized nations and the foundation of the progress for the developing countries.

The function of the mining engineer is to apply knowledge of pertinent scientific theory, engineering fundamentals, and improved technology to recover natural resources. Mining is a world-wide activity involving the extraction of non-metallics, metal ores of all kinds, and solid fuel and energy sources such as coal and nuclear materials. In addition to mineral extraction, the skills of mining engineers are also needed in a variety of fields where the earth's crust is utilized, such as the underground construction industry. The construction industry, with its requirements of developing earth (rock) systems, tunnels and underground chambers, and the hazardous waste disposal industry are examples of such applications. These are expanding needs, with a shortage of competent people; the mining engineer is well qualified to meet these needs.

The importance of ecological and environmental planning is recognized and given significant attention in all aspects of the mining engineering curriculum.

CSM mining engineering students study the principles and techniques of mineral exploration, and underground and surface mining operations, as well as, mineral processing technologies. Studies include rock mechanics, rock fragmentation, plant and mine design, mine ventilation, surveying, valuation, industrial hygiene, mineral law, mine safety, computing, mineral processing, solution mining and operations research. Throughout the mining engineering curriculum, a constant effort is made to maintain a balance between theoretical principles and their engineering applications. The mining engineering graduate is qualified for positions in engineering, supervision, and research.

The Department recognizes the high expectations that industry has for our graduates as well as the responsibility we have to prepare our students for successful professional careers. To be successful, it is imperative that mining graduates possess an ever-growing set of technical skills, knowledge, and expertise. Beyond the technical aspects of basic sciences, engineering fundamentals, and problem-solving, mining engineering graduates must also acquire a host of other skills which are essential in today's global economy.

These include:

- The ability to work in interdisciplinary teams and communicate effectively to different types of audiences,
- An appreciation of the social, political, and economic realities of different cultures, countries, and indigenous peoples,
- An understanding of the global role mineral extraction and resource development have on local, regional, and international levels,
- The desire for continuing and life-long education, intellectual and professional development, analysis, and creativity,
- The need to maintain high professional and ethical standards,

- The importance of self-confidence, conviction, and compassion, and
- The skills critical to leadership and supervision.

Put simply, our vision for the Mining Engineering Department is to be internationally recognized as the World's premiere center for education and applied research in the diverse fields of mining and underground construction and tunneling. This vision spans across numerous interdisciplinary areas of study. Through collaborations with other CSM departments, academic institutions, government agencies, and industry, we are committed to expanding the international reputation of the Department for excellence in education, research, industry service, and community outreach.

The Mining Engineering Department's program objectives are:

1. Have knowledge of, and skills in, engineering fundamentals to solve complex and open-ended mining and earth systems-related problems.
2. Demonstrate teamwork and leadership skills relevant to their chosen profession.
3. Several years after leaving CSM, our graduates will achieve professional growth.

The program leading to the degree Bachelor of Science in Mining Engineering is accredited by:

The Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology  
111 Market Place, Suite 1050  
Baltimore, MD 21202-4012  
Telephone (410) 347-7700

## Program Educational Objectives (Bachelor of Science in Mining Engineering)

In addition to contributing toward achieving the educational objectives described in the CSM Graduate profile and the ABET Accreditation Criteria, the educational objectives which the Mining Engineering Department aspires to accomplish can be seen in the attributes of our graduates. The graduate is equipped with:

- A sound knowledge in the required basic sciences and engineering fundamentals;
- Knowledge and experience in the application of engineering principles to the exploitation of earth's resources and construction of earth (rock) systems in an engineering systems orientation and setting;
- Ability to solve complex mining and earth systems related problems;
- Capability for team work and decision making;
- Appreciation of the global role of minerals in the changing world;
- Desire for continuing education, intellectual and professional development, analysis and creativity;
- Self confidence and articulation, with high professional and ethical standards.

## Curriculum

The mining engineering curriculum is devised to facilitate the widest employability of CSM graduates. The curriculum is based on scientific engineering and geologic fundamentals and the application of these fundamentals to design and operate mines and to create structures in rock and prepare mine products for the market. To achieve this goal, the curriculum is designed to ensure that the graduates:

- become broad based mining engineers who can tackle the problems of both hard and soft rock mining, regardless of whether the mineral deposit requires surface or underground methods of extraction,
- have an opportunity, through elective courses, to specialize in one or more aspects of the mining engineering profession,
- are interested in an academic or research career, or wish to pursue employment in related fields, have a sufficiently sound scientific and engineering foundation to do so effectively.

This purpose permeates both the lower and upper division courses. Another important aspect of the curriculum is the development of the students' capabilities to be team members, with the added objective of preparing them for leadership in their professional life. The curriculum focuses on the application of engineering principles to solving problems, in short, engineering design in an earth systems approach.

### Degree Requirements (Mining Engineering)

#### Freshman

		lec	lab	sem.hrs
CORE	Common Core			33.0
				<b>33.0</b>

#### Sophomore

Fall		lec	lab	sem.hrs
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3
DCGN241	DIST CORE - STATICS	3.0		3
EPIC251	DESIGN (EPICS) II	2.0	3.0	3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>18.0</b>

Spring		lec	lab	sem.hrs
EGGN351	FLUID MECHANICS	3.0		3
MATH225	DIFFERENTIAL EQUATIONS	3.0		3
MNGN210	INTRODUCTORY MINING	3.0		3
SYGN200	HUMAN SYSTEMS	3.0		3
MNGN317	DYNAMICS FOR MINING ENGINEERS	1.0		1
EGGN320	MECHANICS OF MATERIALS	3.0		3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>16.5</b>

Summer		lec	lab	sem.hrs
MNGN308	MINE SAFETY	1.0		1
MNGN300	SUMMER FIELD SESSION	3.0		3
				<b>4.0</b>

#### Junior

Fall		lec	lab	sem.hrs
EGGN371	THERMODYNAMICS I	3.0		3
MNGN309	MINING ENGINEERING LABORATORY		8.0	2
MNGN312	SURFACE MINE DESIGN	2.0	3.0	3
MNGN321	INTRODUCTION TO ROCK MECHANICS	2.0	3.0	3

GEOL310	EARTH MATERIALS AND RESOURCES	4.0		4
FREE	Free Elective	3.0		3.0
				<b>18.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
LAIS/EBGN	H&SS Restricted Elective I	3.0		3.0
EGGN281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER			3
MNGN314	UNDERGROUND MINE DESIGN	3.0		3
MNGN316	COAL MINING METHODS	2.0	3.0	3
GEOL311	STRUCTURAL GEOLOGY FOR MINING ENGINEERS	2.0		2
FREE	Free Elective	3.0		3.0
				<b>17.0</b>

#### Senior

Fall		lec	lab	sem.hrs
MNGN414	MINE PLANT DESIGN	2.0	3.0	3
MNGN408	UNDERGROUND DESIGN AND CONSTRUCTION	2.0		2
MNGN428	MINING ENGINEERING EVALUATION AND DESIGN REPORT I	3.0		1
MNGN438	GEOSTATISTICS	2.0	3.0	3
MNGN322/	INTRODUCTION TO MINERAL PROCESSING AND LABORATORY	3.0	2.0	3
LAIS/EBGN	H&SS Restricted Elective II	3.0		3.0
FREE	Free Elective	3.0		3.0
				<b>18.0</b>

Spring		lec	lab	sem.hrs
MNGN429	MINING ENGINEERING EVALUATION AND DESIGN REPORT II		3.0	2
MNGN433	MINE SYSTEMS ANALYSIS I	3.0		3
MNGN427	MINE VALUATION	2.0		2
MNGN424	MINE VENTILATION	2.0	3.0	3
MNGN410	EXCAVATION PROJECT MANAGEMENT	2.0		2
LAIS/EBGN	H&SS Restricted Elective III	3.0		3.0
				<b>15.0</b>

Total Hours: 139.5

General CSM Minor/ASI requirements can be found [here](#).

### Minor Programs

The Mining Engineering Department offers two minor programs; the traditional mining engineering program for non-mining majors and in explosive engineering.

### Mining Engineering Minor

The minor program in mining engineering requires students to take:

MNGN210	INTRODUCTORY MINING	3.0
Select two of the following:		<b>6.0</b>

MNGN312	SURFACE MINE DESIGN	
MNGN314	UNDERGROUND MINE DESIGN	
MNGN316	COAL MINING METHODS	
Other courses from mining engineering		9.0
Total Hours		18.0

The list of available courses can be found in the mining engineering department office.

**Area of Specialization** in mining engineering (12 credit hours of course work) is also available and should be discussed with a faculty member in the mining engineering department and approved by the Department Head.

## Explosive Engineering Minor

**Program Advisor: Dr. Vilem Petr**

There are very few academic explosive engineering programs world wide. In fact, Colorado School of Mines is the only educational institution that offers an explosive engineering minor program in the U.S.A. Developed in the CSM tradition of combining academic education with hands-on experience, this minor program will prepare students for new and developing applications involving the use of explosives in the mining and materials engineering, underground construction, oil and gas operations, demolition, homeland security, military, forensic investigations, manufacturing and material synthesis.

With the proper program development of courses and basic knowledge in explosive engineering, students enrolled in this program will discover and gain insight into the exciting industrial applications of explosives, selection of explosives, and the correct and safe use of the energetic materials. With the help of the program advisor, the students will design and select the proper course sequence and complete a hands-on research project under the supervision of a faculty advisor.

## Explosive Engineering Area of Special Interest (ASI)

**Program Advisor: Dr. Vilem Petr**

A total of 12 credit hours are needed to complete the Area of Special Interest in Explosive Engineering Program. This is the preferred route for students that would like to specialize in explosive engineering. The first three (required) courses will provide the students with basic knowledge in explosive engineering. And the fourth course will provide the students with mining application such for surface, underground or underground construction. No more than 3 credit hours used for the ASI may be required for the degree-granting program in which the student is graduating.

### Required of All Students

MNGN429	MINING ENGINEERING EVALUATION AND DESIGN REPORT II	2
MNGN407	ROCK FRAGMENTATION	3.0
MNGN444	EXPLOSIVES ENGINEERING II	3.0
Select at least one of the following:		3.0
MNGN210	INTRODUCTORY MINING	
MNGN308	MINE SAFETY	
MNGN309	MINING ENGINEERING LABORATORY	
MNGN312	SURFACE MINE DESIGN	
MNGN314	UNDERGROUND MINE DESIGN	
MNGN316	COAL MINING METHODS	
MNGN321	INTRODUCTION TO ROCK MECHANICS	

MNGN404	TUNNELING	
MNGN405	ROCK MECHANICS IN MINING	
MNGN406	DESIGN AND SUPPORT OF UNDERGROUND EXCAVATIONS	
MNGN408	UNDERGROUND DESIGN AND CONSTRUCTION	
Total Hours		11.0

## Courses

### DCGN241. DIST CORE - STATICS. 3.0 Hours.

Forces, moments, couples, equilibrium, centroids and second moments of areas, volumes and masses, hydrostatics, friction, virtual work. Applications of vector algebra to structures. Prerequisite: PHGN100 and credit or concurrent enrollment in MATH112. 3 hours lecture; 3 semester hours.

### MNGN198. SPECIAL TOPICS IN MINING ENGINEERING. 1-6 Hour.

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### MNGN199. INDEPENDENT STUDY. 1-6 Hour.

(I, II) (WI) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

### MNGN210. INTRODUCTORY MINING. 3.0 Hours.

(I, II) Survey of mining and mining economics. Topics include mining law, exploration and sampling, reserve estimation, project evaluation, basic unit operations including drilling, blasting, loading and hauling, support, shaft sinking and an introduction to surface and underground mining methods. Prerequisite: None. 3 hours lecture; 3 semester hours.

### MNGN222. INTRODUCTION TO EXPLOSIVES ENGINEERING. 3.0 Hours.

A basic introduction to explosive engineering and applied explosive science for students that recently completed their freshman or sophomore years at CSM. Topics covered will include safety and explosive regulations, chemistry of explosives, explosives physics, and detonation properties. The course features a significant practical learning component with several sessions held at the Explosives Research Laboratory in Idaho Springs. Students completing this course will be well prepared for more advanced work in MNGN 333 and MNGN 444. Prerequisites: PHGN100, MATH111, MATH112, CHGN121, and CHGN122. 3 hours lecture, 3 semester hours.

### MNGN298. SPECIAL TOPICS IN MINING ENGINEERING. 6.0 Hours.

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MNGN300. SUMMER FIELD SESSION. 3.0 Hours.**

(S) Classroom and field instructions in the theory and practice of surface and underground mine surveying. Introduction to the application of various computer-aided mine design software packages incorporated in upper division mining courses. Prerequisite: completion of sophomore year; Duration: first three weeks of summer term; 3 semester hours.

**MNGN308. MINE SAFETY. 1.0 Hour.**

(I) Causes and prevention of accidents. Mine safety regulations. Mine rescue training. Safety management and organization. Prerequisite: MNGN210. 1 hour lecture; 1 semester hour. Taken as the first week of summer session.

**MNGN309. MINING ENGINEERING LABORATORY. 2.0 Hours.**

(I, II) Training in practical mine labor functions including: operation of jackleg drills, jumbo drills, muckers, and LHD machines. Training stresses safe operation of equipment and safe handling of explosives. Introduction to front-line management techniques. Prerequisite: MNGN210, MNGN308 or consent of instructor. 2 semester hours.

**MNGN312. SURFACE MINE DESIGN. 3.0 Hours.**

(I) (WI) Analysis of elements of surface mine operation and design of surface mining system components with emphasis on minimization of adverse environmental impact and maximization of efficient use of mineral resources. Ore estimates, unit operations, equipment selection, final pit determinations, short- and longrange planning, road layouts, dump planning, and cost estimation. Prerequisite: MNGN210 and MNGN300. 2 hours lecture, 3 hours lab; 3 semester hours.

**MNGN314. UNDERGROUND MINE DESIGN. 3.0 Hours.**

(II) Selection, design, and development of most suitable underground mining methods based upon the physical and the geological properties of mineral deposits (metallics and nonmetallics), conservation considerations, and associated environmental impacts. Reserve estimates, development and production planning, engineering drawings for development and extraction, underground haulage systems, and cost estimates. Prerequisite: MNGN210. 2 hours lecture, 3 hours lab; 3 semester hours.

**MNGN316. COAL MINING METHODS. 3.0 Hours.**

(II) (WI) Devoted to surface and underground coal mining methods and design. The surface mining portion emphasizes area-mining methods, including pertinent design-related regulations, and overburden removal systems. Pit layout, sequencing, overburden equipment selection and cost estimation are presented. The underground mining portion emphasizes general mine layout; detailed layout of continuous, conventional, longwall, and shortwall sections. General cost and manning requirements; and production analysis. Federal and state health and safety regulations are included in all aspects of mine layout. Prerequisite: MNGN210. 2 hours lecture, 3 hours lab, 3 semester hours.

**MNGN317. DYNAMICS FOR MINING ENGINEERS. 1.0 Hour.**

(II) For mining engineering majors only. Absolute and relative motions, kinetics, work-energy, impulse-momentum and angular impulse-momentum. Prerequisite: MATH213/MATH223, DCGN241. 1 hour lecture; 1 semester hour.

**MNGN321. INTRODUCTION TO ROCK MECHANICS. 3.0 Hours.**

Physical properties of rock, and fundamentals of rock substance and rock mass response to applied loads. Principles of elastic analysis and stress-strain relationships. Elementary principles of the theoretical and applied design of underground openings and pit slopes. Emphasis on practical applied aspects. Prerequisite: DCGN241 or MNGN317. 2 hours lecture, 3 hours lab; 3 semester hours.

**MNGN322. INTRODUCTION TO MINERAL PROCESSING AND LABORATORY. 3.0 Hours.**

(I) Principles and practice of crushing, grinding, size classification; mineral concentration technologies including magnetic and electrostatic separation, gravity separation, and flotation. Sedimentation, thickening, filtration and product drying as well as tailings disposal technologies are included. The course is open to all CSM students. Prerequisite: PHGN200/PHGN210, MATH213/MATH223. 2 hours lecture; 3 hours lab; 3 semester hours.

**MNGN333. EXPLOSIVES ENGINEERING I. 3.0 Hours.**

This course gives students in engineering and applied sciences the opportunity to examine and develop a fundamental knowledge including terminology and understanding of explosives science and engineering concepts. Student learning will be demonstrated by assignments, quizzes, and exams. Learning assistance will come in the form of multidisciplinary lectures complemented by a few experts' lectures from government, industry and the explosives engineering community. Prerequisites: none. 3 semester hours.

**MNGN340. COOPERATIVE EDUCATION. 3.0 Hours.**

(I, II, S) Supervised, full-time, engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions.

**MNGN350. INTRODUCTION TO GEOTHERMAL ENERGY. 3.0 Hours.**

Geothermal energy resources and their utilization, based on geoscience and engineering perspectives. Geoscience topics include world wide occurrences of resources and their classification, heat and mass transfer, geothermal reservoirs, hydrothermal geochemistry, exploration methods, and resource assessment. Engineering topics include thermodynamics of water, power cycles, electricity generation, drilling and well measurements, reservoir-surface engineering, and direct utilization. Economic and environmental considerations and case studies are also presented. Prerequisites: ENGY200. 3 credit hours.

**MNGN398. SPECIAL TOPICS IN MINING ENGINEERING. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MNGN399. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) (WI) Individual research or special problem projects supervised by a faculty member. When a student and instructor agree on a subject matter, content, method of assessment, and credit hours, it must be approved by the Department Head. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**MNGN404. TUNNELING. 3.0 Hours.**

(I) Modern tunneling techniques. Emphasis on evaluation of ground conditions, estimation of support requirements, methods of tunnel driving and boring, design systems and equipment, and safety. Prerequisite: none. 3 hours lecture; 3 semester hours.

**MNGN405. ROCK MECHANICS IN MINING. 3.0 Hours.**

(I) The course deals with the rock mechanics aspect of design of mine layouts developed in both underground and surface. Underground mining sections include design of coal and hard rock pillars, mine layout design for tabular and massive ore bodies, assessment of caving characteristics or ore bodies, performance and application of backfill, and phenomenon of rock burst and its alleviation. Surface mining portion covers rock mass characterization, failure modes of slopes excavated in rock masses, probabilistic and deterministic approaches to design of slopes, and remedial measures for slope stability problems. Prerequisite: MN321 or equivalent. 3 hours lecture; 3 semester hour.

**MNGN406. DESIGN AND SUPPORT OF UNDERGROUND EXCAVATIONS. 3.0 Hours.**

Design of underground excavations and support. Analysis of stress and rock mass deformations around excavations using analytical and numerical methods. Collections, preparation, and evaluation of in situ and laboratory data for excavation design. Use of rock mass rating systems for site characterization and excavation design. Study of support types and selection of support for underground excavations. Use of numerical models for design of shafts, tunnels and large chambers. Prerequisite: Instructor's consent. 3 hours lecture; 3 semester hours. Offered in odd years.

**MNGN407. ROCK FRAGMENTATION. 3.0 Hours.**

(II) Theory and application of rock drilling, rock boring, explosives, blasting, and mechanical rock breakage. Design of blasting rounds, applications to surface and underground excavation. Prerequisite: DCGN241, concurrent enrollment or Instructor's consent. 3 hours lecture; 3 semester hours.

**MNGN408. UNDERGROUND DESIGN AND CONSTRUCTION. 2.0 Hours.**

(I) Soil and rock engineering applied to underground civil works. Tunneling and the construction of underground openings for power facilities, water conveyance, transportation, and waste disposal; design, excavation and support of underground openings. Emphasis on consulting practice, case studies, geotechnical design, and construction methods. Prerequisite: EGGN361 OR MNGN321, or Instructor's consent. 2 hours of lecture; 2 semester hours.

**MNGN410. EXCAVATION PROJECT MANAGEMENT. 2.0 Hours.**

(II) Successful implementation and management of surface and underground construction projects, preparation of contract documents, project bidding and estimating, contract awarding and notice to proceed, value engineering, risk management, construction management and dispute resolution, evaluation of differing site conditions claims. Prerequisite: MNGN210 or Instructor's consent, 2-hour lecture, 2 semester hours.

**MNGN414. MINE PLANT DESIGN. 3.0 Hours.**

(I) Analysis of mine plant elements with emphasis on design. Materials handling, dewatering, hoisting, belt conveyor and other material handling systems for underground mines. Prerequisite: MNGN312, MNGN314 or Instructor's consent. 2 hours lecture, 3 hours lab; 3 semester hour.

**MNGN418. ADVANCED ROCK MECHANICS. 3.0 Hours.**

Analytical and numerical modeling analysis of stresses and displacements induced around engineering excavations in rock. In-situ stress. Rock failure criteria. Complete load deformation behavior of rocks. Measurement and monitoring techniques in rock mechanics. Principles of design of excavation in rocks. Analytical, numerical modeling and empirical design methods. Probabilistic and deterministic approaches to rock engineering designs. Excavation design examples for shafts, tunnels, large chambers and mine pillars. Seismic loading of structures in rock. Phenomenon of rock burst and its alleviation. Prerequisite: MNGN321 or Instructor's consent. 3 hours lecture; 3 semester hours.

**MNGN421. DESIGN OF UNDERGROUND EXCAVATIONS. 3.0 Hours.**

(II) Design of underground openings in competent and broken ground using rock mechanics principles. Rock bolting design and other ground support methods. Coal, evaporite, metallic and nonmetallic deposits included. Prerequisite: MNGN321, concurrent enrollment or Instructor's consent. 3 hours lecture; 3 semester hours.

**MNGN422. FLOTATION. 2.0 Hours.**

Science and engineering governing the practice of mineral concentration by flotation. Interfacial phenomena, flotation reagents, mineral-reagent interactions, and zeta-potential are covered. Flotation circuit design and evaluation as well as tailings handling are also covered. The course also includes laboratory demonstrations of some fundamental concepts. 3 hours lecture; 3 semester hours.

**MNGN423. FLOTATION LABORATORY. 1.0 Hour.**

(I) Experiments to accompany the lectures in MNGN422. Co-requisite: MNGN421 or Instructor's consent.. 3 hours lab; 1 semester hour.

**MNGN424. MINE VENTILATION. 3.0 Hours.**

(II) Fundamentals of mine ventilation, including control of gas, dust, temperature, and humidity; ventilation network analysis and design of systems. Prerequisite: EGGN351, EGGN371 and MNGN314 or Instructor's consent. 2 hours lecture, 3 hours lab; 3 semester hours.

**MNGN427. MINE VALUATION. 2.0 Hours.**

(II) Course emphasis is on the business aspects of mining. Topics include time valuation of money and interest formulas, cash flow, investment criteria, tax considerations, risk and sensitivity analysis, escalation and inflation and cost of capital. Calculation procedures are illustrated by case studies. Computer programs are used. Prerequisite: Senior in Mining, graduate status or Instructor's consent. 2 hours lecture; 2 semester hours.

**MNGN428. MINING ENGINEERING EVALUATION AND DESIGN REPORT I. 1.0 Hour.**

(I) (WI) Preparation of phase I engineering report based on coordination of all previous work. Includes mineral deposit selection, geologic description, mining method selection, ore reserve determination, and permit process outline. Emphasis is on detailed mine design and cost analysis evaluation in preparation for MNGN429. Prerequisites: MNGN210: MNGN300, MNGN308, MNGN312, MNGN314, MNGN309, MNGN321, MNGN316, GEOL310, GEOL311. Concurrent: MNGN438. 3 hours lab; 1 semester hour.

**MNGN429. MINING ENGINEERING EVALUATION AND DESIGN REPORT II. 2.0 Hours.**

(II) (WI) Preparation of formal engineering report based on all course work in the mining option. Emphasis is on mine design, equipment selection, production scheduling, evaluation and cost analysis. Prerequisite: MNGN428, MNGN210: MNGN300, MNGN308, MNGN312, MNGN314, MNGN309, MNGN321, MNGN316, GEOL310, GEOL311, MNGN438, MNGN414; Concurrent: MNGN322/MNGN323, MNGN427, MNGN433. 3 hours lab; 2 semester hours.

**MNGN431. MINING AND METALLURGICAL ENVIRONMENT. 3.0 Hours.**

This course covers studies of the interface between mining and metallurgical process engineering and environmental engineering areas. Wastes, effluents and their point sources in mining and metallurgical processes such as mineral concentration, value extraction and process metallurgy are studied in context. Fundamentals of unit operations and unit processes with those applicable to waste and effluent control, disposal and materials recycling are covered. Engineering design and engineering cost components are also included for some examples chosen. The ratio of fundamentals applications coverage is about 1:1. Prerequisite: Instructor's consent. 3 hours lecture; 3 semester hours.

**MNGN433. MINE SYSTEMS ANALYSIS I. 3.0 Hours.**

(II) Application of statistics, systems analysis, and operations research techniques to mineral industry problems. Laboratory work using computer techniques to improve efficiency of mining operations. Prerequisite: Senior or graduate status. 2 hours lecture, 3 hours lab; 3 semester hours.

**MNGN434. PROCESS ANALYSIS. 1.0 Hour.**

Projects to accompany the lectures in MNGN422. Prerequisite: MNGN422 or Instructor's consent. 3 hours lab; 1 semester hour.

**MNGN436. UNDERGROUND COAL MINE DESIGN. 3.0 Hours.**

(II) Design of an underground coal mine based on an actual coal reserve. This course shall utilize all previous course material in the actual design of an underground coal mine. Ventilation, materials handling, electrical transmission and distribution, fluid mechanics, equipment selection and application, mine plant design. Information from all basic mining survey courses will be used. Prerequisite: MNGN316, MNGN321, MNGN414, EGGN329 and MNGN381 or MNGN384. Concurrent enrollment with the Instructor's consent permitted. 3 hours lecture, 3 hours lab; 3 semester hours.

**MNGN438. GEOSTATISTICS. 3.0 Hours.**

(I) Introduction to elementary probability theory and its applications in engineering and sciences; discrete and continuous probability distributions; parameter estimation; hypothesis testing; linear regression; spatial correlations and geostatistics with emphasis on applications in earth sciences and engineering. Prerequisites: MATH112. 2 hours of lecture and 3 hours of lab. 3 semester hours.

**MNGN440. EQUIPMENT REPLACEMENT ANALYSIS. 2.0 Hours.**

(I) Introduction to the fundamentals of classical equipment replacement theory. Emphasis on new, practical approaches to equipment replacement decision making. Topics include: operating and maintenance costs, obsolescence factors, technological changes, salvage, capital investments, minimal average annual costs, optimum economic life, infinite and finite planning horizons, replacement cycles, replacement vs. expansion, maximization of returns from equipment replacement expenditures. Prerequisite: MNGN427, senior or graduate status. 2 hours lecture; 2 semester hours.

**MNGN444. EXPLOSIVES ENGINEERING II. 3.0 Hours.**

This course gives students in engineering and applied sciences the opportunity to acquire the fundamental concepts of explosives engineering and science applications as they apply to industry and real life examples. Students will expand upon their MNGN333 knowledge and develop a more advanced knowledge base including an understanding of the subject as it applies to their specific project interests. Assignments, quizzes, concept modeling and their project development and presentation will demonstrate student's progress. Prerequisite: none. 3 hours lecture, 3 semester hours.

**MNGN445. ROCK SLOPE ENGINEERING. 3.0 Hours.**

Introduction to the analysis and design of slopes excavated in rock. Rock mass classification and strength determinations, geological structural parameters, properties of fracture sets, data collection techniques, hydrological factors, methods of analysis of slope stability, wedge intersections, monitoring and maintenance of final pit slopes, classification of slides. Deterministic and probabilistic approaches in slope design. Remedial measures. Laboratory and field exercise in slope design. Collection of data and specimens in the field for deterring physical properties required for slope design. Application of numerical modeling and analytical techniques to slope stability determinations for hard rock and soft rock environments. Prerequisite: Instructor's consent. 3 hours lecture. 3 semester hours.

**MNGN452. SOLUTION MINING AND PROCESSING OF ORES. 3.0 Hours.**

(II) Theory and application of advanced methods of extracting and processing of minerals, underground or in situ, to recover solutions and concentrates of value-materials, by minimization of the traditional surface processing and disposal of tailings to minimize environmental impacts. Prerequisite: Senior or graduate status; Instructor's consent. 3 hours lecture, 3 semester hours. Offered in spring.

**MNGN460. INDUSTRIAL MINERALS PRODUCTION. 3.0 Hours.**

(II) This course describes the engineering principles and practices associated with quarry mining operations related to the cement and aggregates industries. The course will cover resource definition, quarry planning and design, extraction, and processing of material for cement and aggregate production. Permitting issues and reclamation, particle sizing and environmental practices, will be studied in depth. Prerequisite: MNGN312, MNGN322, MNGN323, or Instructor's consent. 3 hours lecture; 3 semester hours. Offered in spring.

**MNGN482. MINE MANAGEMENT. 3.0 Hours.**

(II) Basic principles of successful mine management including supervision skills, administrative policies, industrial and human relations, improvement engineering, risk management, conflict resolution and external affairs. Prerequisite: Senior or graduate status or Instructor's consent. 2 hours lecture and 1 hour case study presentation / discussion per week; 3 semester hours.

**MNGN490. ENERGY AND SOCIETY. 3.0 Hours.**

(II). A transdisciplinary capstone seminar that explores a spectrum of approaches to the understanding, planning, and implementation of energy production and use, including those typical of diverse private and public (national and international) corporations, organizations, states, and agencies. Aspects of global energy policy that may be considered include the historical, social, cultural, economic, ethical, political, and environmental aspects of energy together with comparative methodologies and assessments of diverse forms of energy development. Prerequisites: ENGY330/EBGN330 and one of either ENGY310, ENGY320, or ENGY340; or consent of instructor. 3 hours lecture/seminar; 3 semester hours.

**MNGN498. SPECIAL TOPICS IN MINING ENGINEERING. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MNGN499. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) (WI) Individual research or special problem projects supervised by a faculty member. When a student and instructor agree on a subject matter, content, method of assessment, and credit hours, it must be approved by the Department Head. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

# Petroleum Engineering

## Program Description

The primary objectives of petroleum engineering are the safe and environmentally sound exploration, evaluation, development, and recovery of oil, gas, geothermal, and other fluids in the earth. Skills in this branch of engineering are needed to meet the world's ever-increasing demand for hydrocarbon fuel, thermal energy, and waste and pollution management.

Graduates of our program are in great demand in private industry, as evidenced by the strong job market and high salaries. The petroleum industry offers a wide range of employment opportunities for Petroleum Engineering students during summer breaks and after graduation. Exciting experiences range from field work in drilling and producing oil and gas fields to office jobs in small towns or large cities. Worldwide travel and overseas assignments are available for interested students.

One of our objectives in the Petroleum Engineering Department is to prepare students to succeed in an energy industry that is evolving into an industry working with many energy sources. Besides developing technical competence in petroleum engineering, you will learn how your education can help you contribute to the development of alternative energy sources such as geothermal. In addition to exciting careers in the petroleum industry, many petroleum engineering graduates find rewarding careers in the environmental arena, law, medicine, business, and many other walks of life.

The department offers semester-abroad opportunities through formal exchange programs with the Petroleum Engineering Department at the Montanuniversität Leoben in Austria, Technical University in Delft, Holland, the University of Adelaide, Adelaide, Australia, and the Petroleum Institute in Abu Dhabi, UAE. Qualified undergraduate and graduate students from each school can attend the other for one semester and receive full transfer credit back at the home university.

Graduate courses emphasize the research aspects of the profession, as well as advanced engineering applications. Qualified students may continue their education and earn a Master of Science, Master of Engineering, and Doctor of Philosophy degrees.

To facilitate classroom instruction and the learning experience, the Petroleum Engineering faculty recommend that all petroleum engineering students have notebook computers. Recommended specifications for the computer can be obtained from the CSM Academic Computing & Networking web site.

The Petroleum Engineering Department encourages student involvement with the Society of Petroleum Engineers, the American Association of Drilling Engineers, and the American Rock Mechanics Association. The department provides some financial support for students attending the annual technical conferences for these professional societies.

In the fall of 2012, the new Petroleum Engineering building, Marquez (pronounced Marcus) Hall, was opened. The new home for the Petroleum Engineering Department is a prominent campus landmark, showcasing Mines' longstanding strengths in its core focus areas and our commitment to staying at the forefront of innovation. The new building is designed using aggressive energy saving strategies and will be LEED certified. Marquez Hall is the first building on the Colorado School of Mines Campus that is funded entirely by donations.

New laboratory and computer equipment added to Marquez Hall include:

## Computer Laboratory

This computer laboratory is available for general use and classroom instruction. It is continuously open for student use. Software includes more than \$5.0 million in donated industry software used by oil and gas companies and research labs around the world.

## Drilling Simulator Laboratory

Rare on university campuses, this lab contains a computer controlled, full-scale, drilling rig simulator. It includes drilling controls that can be used to simulate onshore and offshore drilling operations and well control situations. This lab also has three small scale drilling rig simulators, identical to those used in industrial well control training facilities.

## Reservoir Characterization Laboratory

Rock properties are measured that affect economic development of reservoir resources of oil and gas. Measured properties include permeability, porosity, and relative permeability. "Hands on" experiences with simple and sophisticated equipment are provided.

## Drilling Fluids Laboratory

Modern equipment found on drilling rigs world-wide enables students to evaluate and design fluid systems required in drilling operations.

## Fluids Characterization Laboratory

A variety of properties of fluids from oil and gas reservoirs are measured for realistic conditions of elevated temperature and pressure. This laboratory accentuates principles studied in lectures.

## Petroleum Engineering Summer Sessions

Two summer sessions, one after the completion of the sophomore year and one after the junior year, are important parts of the educational experience. The first is a two-week session designed to introduce the student to the petroleum industry. Various career opportunities are highlighted as well as showing petroleum field and office operations and geology. In addition, students are indoctrinated in health, safety, and environmental awareness. Petroleum Engineering, a truly unique and exciting engineering discipline, can be experienced by visiting petroleum operations. Historically, the areas visited have included Europe, Alaska, Canada, the U.S. Gulf Coast, California, the Midcontinent, the Northeast US, and the Rocky Mountain Region.

The second two-week session, after the junior year, is an in-depth study of the Rangely Oil Field and surrounding geology in Western Colorado. The Rangely Oil Field is the largest oil field in the Rocky Mountain region and has undergone primary, secondary, and enhanced recovery processes. Field work in the area provide the setting for understanding the complexity of geologic systems and the environmental and safety issues in the context of reservoir development and management.

## Other Opportunities

It is recommended that all students considering majoring or minoring in Petroleum Engineering sign up for the elective course PEGN102, Introduction to the Petroleum Industry in the spring semester. Also, seniors may take 500-level graduate courses that include topics such as drilling, reservoir, and production engineering; reservoir simulation and characterization, and economics and risk analysis with instructor concurrence (see the CSM Graduate Bulletin ([bulletin.mines.edu/graduate/thegraduateschool](http://bulletin.mines.edu/graduate/thegraduateschool)) for course offerings).



## Program Educational Objectives (Bachelor of Science in Petroleum Engineering)

The Petroleum Engineering Department is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012, telephone (410) 347-7700.

The Mission of the Petroleum Engineering Program continues to evolve over time in response to the needs of the graduates and industry; in concert with the Colorado School of Mines Institutional Mission Statement and the Profile of the Future Graduate; and in recognition of accreditation requirements specified by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology. The Mission of the Petroleum Engineering Program is:

To educate engineers for the worldwide petroleum industry at the undergraduate and graduate levels, perform research that enhances the state-of-the-art in petroleum technology, and to serve the industry and public good through professional societies and public service. This mission is achieved through proactive leadership in providing a solid foundation for both the undergraduate and graduate programs. Students are well prepared for life-long learning, an international and diverse career, further education, and public service. The program emphasizes integrated and multi-disciplinary teamwork in classroom instruction and in research, and actively pursues interdisciplinary activities with many other CSM departments, particularly the Earth Science/Engineering programs.

As part of the that process, the faculty of the department has objectives that they want to see their alumni accomplish within three to five years from graduation. Therefore, the Petroleum Engineering Department's faculty has affirmed the following Program Educational Objectives as follows:

- Our Alumni will practice their professions in an ethical, social, and environmentally responsible manner.
- Our Alumni will serve society and individuals through professional societies, educational institutions, and governmental organizations.
- Our Alumni will have a high-level competency in engineering principles and practices.
- Our Alumni will pursue successful and diverse professional careers, or will continue education in the US or abroad.
- Our Alumni will work on multidisciplinary teams across multitude of cultures.
- Our Alumni will be effective communicators.

To accomplish these objectives, the Petroleum Engineering program has, in addition to the school's Graduate Profile and the overall objectives, certain student objectives particular to the Department. These include:

- A broad education, based on science, technology, engineering, and mathematics basics, effective communication skills, the skills necessary for diverse and international professional career, and the recognition of need and ability to engage in lifelong learning.
- A solid foundation in engineering principles and practices, based upon the Society of Petroleum Engineer's ABET Guidelines, a strong petroleum engineering department faculty with diverse backgrounds, and various technical seminars, field trips, and our field sessions.
- Applying problem solving skills, as demonstrated by designing and conducting experiments, analyzing and interpreting data, developing problem solving skills in engineering practice by working real world problems.

- An understanding of ethical, social, environmental, and professional responsibilities as demonstrated by following established department and Colorado School of Mines honor codes, integrating ethical and environmental issues into real world problems, and developing an awareness of health and safety issues.
- And by developing multidisciplinary team skills, as demonstrated by the ability to integrate information and data from multiple sources and to enhance critical team skills sets.

These program objectives and student outcomes can be found on the Petroleum Engineering Department's website under the Colorado School of Mines website. These are also found publicly posted in the ABET bulletin board outside the department offices.

## Curriculum

All disciplines within petroleum engineering are covered to great depth at the undergraduate and graduate levels, both in the classroom and laboratory instruction, and in research. Specific areas include fundamental fluid and rock behavior, drilling, formation evaluation, well completions and stimulation, well testing, production operations and artificial lift, reservoir engineering, supplemental and enhanced oil recovery, economic evaluation of petroleum projects, environmental and safety issues, and the computer simulation of most of these topics.

The Petroleum Engineering student studies mathematics, computer science, chemistry, physics, general engineering, geology, the humanities, technical communication (including researching subjects, report writing, oral presentations, and listening skills), and environmental topics. A unique aspect is the breadth and depth of the total program structured in a manner that prepares each graduate for a successful career from the standpoints of technical competence, managerial abilities, and multidisciplinary experiences. The needs for continued learning and professionalism are stressed.

The strength of the program comes from the high quality of students and professors. The faculty has expertise in teaching and research in all the major areas of petroleum engineering listed above. Additionally, the faculty members have significant industrial backgrounds that lead to meaningful design experiences for the students. Engineering design is taught throughout the curriculum including a senior design course on applying the learned skills to real world reservoir development and management problems. The senior design course is truly multidisciplinary with students and professors from the Petroleum Engineering, Geophysics, and Geology and Geological Engineering departments.

As of August 2012 the program has new facilities and equipment for laboratory instruction and experimental research. To maintain leadership in future petroleum engineering technology, decision making, and management, computers are incorporated into every part of the program, from undergraduate instruction through graduate student and faculty research.

The department is close to oil and gas field operations, petroleum companies, research laboratories, and geologic out-crops of nearby producing formations. There are many opportunities for short field trips and for summer and part-time employment in the oil and gas industry.

## Degree Requirements (Petroleum Engineering)

### Freshman

	lec	lab	sem.hrs
Common Core			33.0
			<b>33.0</b>

**Sophomore**

		lec	lab	sem.hrs
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3
EPIC251	DESIGN (EPICS) II or 268	3.0		3
DCGN241	DIST CORE - STATICS	3.0		3
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>18.0</b>

		lec	lab	sem.hrs
DCGN209	DIST CORE THERMO	3.0		3
EGGN320	MECHANICS OF MATERIALS	3.0		3
PEGN251	FLUID MECHANICS	3.0		3
PEGN308	RESERVOIR ROCK PROPERTIES	2.0	3.0	3
MATH225	DIFFERENTIAL EQUATIONS	3.0		3
SYGN200	HUMAN SYSTEMS	3.0		3
				<b>18.0</b>

		lec	lab	sem.hrs
PEGN315	SUMMER FIELD SESSION I	2.0		2
				<b>2.0</b>

**Junior**

		lec	lab	sem.hrs
GEOL315	SEDIMENTOLOGY AND STRATIGRAPHY	2.0	3.0	3
PEGN305	COMPUTATIONAL METHODS IN PETROLEUM ENGINEERING	2.0		2
PEGN310	RESERVOIR FLUID PROPERTIES	2.0		2
PEGN311	DRILLING ENGINEERING	3.0	3.0	4
PEGN419	WELL LOG ANALYSIS AND FORMATION EVALUATION	2.0	3.0	3
LAIS/EBGN	H&SS Restricted Elective I	3.0		3.0
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>17.5</b>

		lec	lab	sem.hrs
GEOL308	INTRODUCTORY APPLIED STRUCTURAL GEOLOGY	2.0	3.0	3
PEGN438	GEOSTATISTICS	2.0	3.0	3
PEGN361	COMPLETION ENGINEERING	3.0		3
PEGN411	MECHANICS OF PETROLEUM PRODUCTION	3.0		3
LAIS/EBGN	H&SS Restricted Elective II	3.0		3.0
FREE	Free Elective	3.0		3.0
				<b>18.0</b>

		lec	lab	sem.hrs
PEGN316	SUMMER FIELD SESSION II	2.0		2
				<b>2.0</b>

**Senior**

		lec	lab	sem.hrs
PEGN481	PETROLEUM SEMINAR	2.0		2
PEGN423	PETROLEUM RESERVOIR ENGINEERING I	3.0		3
PEGN413	GAS MEASUREMENT AND FORMATION EVALUATION LAB		6.0	2
PEGN414	WELL TEST ANALYSIS AND DESIGN	3.0		3
PEGN422	ECONOMICS AND EVALUATION OF OIL AND GAS PROJECTS	3.0		3
FREE	Free Elective	3.0		3.0
				<b>16.0</b>

		lec	lab	sem.hrs
PEGN424	PETROLEUM RESERVOIR ENGINEERING II	3.0		3
PEGN426	WELL COMPLETIONS AND STIMULATION	3.0		3
PEGN439	MULTIDISCIPLINARY PETROLEUM DESIGN	2.0	3.0	3
LAIS/EBGN	H&SS Restricted Elective III	3.0		3.0
FREE	Free Elective	3.0		3.0
				<b>15.0</b>

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 Total Hours: 139.5

## Five Year Combined Baccalaureate and Masters Degree

The Petroleum Engineering Department offers the opportunity to begin work on a Master of Engineering or Master of Science Degree while completing the requirements for the Bachelor's Degree. These degrees are of special interest to those planning on studying abroad or wanting to get a head start on graduate education. These combined programs are individualized and a plan of study should be discussed with the student's academic advisor any time after the Sophomore year.

General CSM Minor/ASI requirements can be found [here](#).

## Courses

### PEGN102. INTRODUCTION TO PETROLEUM INDUSTRY. 3.0 Hours.

(II) A survey of the elements comprising the petroleum industry- exploration, development, processing, transportation, distribution, engineering ethics and professionalism. This elective course is recommended for all PE majors, minors, and other interested students. 3 hours lecture; 3 semester hours.

### PEGN198. SPECIAL TOPICS IN PETROLEUM ENGINEERING. 1-6 Hour.

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**PEGN199. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**PEGN251. FLUID MECHANICS. 3.0 Hours.**

(II) Fundamental course in engineering fluid flow introducing flow in pipelines, surface facilities and oil and gas wells. Theory and application of incompressible and compressible flow, fluid statics, dimensional analysis, laminar and turbulent flow, Newtonian and non-Newtonian fluids, and two-phase flow. Lecture format with demonstrations and practical problem solving, coordinated with PEGN308. Students cannot receive credit for both PEGN251 Fluid Mechanics and EGGN351 Fluid Mechanics. Prerequisite: MATH213. Co-requisites: PEGN308, DCGN209, DCGN241. 3 hours lecture; 3 semester hours.

**PEGN298. SPECIAL TOPICS IN PETROLEUM ENGINEERING. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**PEGN299. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**PEGN305. COMPUTATIONAL METHODS IN PETROLEUM ENGINEERING. 2.0 Hours.**

(I) This course is an introduction to computers and computer programming applied to petroleum engineering. Emphasis will be on learning Visual Basic programming techniques to solve engineering problems. A toolbox of fluid property and numerical techniques will be developed. Prerequisite: MATH213. Co-Requisite: PEGN310. 2 hours lecture; 2 semester hours.

**PEGN308. RESERVOIR ROCK PROPERTIES. 3.0 Hours.**

(II) (WI) Intro duction to basic reservoir rock properties and their measurements. Topics covered include: porosity, saturations, volumetric equations, land descriptions, trapping mechanism, pressure and temperature gradients, abnormally pressured reservoirs. Darcy's law for linear horizontal and tilted flow, radial flow for single phase liquids and gases, multiphase flow (relative permeability). Capillary pressure and formation compressibility are also discussed. This course is designated as a writing intensive course (WI). Co-requisites: DCGN241, PEGN251. 2 hours lecture, 3 hours lab; 3 semester hours.

**PEGN310. RESERVOIR FLUID PROPERTIES. 2.0 Hours.**

(I) Properties of fluids encountered in petroleum engineering. Phase behavior, density, viscosity, interfacial tension, and composition of oil, gas, and brine systems. Interpreting lab data for engineering applications. Flash calculations with k-values and equation of state. Introduction to reservoir simulation software. Prerequisites: DCGN209 and PEGN308. 2 hours lecture; 2 semester hours.

**PEGN311. DRILLING ENGINEERING. 4.0 Hours.**

(I) Study of drilling operations, fluid design, hydraulics, drilling contracts, rig selection, rotary system, well control, bit selection, drill string design, directional drilling, and casing seat selection. Prerequisites: PEGN251, PEGN315, DCGN241. 3 hours lecture, 3 hours lab; 4 semester hours.

**PEGN315. SUMMER FIELD SESSION I. 2.0 Hours.**

(S) This twoweek course taken after the completion of the sophomore year is designed to introduce the student to oil and gas field and other engineering operations. Engineering design problems are integrated throughout the two-week session. On-site visits to various oil field operations in the past included the Rocky Mountain region, the U.S. Gulf Coast, California, Alaska, Canada and Europe. Topics covered include drilling, completions, stimulations, surface facilities, production, artificial lift, reservoir, geology and geophysics. Also included are environmental and safety issues as related to the petroleum industry. Prerequisite: PEGN308. 2 semester hours.

**PEGN316. SUMMER FIELD SESSION II. 2.0 Hours.**

(S) This twoweek course is taken after the completion of the junior year. Emphasis is placed on the multidisciplinary nature of reservoir management. Field trips in the area provide the opportunity to study eolian, fluvial, lacustrine, near shore, and marine depositional systems. These field trips provide the setting for understanding the complexity of each system in the context of reservoir development and management. Petroleum systems including the source, maturity, and trapping of hydrocarbons are studied in the context of petroleum exploration and development. Geologic methods incorporating both surface and subsurface data are used extensively. Prerequisites: PEGN315, PEGN411, PEGN419, GEOL308, and GEOL315. 2 semester hours.

**PEGN340. COOPERATIVE EDUCATION. 3.0 Hours.**

(I, II, S) Supervised, full-time, engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions.

**PEGN350. SUSTAINABLE ENERGY SYSTEMS. 3.0 Hours.**

(I or II) A sustainable energy system is a system that lets us meet present energy needs while preserving the ability of future generations to meet their needs. Sustainable Energy Systems introduces undergraduate students to sustainable energy systems that will be available in the 21st century. The course focuses on sustainable energy sources, especially renewable energy sources and nuclear energy (e.g., fusion). Students are introduced to the existing energy infrastructure, become familiar with finite energy sources, and learn from a study of energy supply and demand that sustainable energy systems are needed. The ability to improve energy use efficiency and the impact of energy sources on the environment are discussed. Examples of sustainable energy systems and their applicability to different energy sectors are presented. The course is recommended for students who plan to enter the energy industry or students who would like an introduction to sustainable energy systems. Prerequisites: EPIC 151 or consent of instructor. 3 hours lecture; 3 semester hours.

**PEGN361. COMPLETION ENGINEERING. 3.0 Hours.**

(II) (WI) This class is a continuation from drilling in PEGN311 into completion operations. Topics include casing design, cement planning, completion techniques and equipment, tubing design, wellhead selection, and sand control, and perforation procedures. This course is designed as a writing intensive course (WI). Prerequisite: PEGN311, EGGN320, and EPIC251. 3 hours lecture; 3 semester hours.

**PEGN398. SPECIAL TOPICS IN PETROLEUM ENGINEERING. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**PEGN399. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**PEGN411. MECHANICS OF PETROLEUM PRODUCTION. 3.0 Hours.**

(II) Nodal analysis for pipe and formation deliverability including single and multiphase flow. Natural flow and design of artificial lift methods including gas lift, sucker rod pumps, electrical submersible pumps, and hydraulic pumps. Prerequisites: PEGN 251, PEGN308, PEGN310, and PEGN311. 3 hours lecture; 3 semester hours.

**PEGN413. GAS MEASUREMENT AND FORMATION EVALUATION LAB. 2.0 Hours.**

(I) (WI) This lab investigates the properties of a gas such as vapor pressure, dew point pressure, and field methods of measuring gas volumes. The application of well logging and formation evaluation concepts are also investigated. This course is designated as a writing intensive course (WI). Prerequisites: PEGN308 and PEGN310. Corequisite: PEGN423. 6 hours lab; 2 semester hours.

**PEGN414. WELL TEST ANALYSIS AND DESIGN. 3.0 Hours.**

(I) Solution to the diffusivity equation. Transient well testing: build-up, drawdown, multi-rate test analysis for oil and gas. Flow tests and well deliverabilities. Type curve analysis. Super position, active and interference tests. Well test design. Prerequisites: MATH225 and PEGN419. 3 hours lecture; 3 semester hours.

**PEGN419. WELL LOG ANALYSIS AND FORMATION EVALUATION. 3.0 Hours.**

(I) An introduction to well logging methods, including the relationship between measured properties and reservoir properties. Analysis of log suites for reservoir size and content. Graphical and analytical methods will be developed to allow the student to better visualize the reservoir, its contents, and its potential for production. Use of the computer as a tool to handle data, create graphs and log traces, and make computations of reservoir parameters is required. Prerequisite: PEGN308, GPGN302 and GPGN303. Co-requisites: PEGN310, GEOL315. 2 hours lecture, 3 hours lab; 3 semester hours.

**PEGN422. ECONOMICS AND EVALUATION OF OIL AND GAS PROJECTS. 3.0 Hours.**

(I) Project economics for oil and gas projects under conditions of certainty and uncertainty. Topics include time value of money concepts, discount rate assumptions, measures of project profitability, costs, taxes, expected value concept, decision trees, gambler's ruin, and Monte Carlo simulation techniques. Prerequisite: PEGN438/MNGN438. 3 hours lecture; 3 semester hours.

**PEGN423. PETROLEUM RESERVOIR ENGINEERING I. 3.0 Hours.**

(I) Data requirements for reservoir engineering studies. Material balance calculations for normal gas, retrograde gas condensate, solution-gas and gas-cap reservoirs with or without water drive. Primary reservoir performance. Forecasting future recoveries by incremental material balance. Prerequisites: PEGN316, PEGN419 and MATH225 (MATH225 only for non PE majors). 3 hours lecture; 3 semester hours.

**PEGN424. PETROLEUM RESERVOIR ENGINEERING II. 3.0 Hours.**

(II) Reservoir engineering aspects of supplemental recovery processes. Introduction to liquid-liquid displacement processes, gas-liquid displacement processes, and thermal recovery processes. Introduction to numerical reservoir simulation, history matching and forecasting. Prerequisite: PEGN423. 3 hours lecture; 3 semester hours.

**PEGN426. WELL COMPLETIONS AND STIMULATION. 3.0 Hours.**

(II) Completion parameters; design for well conditions. Skin damage associated with completions and well productivity. Fluid types and properties; characterizations of compatibilities. Stimulation techniques; acidizing and fracturing. Selection of proppants and fluids; types, placement and compatibilities. Estimation of rates, volumes and fracture dimensions. Reservoir considerations in fracture propagation and design. Prerequisite: PEGN361 and PEGN411. 3 hours lecture; 3 semester hours.

**PEGN428. ADVANCED DRILLING ENGINEERING. 3.0 Hours.**

(II) Rotary drilling systems with emphasis on design of drilling programs, directional and horizontal well planning. This elective course is recommended for petroleum engineering majors interested in drilling. Prerequisite: PEGN311, PEGN361. 3 hours lecture; 3 semester hours.

**PEGN438. GEOSTATISTICS. 3.0 Hours.**

(I & II) Introduction to elementary probability theory and its applications in engineering and sciences; discrete and continuous probability distributions; parameter estimation; hypothesis testing; linear regression; spatial correlations and geostatistics with emphasis on applications in earth sciences and engineering. Prerequisites: MATH112. 2 hours lecture; 3 hours lab; 3 semester hours.

**PEGN439. MULTIDISCIPLINARY PETROLEUM DESIGN. 3.0 Hours.**

(II) (WI) This is a multi-disciplinary design course that integrates fundamentals and design concepts in geology, geophysics, and petroleum engineering. Students work in integrated teams consisting of students from each of the disciplines. Multiple open-ended design problems in oil and gas exploration and field development, including the development of a prospect in an exploration play and a detailed engineering field study are assigned. Several detailed written and oral presentations are made throughout the semester. Project economics including risk analysis are an integral part of the course. Prerequisites: GE Majors: GEOL309, GEOL314, GEGN438, and EPIC264; GP Majors: GPGN302, GPGN303, and EPIC268; PE Majors: GEOL308, PEGN316 and PEGN426. 2 hours lecture, 3 hours lab; 3 semester hours.

**PEGN450. ENERGY ENGINEERING. 3.0 Hours.**

(I or II) Energy Engineering is an overview of energy sources that will be available for use in the 21st century. After discussing the history of energy and its contribution to society, we survey the science and technology of energy, including geothermal energy, fossil energy, solar energy, nuclear energy, wind energy, hydro energy, bio energy, energy and the environment, energy and economics, the hydrogen economy, and energy forecasts. This broad background will give you additional flexibility during your career and help you thrive in an energy industry that is evolving from an industry dominated by fossil fuels to an industry working with many energy sources. Prerequisite: MATH213, PHGN200. 3 hours lecture; 3 semester hours.

**PEGN481. PETROLEUM SEMINAR. 2.0 Hours.**

(I) (WI) Written and oral presentations by each student on current energy topics.

This course is designated as a writing intensive course (WI). Prerequisite: Consent of instructor. 2 hours lecture; 2 semester hours.

**PEGN490. RESERVOIR GEOMECHANICS. 3.0 Hours.**

(I) The course provides an introduction to fundamental rock mechanics and aims to emphasize their role in oil and gas exploration, drilling, completion and production engineering operations. Deformation as a function of stress, elastic moduli, in situ stress, stress magnitude and orientation, pore pressure, strength and fracture gradient, rock characteristic from field data (seismic, logging, drilling, production), integrated wellbore stability analysis, depletion and drilling induced fractures, compaction and associated changes in rock properties, hydraulic fracturing and fracture stability are among the topics to be covered. Pre-requisites: EGGN320. 3 hours lecture; 3 hours lab, 3 semester hours.

**PEGN498. SPECIAL TOPICS IN PETROLEUM ENGINEERING. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**PEGN499. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

## Chemical and Biological Engineering

<http://chemeng.mines.edu>

### Program Description

The Chemical and Biological Engineering Department ([bulletin.mines.edu/undergraduate/programs/appliedscieng/chemicalandbiologicalengineering/http://chemeng.mines.edu](http://bulletin.mines.edu/undergraduate/programs/appliedscieng/chemicalandbiologicalengineering/http://chemeng.mines.edu)) offers two different degrees:

- Bachelor of Science in Chemical Engineering and
- Bachelor of Science in Chemical and Biochemical Engineering.

Generally, the fields of chemical and biochemical engineering are extremely broad, and encompass all technologies and industries where chemical processing is utilized in any form. Students with baccalaureate (BS) Chemical Engineering or Chemical and Biochemical Engineering degrees from CSM can find employment in many diverse fields, including: advanced materials synthesis and processing, product and process research and development, food and pharmaceutical processing and synthesis, biochemical and biomedical materials and products, microelectronics manufacturing, petroleum and petrochemical processing, and process and product design. A student seeking the degree of BS in Chemical and Biochemical Engineering graduates as a fully-qualified Chemical Engineer with additional training in bioprocessing technologies that are of interest in renewable energy and other emerging fields.

The practice of chemical engineering draws from the fundamentals of biology, chemistry, mathematics, and physics. Accordingly, undergraduate students must initially complete a program of study that stresses these basic fields of science. Chemical engineering coursework blends these four disciplines into a series of engineering fundamentals relating to how materials are produced and processed both in the laboratory and in large industrial-scale facilities. Courses such as fluid mechanics, heat and mass transfer, thermodynamics, reaction kinetics, and chemical process control are at the heart of the chemical engineering curriculum at CSM. In addition, it is becoming increasingly important for engineers to understand how biological and microscopic, molecular-level properties can influence the macroscopic behavior of materials, biological, and chemical systems. This somewhat unique focus is first introduced at CSM through the physical and organic chemistry sequences, and the theme is continued and developed within the chemical engineering curriculum via material and projects introduced in advanced courses. Our undergraduate program at CSM is exemplified by intensive integration of computer-aided simulation and computer-aided process modeling in the curriculum and by our unique approach to teaching of the unit operations laboratory sequence. The unit operations lab course is offered only in the summer as a 6-week intensive session. Here, the fundamentals of heat, mass, and momentum transfer and applied thermodynamics are reviewed in a practical, applications-oriented setting. The important skills of teamwork, critical thinking, time management, and oral and written technical communications skills are also stressed in this course.

Facilities for the study of chemical engineering or chemical and biochemical engineering at the Colorado School of Mines are among the best in the nation. Our modern in-house computer laboratory supports nearly 60 workstations for students to use in completing their assigned coursework. In addition, specialized undergraduate laboratory facilities exist for studying polymer properties, measuring reaction kinetics, characterizing transport phenomena, and for studying several typical

chemical unit operations. Our honors undergraduate research program is open to highly qualified students and provides our undergraduates with the opportunity to carry out independent research or to join a graduate research team. This program has been highly successful and our undergraduate chemical engineering and chemical and biochemical engineering students have won several national competitions and awards based on research conducted while pursuing their baccalaureate degrees. We also have a cooperative (Co-Op) education program in which students can earn course credit while gaining work experience in industry.

Programs leading to the degree of Bachelor of Science in Chemical Engineering and to the degree of Bachelor of Science in Chemical and Biochemical Engineering are both accredited by:

The Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET)  
111 Market Place, Suite 1050  
Baltimore, MD 21202-4012  
telephone (410) 347-7700

### Program Educational Objectives (Bachelor of Science in Chemical Engineering and Bachelor of Science in Chemical and Biochemical Engineering)

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria, the Chemical and Biological Engineering Department at CSM has established 3 program educational objectives for all of its graduates and one additional objective specifically for its chemical and biochemical engineering graduates. Our graduates within 3 to 5 years of completing their degree will:

- be in graduate school or in the workforce utilizing their education in chemical engineering fundamentals
- be applying their knowledge of and skills in engineering fundamentals in conventional areas of chemical engineering and in contemporary and growing fields
- have demonstrated both their commitment to continuing to develop personally and professionally and an appreciation for the ethical and social responsibilities associated with being an engineer and a world citizen

Additionally, our Chemical and Biochemical Engineering graduates within 3 to 5 years of completing their degree will be applying their knowledge of and skills in biochemical engineering fundamentals.

### Combined Baccalaureate/Masters Degree Program

The Chemical and Biological Engineering Department offers the opportunity to begin work on a Master of Science (with or without thesis) degree while completing the requirements of the BS degree. These combined BS/MS degrees are designed to allow undergraduates engaged in research, or simply interested in furthering their studies beyond a BS degree, to apply their experience and interest to an advanced degree. Students may take graduate courses while completing their undergraduate degrees and count them towards their graduate degree. The requirements for the MS degree consist of the four core graduate courses:

CHEN509	ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS	3
CHEN516	TRANSPORT PHENOMENA	3
CHEN518	REACTION KINETICS AND CATALYSIS	3
CHEN568	INTRODUCTION TO CHEMICAL ENGINEERING RESEARCH	3
Additional credits		18.0
Total Hours		30.0

It is expected that a student would be able to complete both degrees in 5 to 5 1/2 years. To take advantage of the combined program, students are encouraged to engage in research and take some graduate coursework during their senior year. The application process and requirements are identical to our normal MS degree programs. Applications may be completed online and require 3 letters of recommendation, a statement of purpose, and completion of the graduate record exam (GRE). For students who intend to begin the BS/MS program in Fall, applications are due by April 1st. The deadline is November 1st for students intending to enroll in the Spring semester. Students must have a GPA greater than 3.0 to be considered for the program. Interested students are encouraged to get more information from their advisor and/or the current faculty member in charge of Graduate Affairs.

## Curriculum

The chemical engineering and chemical and biochemical engineering curricula are structured according to the goals outlined above. Accordingly, the programs of study are organized to include 3 semesters of science and general engineering fundamentals followed by 5 semesters of chemical/biochemical engineering fundamentals and applications. An optional 'track' system exists, which allows students majoring in chemical engineering to structure their electives credits into one of several specialty application areas. Courses may be categorized according to the following general system.

### A. Chemical/Chemical and Biochemical Engineering Fundamentals

The following courses represent the basic knowledge component of the chemical engineering curriculum at CSM.

CHEN201	MATERIAL AND ENERGY BALANCES	3.0
CHEN307	FLUID MECHANICS	3.0
CHEN308	HEAT TRANSFER	3.0
CHEN357	CHEMICAL ENGINEERING THERMODYNAMICS	3.0
CHEN375	MASS TRANSFER	3.0
CHEN430	TRANSPORT PHENOMENA	3.0

### B. Chemical/Chemical and Biochemical Engineering Applications

The following courses are applications-oriented courses that build on the student's basic knowledge of science and engineering fundamentals:

CHEN312	UNIT OPERATIONS LABORATORY	3.0
CHEN418	KINETICS AND REACTION ENGINEERING	3.0
CHEN403	PROCESS DYNAMICS AND CONTROL	3.0
CHEN402	CHEMICAL ENGINEERING DESIGN	3.0
CHEN460	BIOCHEMICAL PROCESS ENGINEERING	3.0
Chemical Engineering Technical Electives		

## C. Elective Tracks

Whereas Chemical and Biochemical Engineering majors have specific additional required courses to give them the biochemical engineering training they need, Chemical Engineering majors have technical electives credit requirements that may be fulfilled with several different courses. Students may elect to structure their electives into:

Formal Minor program of study	18.0
Area of Special Interest	12.0
Specialty Track	9.0

Minors and ASIs can be developed by the student in a variety of different areas and programs as approved by the student's advisor and the heads of the relevant sponsoring academic programs. Some examples of Specialty Tracks for Chemical Engineering majors include:

- Microelectronics
- Bioengineering and Life Sciences
- Polymers and Materials
- Molecular Modeling
- Environmental
- Energy
- Business and Economics

Details on recommended courses for Specialty Tracks can be obtained from the student's academic advisor. Alternatively, students may opt to take an assorted combination of approved courses on diverse topics to fulfill their technical electives credits.

## Requirements (Chemical Engineering)

### Freshman

	lec	lab	sem.hrs
Common Core *			33.0
			<b>33.0</b>

### Sophomore

Fall	lec	lab	sem.hrs
MATH213 CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4
PHGN200 PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
DCGN210 INTRO TO ENG THERMODYNAMICS	3.0		3
CHGN221 ORGANIC CHEMISTRY I	3.0		3
CHGN223 ORGANIC CHEMISTRY I LABORATORY		3.0	1
PAGN2XX PHYSICAL EDUCATION			0.5
			<b>16.0</b>

### Spring

	lec	lab	sem.hrs
MATH225 DIFFERENTIAL EQUATIONS	3.0		3
EBGN201 PRINCIPLES OF ECONOMICS	3.0		3
CHEN201 MATERIAL AND ENERGY BALANCES	3.0		3
CHEN202 CHEMICAL PROCESS PRINCIPLES LABORATORY		1.0	1
CHGN222 ORGANIC CHEMISTRY II	3.0		3

EPIC266	EPICS II: CHEMICAL PROCESSES**	3.0		3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>16.5</b>
<b>Junior</b>				
<b>Fall</b>				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	3.0	4
CHEN307	FLUID MECHANICS	3.0		3
CHEN357	CHEMICAL ENGINEERING THERMODYNAMICS	3.0		3
SYGN200	HUMAN SYSTEMS	3.0		3
CHEN ELECT	Chemical Engineering Elective***	3.0		3.0
				<b>16.0</b>
<b>Spring</b>				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHEN358	CHEMICAL ENGINEERING THERMODYNAMICS LABORATORY		3.0	1
CHEN375	MASS TRANSFER	3.0		3
CHEN308	HEAT TRANSFER	3.0		3
LAIS/EBGN	H&SS Restricted Elective I	3.0		3.0
CHEN ELECT	400-LEVEL Chemical Engineering Elective(s)***	3.0		3.0
CHGN/ CHEN ELECT	Chemistry or Chemical Engineering Elective****	3.0		3.0
				<b>16.0</b>
<b>Summer</b>				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHEN312/313	UNIT OPERATIONS LABORATORY			6.0
				<b>6.0</b>
<b>Senior</b>				
<b>Fall</b>				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHEN418	KINETICS AND REACTION ENGINEERING	3.0		3
CHEN430	TRANSPORT PHENOMENA	3.0		3
LAIS/EBGN	H&SS Restricted Elective II	3.0		3.0
FREE	FREE ELECTIVE***	7.0		7.0
				<b>16.0</b>
<b>Spring</b>				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHEN402	CHEMICAL ENGINEERING DESIGN	3.0		3
CHEN403	PROCESS DYNAMICS AND CONTROL	3.0		3
LAIS/EBGN	H&SS Restricted Elective III	3.0		3.0
CHEN421	ENGINEERING ECONOMICS	3.0		3
FREE ELECT	FREE ELECTIVE***	3.0		3.0
				<b>15.0</b>

Total Hours: 134.5

- \* Chemical Engineering students take the common core with Biological and Environmental Systems (BELS101) rather than Earth and Environmental Systems (SYGN101).
- \*\* Certain other EPIC2xx courses can be substituted for EPIC266 with approval of the department head or assistant department head.
- \*\*\* Six of the electives credits must be CHEN courses, at least 3 of which must be at the 400 level.
- \*\*\*\* An additional 3 of the electives credits must be either CHGN or CHEN credits.

## Requirements (Chemical and Biochemical Engineering)

<b>Freshman</b>				
Common Core*				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
				33.0
				<b>33.0</b>
<b>Sophomore</b>				
<b>Fall</b>				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
DCGN210	INTRO TO ENG THERMODYNAMICS	3.0		3
CHGN221	ORGANIC CHEMISTRY I	3.0		3
CHGN223	ORGANIC CHEMISTRY I LABORATORY		3.0	1
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>16.0</b>
<b>Spring</b>				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH225	DIFFERENTIAL EQUATIONS	3.0		3
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3
CHEN201	MATERIAL AND ENERGY BALANCES	3.0		3
CHEN202	CHEMICAL PROCESS PRINCIPLES LABORATORY		1.0	1
CHGN222	ORGANIC CHEMISTRY II	3.0		3
EPIC265	EPIC II: BIOCHEMICAL PROCESSES	3.0		3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>16.5</b>
<b>Junior</b>				
<b>Fall</b>				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	3.0	4
CHEN307	FLUID MECHANICS	3.0		3
CHEN357	CHEMICAL ENGINEERING THERMODYNAMICS	3.0		3
SYGN200	HUMAN SYSTEMS	3.0		3
FREE	Free Elective	3.0		3.0
				<b>16.0</b>
<b>Spring</b>				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHGN428	BIOCHEMISTRY	3.0		3



CHEN358	CHEMICAL ENGINEERING THERMODYNAMICS LABORATORY	3.0	1	
CHEN375	MASS TRANSFER	3.0	3	
CHEN308	HEAT TRANSFER	3.0	3	
LAIS/EBGN	H&SS Restricted Elective I	3.0	3.0	
CHGN462	MICROBIOLOGY AND THE ENVIRONMENT	3.0	3	
				<b>16.0</b>
<b>Summer</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHEN312/313	UNIT OPERATIONS LABORATORY			6.0
				<b>6.0</b>
<b>Senior</b>				
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHEN418	KINETICS AND REACTION ENGINEERING	3.0	3	
CHEN430	TRANSPORT PHENOMENA	3.0	3	
LAIS/EBGN	H&SS Restricted Elective II	3.0	3.0	
CHEN460	BIOCHEMICAL PROCESS ENGINEERING	3.0	3	
CHEN461	BIOCHEMICAL PROCESS ENGINEERING LABORATORY		3.0	1
FREE	Free Elective	3.0		3.0
				<b>16.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHEN402	CHEMICAL ENGINEERING DESIGN	3.0		3
CHEN403	PROCESS DYNAMICS AND CONTROL	3.0		3
LAIS/EBGN	H&SS Restricted Elective III	3.0		3.0
CHEN421	ENGINEERING ECONOMICS	3.0		3
FREE	Free Elective	3.0		3.0
				<b>15.0</b>

Total Hours: 134.5

\* Chemical and Biochemical Engineering Students take the common core with Biological and Environmental Systems (BELS101) rather than Earth and Environmental Systems (SYGN101).

General CSM Minor/ASI requirements can be found [here](#).

## Courses

### BELS101. BIOLOGICAL AND ENVIRONMENTAL SYSTEMS. 4.0

#### Hours.

(I,II) This course presents the basic principles and properties of biological and environmental systems. It considers the chemistry of life and the structure and function of cells and organisms. Concepts related to physiology, energetics, and genetics are introduced. The fundamentals of environmental science are presented and we consider how organisms interact with each other and with their environment and discuss the possibilities and problems of these interactions. Basic engineering principles of thermodynamics, kinetics, mass balance, transport phenomena and material science are presented and applied to biological systems. 4 semester hours.

### BELS198. SPECIAL TOPICS. 1-6 Hour.

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### BELS301. GENERAL BIOLOGY I. 3.0 Hours.

(I, II) This is the first semester of an introductory course in Biology. Emphasis is placed on the methods of science; structural, molecular, and energetic basis of cellular activities; genetic variability and evolution; diversity and life processes in plants and animals; and, principles of ecology. Prerequisite: None. 3 hours lecture; 3 hours semester hours.

### BELS303. GENERAL BIOLOGY II. 3.0 Hours.

(I, II) This is the continuation of General Biology I. Emphasis is placed on an examination of organisms as the products of evolution. The diversity of life forms will be explored. Special attention will be given to the vertebrate body (organs, tissues, and systems) and how it functions. Prerequisite: General Biology I, or equivalent. 3 hours lecture; 3 semester hours.

### BELS311. GENERAL BIOLOGY I LABORATORY. 1.0 Hour.

(I, II) This Course provides students with laboratory exercises that complement lectures given in BELS301, the first semester introductory course in Biology. Emphasis is placed on the methods of science; structural, molecular, and energetic basis of cellular activities; genetic variability and evolution; diversity and life processes in plants and animals; and, principles of ecology. Co-requisite or Prerequisite: EGGN/BELS301 or equivalent. 3 hours laboratory; 1 semester hour.

### BELS313. GENERAL BIOLOGY II LABORATORY. 1.0 Hour.

(I, II) This Course provides students with laboratory exercises that complement lectures given in BELS303, the second semester introductory course in Biology. Emphasis is placed on an examination of organisms as the products of evolution. The diversity of life forms will be explored. Special attention will be given to the vertebrate body (organs, tissues and systems) and how it functions. Co-requisite or Prerequisite: BELS303 or equivalent. 3 hours laboratory; 1 semester hour.

**BELS320. INTRODUCTION TO ETHICS. 3.0 Hours.**

A general introduction to ethics that explores its analytic and historical traditions. Reference will commonly be made to one or more significant texts by such moral philosophers as Plato, Aristotle, Augustine, Thomas Aquinas, Kant, John Stuart Mill, and others. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

**BELS321. INTRO TO GENETICS. 4.0 Hours.**

(II) A study of the mechanisms by which biological information is encoded, stored, and transmitted, including Mendelian genetics, molecular genetics, chromosome structure and rearrangement, cytogenetics, and population genetics. Prerequisite: General biology I or equivalent. 3 hours lecture + 3 hours laboratory; 4 semester hours.

**BELS325. INTRODUCTION TO BIOMECHANICAL ENGINEERING. 3.0 Hours.**

(I) The application of mechanical engineering principles and techniques to the human body presents many unique challenges. The discipline of Biomedical Engineering (more specifically, Biomechanical Engineering) has evolved over the past 50 years to address these challenges. Biomechanical Engineering includes such areas as biomechanics, biomaterials, bioinstrumentation, medical imaging, and rehabilitation. This course is intended to provide an introduction to, and overview of, Biomechanical Engineering and to prepare the student for more advanced Biomechanical coursework. At the end of the semester, students should have a working knowledge of the special considerations necessary to apply various mechanical engineering principles to the human body. Prerequisites: EGGN320, PHGN200. Co-requisites: EGGN315. 3 hours lecture; 3 semester hours.

**BELS333. INTRODUCTION TO BIOPHYSICS. 3.0 Hours.**

This course is designed to show the application of physics to biology. It will assess the relationships between sequence structure and function in complex biological networks and the interfaces between physics, chemistry, biology and medicine.

Topics include: biological membranes, biological mechanics and movement, neural networks, medical imaging basics including optical methods, MRI, isotopic tracers and CT, biomagnetism and pharmacokinetics. Prerequisites: PHGN200 and BELS301, or permission of the instructor. 3 hours lecture, 3 semester hours.

**BELS350. HONORS UNDERGRADUATE RESEARCH. 1-3 Hour.**

Scholarly research of an independent nature. Prerequisite: junior standing, consent of instructor. 1 to 3 semester hours.

**BELS351. HONORS UNDERGRADUATE RESEARCH. 1-3 Hour.**

Scholarly research of an independent nature. Prerequisite: junior standing, consent of instructor. 1 to 3 semester hours.

**BELS398. SPECIAL TOPICS IN BIOENGINEERING AND LIFE SCIENCES. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**BELS399. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**BELS402. CELL BIOLOGY AND PHYSIOLOGY. 3.0 Hours.**

(II) An introduction to the morphological, biochemical, and biophysical properties of cells and their significance in the life processes. Prerequisite: General Biology I, or equivalent. 3 hours lecture; 3 semester hours.

**BELS404. ANATOMY AND PHYSIOLOGY. 3.0 Hours.**

(II) This course will cover the basics of human anatomy and physiology of the cardiovascular system and blood, the immune system, the respiratory system, the digestive system, the endocrine system, the urinary system and the reproductive system. We will discuss the gross and microscopic anatomy and the physiology of these major systems. Where possible, we will integrate discussions of disease processes and introduce biomedical engineering concepts and problems. Prerequisite: General Biology I or consent of instructor. 3 hours lecture; 3 semester hours.

**BELS405. ANATOMY AND PHYSIOLOGY LAB. 1.0 Hour.**

(II) In this course we explore the basic concepts of human anatomy and physiology using simulations of the physiology and a virtual human dissector program. These are supplemented as needed with animations, pictures and movies of cadaver dissection to provide the student with a practical experience discovering principles and structures associated with the anatomy and physiology. Corequisite: BELS404. 3 lab hours, 1 semester hour.

**BELS406. ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN. 3.0 Hours.**

(I) This course will cover the basics of human anatomy and physiology of the tissues, skeletal system, muscular system, central nervous system and peripheral nervous system. We will discuss the gross and microscopic anatomy and the physiology of these major systems. Where possible, we will integrate discussions of disease processes and introduce biomedical engineering concepts and problems. Prerequisite: General Biology I or consent of instructor. 3 hour lecture; 3 semester hours.

**BELS407. ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN LABORATORY. 1.0 Hour.**

(I) In this course we explore the basic concepts of human anatomy and physiology of the tissue types, skeletal system, muscular system, and nervous system using anatomical models and medical tissue microscope slides. These are supplemented as needed with pictures, chalk talks, handouts, ultrasound for muscle and skeleton, and EEG recording of brain waves to provide the student with a practical experience discovering principles and structures associated with the anatomy and physiology and to reinforce the material from the lecture course. Prerequisite: General Biology 1 [BELS301] or approval of the instructor. Co-requisites: must either have taken or currently taking Anatomy and Physiology BMB [BELS406]. 3 hour lab; 1 semester hour.

**BELS415. POLYMER SCIENCE AND TECHNOLOGY. 3.0 Hours.**

Chemistry and thermodynamics of polymers and polymer solutions. Reaction engineering of polymerization. Characterization techniques based on solution properties. Materials science of polymers in varying physical states. Processing operations for polymeric materials and use in separations. Prerequisite: CHGN211, MATH225, ChEN357, or consent of instructor. 3 hours lecture; 3 semester hours.

**BELS425. MUSCULOSKELETAL BIOMECHANICS. 3.0 Hours.**

(II) This course is intended to provide mechanical engineering students with a second course in musculoskeletal biomechanics. At the end of the semester, students should have in-depth knowledge and understanding necessary to apply mechanical engineering principles such as statics, dynamics, and mechanics of materials to the human body. The course will focus on the biomechanics of injury since understanding injury will require developing an understanding of normal biomechanics. Prerequisite: EGGN315, EGGN320, EGGN325/BELS325, or instructor permission. 3 hours lecture; 3 semester hours.

**BELS428. COMPUTATIONAL BIOMECHANICS. 3.0 Hours.**

(I) Computational Biomechanics provides an introduction to the application of computer simulation to solve some fundamental problems in biomechanics and bioengineering. Musculoskeletal mechanics, medical image reconstruction, hard and soft tissue modeling, joint mechanics, and inter-subject variability will be considered. An emphasis will be placed on understanding the limitations of the computer model as a predictive tool and the need for rigorous verification and validation of computational techniques. Clinical application of biomechanical modeling tools is highlighted and impact on patient quality of life is demonstrated. Prerequisites: EGGN413 Computer Aided Engineering, EGGN325/BELS325 Introduction to Biomedical Engineering. 3 hours lecture; 3 semester hours.

**BELS431. IMMUNOLOGY FOR ENGINEERS AND SCIENTISTS. 3.0 Hours.**

(II) This course introduces the basic concepts of immunology and their applications in engineering and science. We will discuss the molecular, biochemical and cellular aspects of the immune system including structure and function of the innate and acquired immune systems. Building on this, we will discuss the immune response to infectious agents and the material science of introduced implants and materials such as heart valves, artificial joints, organ transplants and lenses. We will also discuss the role of the immune system in cancer, allergies, immune deficiencies, vaccination and other applications such as immunoassay and flow cytometry. Prerequisites: General Biology BELS301 or equivalent. 3 Lecture hours, 3 semester hours.

**BELS432. TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS. 3.0 Hours.**

The goal of this course is to develop and analyze models of biological transport and reaction processes. We will apply the principles of mass, momentum, and energy conservation to describe mechanisms of physiology and pathology. We will explore the applications of transport phenomena in the design of drug delivery systems, engineered tissues, and biomedical diagnostics with an emphasis on the barriers to molecular transport in cardiovascular disease and cancer. Prerequisites: CHEN430 or equivalent. 3 lecture hours, 3 credit hours.

**BELS450. HONORS UNDERGRADUATE RESEARCH. 1-3 Hour.**

Scholarly research of an independent nature. Prerequisite: senior standing, consent of instructor. 1 to 3 semester hours.

**BELS451. HONORS UNDERGRADUATE RESEARCH. 1-3 Hour.**

Scholarly research of an independent nature. Prerequisite: senior standing, consent of instructor. 1 to 3 semester hours.

**BELS453. WASTEWATER ENGINEERING. 3.0 Hours.**

(I) The goal of this course is to familiarize students with the fundamental phenomena involved in wastewater treatment processes (theory) and the engineering approaches used in designing such processes (design). This course will focus on the physical, chemical and biological processes applied to liquid wastes of municipal origin. Treatment objectives will be discussed as the driving force for wastewater treatment. Prerequisite: ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

**BELS454. APPLIED BIOINFORMATICS. 3.0 Hours.**

(II) In this course we will discuss the concepts and tools of bioinformatics. The molecular biology of genomics and proteomics will be presented and the techniques for collecting, storing, retrieving and processing such data will be discussed. Topics include analyzing DNA, RNA and protein sequences, gene recognition, gene expression, protein structure prediction, modeling evolution, utilizing BLAST and other online tools for the exploration of genome, proteome and other available databases. In parallel, there will be an introduction to the PERL programming language. Practical applications to biological research and disease will be presented and students given opportunities to use the tools discussed. Prerequisites: General Biology BELS301 or Senior/Graduate standing. 3 hour lecture; 3 semester hours.

**BELS470. INTRODUCTION TO MICROFLUIDICS. 3.0 Hours.**

This course introduces the basic principles and applications of microfluidic systems. Concepts related to microscale fluid mechanics, transport, physics, and biology are presented. To gain familiarity with small-scale systems, students are provided with the opportunity to design, fabricate, and test a simple microfluidic device. Prerequisites: CHEN307 (or equivalent) and DCGN210 (or equivalent) or permission of instructor. 3 semester hours.

**BELS498. SPECIAL TOPICS IN BIOENGINEERING AND LIFE SCIENCES. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**BELS499. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**CHEN199. INDEPENDENT STUDY. 0.5-6 Hour.**

Individual research or special problem projects. Topics, content, and credit hours to be agreed upon by student and supervising faculty member. Prerequisite: consent of instructor and department head, submission of "Independent Study" form to CSM Registrar. 1 to 6 semester hours. Repeatable for credit.

**CHEN200. COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING. 3.0 Hours.**

Fundamentals of computer programming as applied to the solution of chemical engineering problems. Introduction to Visual Basic, computational methods and algorithm development. Prerequisite: MATH112 or consent of instructor. 3 hours lecture; 3 semester hours.

**CHEN201. MATERIAL AND ENERGY BALANCES. 3.0 Hours.**

(II) Introduction to the formulation and solution of material and energy balances on chemical processes. Establishes the engineering approach to problem solving, the relations between known and unknown process variables, and appropriate computational methods. Corequisites: DCGN210 (or equivalent); CHEN202, MATH213, MATH225, or consent of instructor. 3 hours lecture; 3 semester hours.

**CHEN202. CHEMICAL PROCESS PRINCIPLES LABORATORY. 1.0 Hour.**

(II) Laboratory measurements demonstrating the first and second laws of thermodynamics, calculation and analysis of experimental results, and professional report writing. Introduction to computer-aided process simulation.

Corequisites: CHEN201. 3 hours laboratory; 1 credit hour.

**CHEN250. INTRODUCTION TO CHEMICAL ENGINEERING ANALYSIS AND DESIGN. 3.0 Hours.**

Introduction to chemical process industries and how analysis and design concepts guide the development of new processes and products. Use of simple mathematical models to describe the performance of common process building blocks including pumps, heat exchangers, chemical reactors, and separators. Prerequisites: Concurrent enrollment in DCGN 210 or consent of instructor. 3 hours lecture; 3 semester hours.

**CHEN298. SPECIAL TOPICS. 1-6 Hour.**

Topical courses in chemical engineering of special interest. Prerequisite: consent of instructor; 1 to 6 semester hours. Repeatable for credit under different titles.

**CHEN307. FLUID MECHANICS. 3.0 Hours.**

(I) This course covers theory and application of momentum transfer and fluid flow. Fundamentals of microscopic phenomena and application to macroscopic systems are addressed. Course work also includes computational fluid dynamics. Prerequisites: MATH225, grade of C- or better in CHEN201. 3 hours lecture; 3 semester hours.

**CHEN308. HEAT TRANSFER. 3.0 Hours.**

(II) This course covers theory and applications of energy transfer: conduction, convection, and radiation. Fundamentals of microscopic phenomena and their application to macroscopic systems are addressed. Course work also includes application of relevant numerical methods to solve heat transfer problems. Prerequisites: MATH225, grade of C- or better in CHEN307. 3 hours lecture; 3 semester hours.

**CHEN312. UNIT OPERATIONS LABORATORY. 3.0 Hours.**

Summer (WI) Unit Operations Laboratory. This course covers principles of mass, energy, and momentum transport as applied to laboratory-scale processing equipment. Written and oral communications skills, teamwork, and critical thinking are emphasized. 6 hours lab, 6 semester hours. Prerequisites: CHEN201, CHEN202, CHEN307, CHEN308, CHEN357, CHEN375, EPIC265 or equivalent.

**CHEN313. UNIT OPERATIONS LABORATORY. 3.0 Hours.**

Summer (WI) Unit Operations Laboratory. This course covers principles of mass, energy, and momentum transport as applied to laboratory-scale processing equipment. Written and oral communications skills, teamwork, and critical thinking are emphasized. 6 hours lab, 6 semester hours. Prerequisites: CHEN201, CHEN202, CHEN307, CHEN308, CHEN357, CHEN375, EPIC265 or equivalent.

**CHEN340. COOPERATIVE EDUCATION. 1-3 Hour.**

Cooperative work/education experience involving employment of a chemical engineering nature in an internship spanning at least one academic semester. Prerequisite: consent of instructor. 1 to 3 semester hours. Repeatable to a maximum of 6 hours.

**CHEN350. HONORS UNDERGRADUATE RESEARCH. 1-3 Hour.**

Scholarly research of an independent nature. Prerequisite: Junior standing, consent of instructor. 1 to 3 semester hours.

**CHEN351. HONORS UNDERGRADUATE RESEARCH. 1-3 Hour.**

Scholarly research of an independent nature. Prerequisite: junior standing, consent of instructor. 1 to 3 semester hours.

**CHEN357. CHEMICAL ENGINEERING THERMODYNAMICS. 3.0 Hours.**

(I) Introduction to non-ideal behavior in thermodynamic systems and their applications. Phase and reaction equilibria are emphasized. Relevant aspects of computer-aided process simulation are incorporated. Prerequisites: DCGN210 (or equivalent), MATH225, grade of C- or better in CHEN201. 3 hours lecture; 3 semester hours.

**CHEN358. CHEMICAL ENGINEERING THERMODYNAMICS LABORATORY. 1.0 Hour.**

(II) This course includes an introduction to process modeling as well as hands-on laboratory measurements of physical data. Methods and concepts explored include calculation and analysis of physical properties, phase equilibria, and reaction equilibria and the application of these concepts in chemical engineering. Prerequisite: CHEN202. Corequisite: CHEN357. 3 hours laboratory; 1 semester hour.

**CHEN368. INTRODUCTION TO UNDERGRADUATE RESEARCH. 1.0 Hour.**

(I, II) Introduction to Undergraduate Research. This course introduces research methods and provides a survey of the various fields in which CBE faculty conduct research. Topics such as how to conduct literature searches, critically reading and analyzing research articles, ethics, lab safety, and how to write papers are addressed. Prerequisites: None. 1 hour lecture; 1 semester hour.

**CHEN375. MASS TRANSFER. 3.0 Hours.**

(II) This course covers fundamentals of stage-wise and diffusional mass transport with applications to chemical engineering systems and processes. Relevant aspects of computer-aided process simulation and computational methods are incorporated. Prerequisites: grade of C- or better in CHEN357. 3 hours lecture; 3 semester hours.

**CHEN398. SPECIAL TOPICS. 1-6 Hour.**

Topical courses in chemical engineering of special interest. Prerequisite: consent of instructor; 1 to 6 semester hours. Repeatable for credit under different titles.

**CHEN399. INDEPENDENT STUDY. 1-6 Hour.**

Individual research or special problem projects. Topics, content, and credit hours to be agreed upon by student and supervising faculty member. Prerequisite: consent of instructor and department head, submission of "Independent Study" form to CSM Registrar. 1 to 6 semester hours. Repeatable for credit.

**CHEN401. INTRODUCTION TO CHEMICAL PROCESS DESIGN. 3.0 Hours.**

(I) This course introduces skills and knowledge required to develop conceptual designs of new processes and tools to analyze, troubleshoot, and optimize existing processes. Prerequisites: ChEN201, ChEN308, ChEN307, ChEN357, ChEN375 or consent of instructor. 3 hours lecture; 3 semester hours.

**CHEN402. CHEMICAL ENGINEERING DESIGN. 3.0 Hours.**

(II) (WI) This course covers simulation, synthesis, analysis, evaluation, as well as costing and economic evaluation of chemical processes. Computer-aided process simulation to plant and process design is applied. 3 hours lecture; 3 Semester hours. Prerequisites: CHEN307, CHEN308, CHEN357, CHEN375, CHEN418 (co-requisite), CHEN421 (co-requisite), or consent of instructor.

**CHEN403. PROCESS DYNAMICS AND CONTROL. 3.0 Hours.**

(II) Mathematical modeling and analysis of transient systems. Applications of control theory to response of dynamic chemical engineering systems and processes. 3 hours lecture, 3 semester hours. Prerequisites: CHEN201, CHEN307, CHEN308, CHEN375, MATH315 or consent on instructor.

**CHEN408. NATURAL GAS PROCESSING. 3.0 Hours.**

(II) Application of chemical engineering principles to the processing of natural gas. Emphasis on using thermodynamics and mass transfer operations to analyze existing plants. Relevant aspects of computer-aided process simulation. Prerequisites: CHGN221, ChEN201, ChEN307, ChEN308, ChEN357, ChEN375, or consent of instructor. 3 hours lecture, 3 semester hours.

**CHEN409. PETROLEUM PROCESSES. 3.0 Hours.**

(I) Application of chemical engineering principles to petroleum refining. Thermodynamics and reaction engineering of complex hydro carbon systems. Relevant aspects of computer-aided process simulation for complex mixtures. Prerequisite: CHGN221, ChEN201, ChEN357, ChEN375, or consent of instructor. 3 hours lecture; 3 semester hours.

**CHEN415. POLYMER SCIENCE AND TECHNOLOGY. 3.0 Hours.**

Chemistry and thermodynamics of polymers and polymer solutions. Reaction engineering of polymerization. Characterization techniques based on solution properties. Materials science of polymers in varying physical states. Processing operations for polymeric materials and use in separations. Prerequisite: CHGN221, MATH225, ChEN357, or consent of instructor. 3 hours lecture; 3 semester hours.

**CHEN416. POLYMER ENGINEERING AND TECHNOLOGY. 3.0 Hours.**

Polymer fluid mechanics, polymer rheological response, and polymer shape forming. Definition and measurement of material properties. Interrelationships between response functions and correlation of data and material response. Theoretical approaches for prediction of polymer properties. Processing operations for polymeric materials; melt and flow instabilities. Prerequisite: ChEN307, MATH225, or consent of instructor. 3 hours lecture; 3 semester hours.

**CHEN418. KINETICS AND REACTION ENGINEERING. 3.0 Hours.**

(I) (WI) This course emphasizes applications of the fundamentals of thermodynamics, physical chemistry, organic chemistry, and material and energy balances to the engineering of reactive processes. Key topics include reactor design, acquisition and analysis of rate data, and heterogeneous catalysis. Computational methods as related to reactor and reaction modeling are incorporated. Prerequisites: CHEN308, CHEN357, MATH225, CHGN221, CHGN353, or consent of instructor. 3 hours lecture; 3 semester hours.

**CHEN420. MATHEMATICAL METHODS IN CHEMICAL ENGINEERING. 3.0 Hours.**

Formulation and solution of chemical engineering problems using numerical solution methods within the Excel and MathCAD environments. Setup and numerical solution of ordinary and partial differential equations for typical chemical engineering systems and transport processes. Prerequisite: MATH225, DCGN209 or DCGN210, ChEN307, ChEN357, or consent of instructor. 3 hours lecture; 3 semester hours.

**CHEN421. ENGINEERING ECONOMICS. 3.0 Hours.**

(II) Time value of money concepts of present worth, future worth, annual worth, rate of return and break-even analysis applied to after-tax economic analysis of mineral, petroleum and general investments. Related topics on proper handling of (1) inflation and escalation, (2) leverage (borrowed money), (3) risk adjustment of analysis using expected value concepts, (4) mutually exclusive alternative analysis and service producing alternatives. Prerequisite: EBGN201. 3 hours lecture; 3 semester hours.

**CHEN430. TRANSPORT PHENOMENA. 3.0 Hours.**

(I) This course covers theory and applications of momentum, energy, and mass transfer based on microscopic control volumes. Analytical and numerical solution methods are employed in this course. Prerequisites: CHEN307, CHEN308, CHEN357, CHEN375, MATH225. 3 hours lecture; 3 semester hours.

**CHEN432. TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS. 3.0 Hours.**

The goal of this course is to develop and analyze models of biological transport and reaction processes. We will apply the principles of mass, momentum, and energy conservation to describe mechanisms of physiology and pathology. We will explore the applications of transport phenomena in the design of drug delivery systems, engineered tissues, and biomedical diagnostics with an emphasis on the barriers to molecular transport in cardiovascular disease and cancer. Prerequisites: CHEN430 or equivalent. 3 lecture hours, 3 credit hours.

**CHEN435. INTERDISCIPLINARY MICROELECTRONICS. 3.0 Hours.**

(II) Application of science and engineering principles to the design, fabrication, and testing of microelectronic devices. Emphasis on specific unit operations and the interrelation among processing steps. Prerequisites: Senior standing in PHGN, ChEN, MTGN, or EGGN. Consent of instructor. Due to lab space the enrollment is limited to 20 students. 1.5 hours lecture, 4 hours lab; 3 semester hours.

**CHEN440. MOLECULAR PERSPECTIVES IN CHEMICAL ENGINEERING. 3.0 Hours.**

Applications of statistical and quantum mechanics to understanding and prediction of equilibrium and transport properties and processes. Relations between microscopic properties of materials and systems to macroscopic behavior. Prerequisite: ChEN307, ChEN308, ChEN357, ChEN375, CHGN351 and CHGN353, CHGN221 and CHGN222, MATH225, or consent of instructor. 3 hours lecture; 3 semester hours.

**CHEN450. HONORS UNDERGRADUATE RESEARCH. 1-3 Hour.**

Scholarly research of an independent nature. Prerequisite: senior standing, consent of instructor. 1 to 3 semester hours.

**CHEN451. HONORS UNDERGRADUATE RESEARCH. 1-3 Hour.**

Scholarly research of an independent nature. Prerequisite: senior standing, consent of instructor. 1 to 3 semester hours.

**CHEN460. BIOCHEMICAL PROCESS ENGINEERING. 3.0 Hours.**

(I) The analysis and design of microbial reactions and biochemical unit operations, including processes used in conjunction with bioreactors, are investigated in this course. Industrial enzyme technologies are developed and explored. A strong focus is given to the basic processes for producing fermentation products and biofuels. Biochemical systems for organic oxidation and fermentation and inorganic oxidation and reduction are presented. Prerequisites: CHEN375, CHGN428, CHGN462 or consent of instructor. 3 hours lecture; 3 semester hours.

**CHEN461. BIOCHEMICAL PROCESS ENGINEERING LABORATORY. 1.0 Hour.**

(I) This course emphasizes bio-based product preparation, laboratory measurement, and calculation and analysis of bioprocesses including fermentation and bio-solids separations and their application to biochemical engineering. Computer-aided process simulation is incorporated. Prerequisites: CHEN375, CHGN428, CHGN462 or consent of instructor. Co-requisite: CHEN460, 3 hours laboratory, 1 semester hour.

**CHEN469. FUEL CELL SCIENCE AND TECHNOLOGY. 3.0 Hours.**

(I) Investigate fundamentals of fuel-cell operation and electrochemistry from a chemical-thermodynamics and materials- science perspective. Review types of fuel cells, fuel-processing requirements and approaches, and fuel-cell system integration. Examine current topics in fuel-cell science and technology. Fabricate and test operational fuel cells in the Colorado Fuel Cell Center. Prerequisites: EGGN371 or ChEN357 or MTGN351, or consent of instructor. 3 hours lecture; 3 semester hours.

**CHEN470. INTRODUCTION TO MICROFLUIDICS. 3.0 Hours.**

(I) This course introduces the basic principles and applications of microfluidic systems. Concepts related to microscale fluid mechanics, transport, physics, and biology are presented. To gain familiarity with small-scale systems, students are provided with the opportunity to design, fabricate, and test a simple microfluidic device. Prerequisites: ChEN307 (or equivalent) and DCGN210 (or equivalent) or permission of instructor. 3 semester hours. ChEN480.

**CHEN472. INTRODUCTION TO ENERGY TECHNOLOGIES. 3.0 Hours.**

(II) In this course the student will gain an understanding about energy technologies including how they work, how they are quantitatively evaluated, what they cost, and what is their benefit or impact on the natural environment. There will be discussions about proposed energy systems and how they might become a part of the existing infrastructure. However, to truly understand the impact of proposed energy systems, the student must also have a grasp on the infrastructure of existing energy systems. Prerequisites: CHEN250 Intro to Chemical Engineering Analysis & Design, CHEN357 Chemical Engineering Thermodynamics (or equivalent). 3 lecture hours, 3 credit hours.

**CHEN480. NATURAL GAS HYDRATES. 3.0 Hours.**

The purpose of this class is to learn about clathrate hydrates, using two of the instructor's books, (1) Clathrate Hydrates of Natural Gases, Third Edition (2008) co-authored by C.A.Koh, and (2) Hydrate Engineering, (2000). Using a basis of these books, and accompanying programs, we have abundant resources to act as professionals who are always learning. 3 hours lecture; 3 semester hours.

**CHEN497. SPECIAL SUMMER COURSE. 15.0 Hours.****CHEN498. SPECIAL TOPICS IN CHEMICAL ENGINEERING. 1-6 Hour.**

Topical courses in chemical engineering of special interest. Prerequisite: consent of instructor; 1 to 6 semester hours. Repeatable for credit under different titles.

**CHEN499. INDEPENDENT STUDY. 1-6 Hour.**

Individual research or special problem projects. Topics, content, and credit hours to be agreed upon by student and supervising faculty member. Prerequisite: consent of instructor and department head, submission of "Independent Study" form to CSM Registrar. 1 to 6 semester hours. Repeatable for credit.

**DCGN210. INTRO TO ENG THERMODYNAMICS. 3.0 Hours.**

(I, II) Introduction to the fundamental principles of classical engineering thermodynamics.

Application of mass and energy balances to closed and open systems including systems undergoing transient processes. Entropy generation and the second law of thermodynamics for closed and open systems. Introduction to phase equilibrium and chemical reaction equilibria. Ideal solution behavior. Prerequisites: CHGN121, CHGN124, MATH111, MATH112, PHGN100. 3 hours lecture; 3 semester hours. Students with credit in DCGN209 may not also receive credit in DCGN210.

# Chemistry and Geochemistry

<http://chemistry.mines.edu>

## Program Description

Chemistry is the field of science associated with atoms and molecules. It focuses on the behavior and properties of matter, the reactions and transformations that dictate chemical processes, and the creation of new substances. Chemistry is the primary field that deals with nanoscience and nanotechnology. It is often considered the central science, linking the physical sciences with engineering, medicine, and life sciences. The subject of chemistry is typically organized into more focused subdisciplines, including organic chemistry, physical chemistry, inorganic chemistry, biochemistry, analytical chemistry, theoretical and computational chemistry, and materials chemistry. A degree in chemistry examines these topics to promote a fundamental understanding of the world and an application toward technological problems. Professional chemists apply their knowledge in many different areas ranging from environmental processes to the development of new materials and renewable energy. They work in academic environments, high-tech start-ups, and research and development laboratories associated with practically every advanced technological field including medicine, energy, biotechnology, computing, and agriculture.

The B.S. degree program in chemistry is approved by the American Chemical Society (ACS) and is designed to educate professionals for the varied career opportunities this central scientific discipline affords. The curricula are therefore founded in rigorous fundamental science complemented by application of these principles to the materials, energy, minerals, or environmental fields. For example, specific curricular tracks emphasizing environmental chemistry or biochemistry are offered along with a more flexible chemistry track that can be tailored to optimize preparation consistent with a student's individual career goals. Those aspiring to enter Ph.D. programs in chemistry are encouraged to include undergraduate research beyond the minimum required among their elective hours. Others interested in industrial chemistry choose area of special interest courses, for example in chemical engineering or metallurgy. A significant number of students complete degrees in both chemistry and chemical engineering as an excellent preparation for industrial careers.

The instructional and research laboratories located in Coolbaugh Hall are state-of-the-art facilities with modern instrumentation for synthesis and characterization of molecules and materials. Instrumentation includes: gas chromatographs (GC), high-performance liquid chromatographs (HPLC), inductively-coupled-plasma-atomic emission spectrometers (ICP-AES), field-flow fractionation (FFF) equipment, mass spectrometry equipment (MS, GC/MS, GC/MS/MS, PY/MS, PY/GC/MS, SFC/MS, MALDI-TOF), 400 MHz and 500 MHz nuclear magnetic resonance spectrometers (NMR), infrared spectrometers (FTIR), ultraviolet-visible (UV) spectrometers, thermogravimetric analyzers (TGA), differential scanning calorimeters (DSC), and others including equipment for microscopy, light scattering, and elemental analysis. In addition, the campus provides access to the CSM 2,144 core 23 teraflop supercomputer for computational research.

## Program Educational Objectives (Bachelor of Science in Chemistry)

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria, the B.S. curricula in chemistry are designed to:

- Impart mastery of chemistry fundamentals;
- Develop ability to apply chemistry fundamentals in solving open-ended problems;
- Impart knowledge of and ability to use modern tools of chemical analysis and synthesis;
- Develop ability to locate and use pertinent information from the chemical literature;
- Develop ability to interpret and use experimental data for chemical systems;
- Develop ability to effectively communicate in both written and oral formats;
- Prepare students for entry to and success in professional careers;
- Prepare students for entry to and success in graduate programs; and
- Prepare students for responsible contribution to society.

## Curriculum

The B.S. chemistry curricula, in addition to the strong basis provided by the common core, contain three components: chemistry fundamentals, laboratory and communication skills, and applications courses.

## Chemistry fundamentals

- Analytical chemistry - sampling, method selection, statistical data analysis, error sources, theory of operation of analytical instruments (atomic and molecular spectroscopy, mass spectrometry, nuclear magnetic resonance spectroscopy, chromatography and other separation methods, electroanalytical methods, and thermal methods), calibration, standardization, stoichiometry of analysis, equilibrium and kinetic principles in analysis.
- Inorganic chemistry - atomic structure and periodicity, crystal lattice structure, molecular geometry and bonding (VSEPR, Lewis structures, VB and MO theory, bond energies and lengths), metals structure and properties, acid-base theories, main-group element chemistry, coordination chemistry, term symbols, ligand field theory, spectra and magnetism of complexes, organometallic chemistry, and nanomaterials chemistry and design.
- Organic chemistry - bonding and structure, structure-physical property relationships, reactivity-structure relationships, reaction mechanisms (nucleophilic and electrophilic substitution, addition, elimination, radical reactions, rearrangements, redox reactions, photochemical reactions, and metal-mediated reactions), chemical kinetics, catalysis, major classes of compounds and their reactions, and design of synthetic pathways.
- Physical chemistry - thermodynamics (energy, enthalpy, entropy, equilibrium constants, free energy, chemical potential, non-ideal systems, standard states, activity, phase rule, phase equilibria, phase diagrams), electrochemistry, kinetic theory (Maxwell-Boltzmann distribution, collision frequency, effusion, heat capacity, equipartition of energy), kinetics (microscopic reversibility, relaxation processes, mechanisms and rate laws, collision and absolute rate theories), quantum mechanics (Schrödinger equations, operators and matrix elements, particle-in-a-box, simple harmonic oscillator, rigid rotor, angular momentum, hydrogen atom, hydrogen wave functions, spin, Pauli principle, LCAO method, MO theory, bonding), spectroscopy (dipole selection rules, rotational spectra, term symbols, atomic and molecular electronic spectra, magnetic spectroscopy, Raman spectroscopy, multiphoton selection rules, lasers), statistical thermodynamics (ensembles, partition functions,



Einstein crystals, Debye crystals), group theory, surface chemistry, X-ray crystallography, electron diffraction, dielectric constants, dipole moments, and elements of computational chemistry.

## Laboratory and communication skills

- Analytical methods - gravimetry, titrimetry, sample dissolution, quantitative spectroscopy, GC, HPLC, GC/MS, potentiometry, NMR, AA, ICP-AES
- Synthesis techniques - batch reactor assembly, inert-atmosphere manipulations, vacuum line methods, high-temperature methods, high-pressure methods, distillation, recrystallization, extraction, sublimation, chromatographic purification, product identification
- Physical measurements - refractometry, viscometry, colligative properties, FTIR, NMR
- Information retrieval - Chemical Abstracts online searching, CA registry numbers, Beilstein, Gmelin, handbooks, organic syntheses, organic reactions, inorganic syntheses, primary sources, ACS Style Guide
- Reporting - lab notebook, experiment and research reports, technical oral reports
- Communication - scientific reviews, seminar presentations, publication of research results

## Applications

- Elective courses - application of chemistry fundamentals in chemistry elective courses or courses in another discipline; e.g. chemical engineering, environmental science, materials science
- Internship - summer or semester experience in an industrial or governmental organization working on real-world problems
- Undergraduate research - open-ended problem solving in the context of a research project

Students are strongly encouraged to go to <http://chemistry.mines.edu> for the most up-to-date curriculum flowcharts and degree requirements.

## Degree Requirements (Chemistry Track)

### Freshman

	lec	lab	sem.hrs
Common Core			33.0
			<b>33.0</b>

### Sophomore

	lec	lab	sem.hrs
<b>Fall</b>			
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0	4
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	2.0	4.0
DCGN209	DIST CORE THERMO	3.0	3
CHGN221	ORGANIC CHEMISTRY I	3.0	3
CHGN223	ORGANIC CHEMISTRY I LABORATORY	3.0	1
PAGN2XX	PHYSICAL EDUCATION		0.5
			<b>16.0</b>
<b>Spring</b>			
SYGN200	HUMAN SYSTEMS	3.0	3
EBGN201	PRINCIPLES OF ECONOMICS	3.0	3

CHGN222	ORGANIC CHEMISTRY II	3.0		3
CHGN224	ORGANIC CHEMISTRY II LABORATORY		3.0	1
MATH225	DIFFERENTIAL EQUATIONS	3.0		3
CHGN335	INSTRUMENTAL ANALYSIS	3.0		3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>16.5</b>

### Junior

		lec	lab	sem.hrs
<b>Fall</b>				
CHGN336	ANALYTICAL CHEMISTRY	3.0		3
CHGN337	ANALYTICAL CHEMISTRY LABORATORY		3.0	1
CHGN341	DESCRIPTIVE INORGANIC CHEMISTRY	3.0		3
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	3.0	4
CHGN395	INTRODUCTION TO UNDERGRADUATE RESEARCH		3.0	1
LAIS/EBGN	H&SS Restricted Elective I	3.0		3.0
FREE	Free Elective	3.0		3.0
				<b>18.0</b>
<b>Spring</b>				
CHGN353	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II	3.0	3.0	4
CHGN323	QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY	1.0	3.0	2
CHGN428	BIOCHEMISTRY	3.0		3
TECH ELECT	Technical Elective *	3.0		3.0
TECH ELECT	Technical Elective *	3.0		3.0
				<b>15.0</b>

		lec	lab	sem.hrs
<b>Summer</b>				
CHGN490	SYNTHESIS AND CHARACTERIZATION		18.0	6
				<b>6.0</b>
<b>Senior</b>				
<b>Fall</b>				
LAIS/EBGN	H&SS Restricted Elective II	3.0		3.0
CHGN ELECT	Chemistry Elective **			3.0
TECH ELECT	Technical Elective *	3.0		3.0
TECH ELECT	Technical Elective *	3.0		3.0
FREE	Free Elective	3.0		3.0
				<b>15.0</b>
<b>Spring</b>				
LAIS/EBGN	H&SS Restricted Elective III	3.0		3.0
CHGN401	THEORETICAL INORGANIC CHEMISTRY	3.0		3

CHGN ELECT	Chemistry Elective **		2.0
TECH ELECT	Technical Elective *	3.0	3.0
FREE	Free Elective	3.0	3.0
			<b>14.0</b>

Total Hours: 133.5

\* Technical Electives are courses in any technical field. Examples of possible electives that will be recommended to students are:

SYGN203	NATURAL & ENGINEERED ENVIR SYS	3.0
PHGN300	PHYSICS III-MODERN PHYSICS I	3.0
EBGN305	FINANCIAL ACCOUNTING	3.0
EBGN306	MANAGERIAL ACCOUNTING	3.0
EBGN310	ENVIRONMENTAL AND RESOURCE ECONOMICS	3.0
BELS301/	GENERAL BIOLOGY I	3.0
ESGN353	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I	3.0
GEGN206	EARTH MATERIALS	3.0
MATH323	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
MATH332	LINEAR ALGEBRA	3.0
MNGN210	INTRODUCTORY MINING	3.0
MTGN311	STRUCTURE OF MATERIALS	4.0
PEGN102	INTRODUCTION TO PETROLEUM INDUSTRY	3.0
PHGN419	PRINCIPLES OF SOLAR ENERGY SYSTEMS	3.0
CHGN430	INTRODUCTION TO POLYMER SCIENCE	3.0
CHGN462	MICROBIOLOGY AND THE ENVIRONMENT	3.0

\*\* Chemistry Electives are non-required courses taught within the Chemistry Department. In addition, graduate level Chemistry and Geochemistry courses taught within the Department are acceptable.

CHGN495 SENIOR UNDERGRADUATE RESEARCH is taught as a possible chemistry elective. Those aspiring to enter Ph.D. programs in Chemistry or related fields are encouraged to include undergraduate research in their curricula. The objective of CHGN495 is that students successfully perform an open-ended research project under the direction of a CSM faculty member. Students must demonstrate through the preparation of a proposal, prepared in consultation with the potential faculty research advisor and the CHGN495 instructor, that they qualify for enrollment in CHGN495. Up to 5 credit hours of CHGN495 can be taken.

**Students are strongly encouraged to go to <http://chemistry.mines.edu> for the most up-to-date curriculum flowcharts and degree requirements.**

## Environmental Chemistry Track

### Freshman

	lec	lab	sem.hrs
Common Core			33.0
			<b>33.0</b>

### Sophomore

	lec	lab	sem.hrs
<b>Fall</b>			
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0	4

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	2.0	4.0	4.5
DCGN209	DIST CORE THERMO	3.0		3
CHGN221	ORGANIC CHEMISTRY I	3.0		3
CHGN223	ORGANIC CHEMISTRY I LABORATORY		3.0	1
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>16.0</b>

<b>Spring</b>		lec	lab	sem.hrs
SYGN200	HUMAN SYSTEMS	3.0		3
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3
CHGN222	ORGANIC CHEMISTRY II	3.0		3
CHGN224	ORGANIC CHEMISTRY II LABORATORY		3.0	1
MATH225	DIFFERENTIAL EQUATIONS	3.0		3
CHGN335	INSTRUMENTAL ANALYSIS	3.0		3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>16.5</b>

<b>Junior</b>		lec	lab	sem.hrs
<b>Fall</b>				
CHGN336	ANALYTICAL CHEMISTRY	3.0		3
CHGN337	ANALYTICAL CHEMISTRY LABORATORY	3.0	1.0	1
CHGN341	DESCRIPTIVE INORGANIC CHEMISTRY	3.0		3
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	3.0	4
CHGN395	INTRODUCTION TO UNDERGRADUATE RESEARCH	3.0	1.0	1
LAIS/EBGN	H&SS Restricted Elective I	3.0		3.0
CHEV ELECT	Environmental Elective **	3.0		3.0
				<b>18.0</b>

<b>Spring</b>		lec	lab	sem.hrs
CHGN353	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II	3.0	3.0	4
CHGN323	QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY	1.0	3.0	2
CHGN428	BIOCHEMISTRY	3.0		3
CHEV ELECT	Environmental Elective **	3.0		3.0
TECH ELECT	Technical Elective *	3.0		3.0
				<b>15.0</b>

<b>Summer</b>		lec	lab	sem.hrs
CHGN490	SYNTHESIS AND CHARACTERIZATION		18.0	6
				<b>6.0</b>

**Senior**

		lec	lab	sem.hrs
<b>Fall</b>				
CHEV ELECT	Environmental Elective **	3.0		3.0
CHEV ELECT	Environmental Elective **	3.0		3.0
LAIS/EBGN	H&SS Restricted Elective II	3.0		3.0
CHGN ELECT	Chemistry Elective **			3.0
FREE	Free Elective	3.0		3.0
				<b>15.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHGN410	SURFACE CHEMISTRY	3.0		3
LAIS/EBGN	H&SS Restricted Elective III	3.0		3.0
CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY	3.0		3
CHGN ELECT	Chemistry Elective **			2.0
FREE	Free Elective	3.0		3.0
				<b>14.0</b>

Total Hours: 133.5

\* Technical Electives are courses in any technical field. LAIS, PAGN, Military Science and ROTC, McBride and the business courses of EBGN are **not** accepted technical electives.

\*\* Chemistry Electives are non-required courses taught within the Chemistry Department. In addition, graduate level Chemistry and Geochemistry courses taught within the Department are acceptable.

CHGN495 SENIOR UNDERGRADUATE RESEARCH is taught as a possible chemistry elective. Those aspiring to enter Ph.D. programs in Chemistry or related fields are encouraged to include undergraduate research in their curricula. The objective of CHGN495 is that students successfully perform an open-ended research project under the direction of a CSM faculty member. Students must demonstrate through the preparation of a proposal, prepared in consultation with the potential faculty research advisor and the CHGN495 instructor, that they qualify for enrollment in CHGN495. Up to 5 credit hours of CHGN495 can be taken.

**Students are strongly encouraged to go to <http://chemistry.mines.edu> for the most up-to-date curriculum flowcharts and degree requirements.**

**Biochemistry Track****Freshman**

		lec	lab	sem.hrs
Common Core				33.0
				<b>33.0</b>

**Sophomore**

		lec	lab	sem.hrs
<b>Fall</b>				
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	2.0	4.0	4.5
DCGN209	DIST CORE THERMO	3.0		3
CHGN221	ORGANIC CHEMISTRY I	3.0		3

CHGN223	ORGANIC CHEMISTRY I LABORATORY	3.0		1
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>16.0</b>

		lec	lab	sem.hrs
<b>Spring</b>				
SYGN200	HUMAN SYSTEMS	3.0		3
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3
CHGN222	ORGANIC CHEMISTRY II	3.0		3
CHGN224	ORGANIC CHEMISTRY II LABORATORY		3.0	1
MATH225	DIFFERENTIAL EQUATIONS	3.0		3
CHGN335	INSTRUMENTAL ANALYSIS	3.0		3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>16.5</b>

**Junior**

		lec	lab	sem.hrs
<b>Fall</b>				
BELS301	GENERAL BIOLOGY I	3.0		3
BELS311	GENERAL BIOLOGY I LABORATORY	3.0	1.0	1
CHGN336	ANALYTICAL CHEMISTRY	3.0		3
CHGN337	ANALYTICAL CHEMISTRY LABORATORY		3.0	1
CHGN341	DESCRIPTIVE INORGANIC CHEMISTRY	3.0		3
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	4.0	4
CHGN395	INTRODUCTION TO UNDERGRADUATE RESEARCH		3.0	1
				<b>16.0</b>

		lec	lab	sem.hrs
<b>Spring</b>				
CHGN353	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II	3.0	3.0	4
CHGN323	QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY	1.0	3.0	2
CHGN428	BIOCHEMISTRY	3.0		3
BELS303	GENERAL BIOLOGY II	3.0		3
BELS313	GENERAL BIOLOGY II LABORATORY	3.0	1.0	1
LAIS/EBGN	H&SS Restricted Elective I	3.0		3.0
				<b>16.0</b>

		lec	lab	sem.hrs
<b>Summer</b>				
CHGN490	SYNTHESIS AND CHARACTERIZATION		18.0	6
				<b>6.0</b>

**Senior**

		lec	lab	sem.hrs
<b>Fall</b>				
CHGN429	BIOCHEMISTRY II	3.0		3
CHGN ELECT	Chemistry Elective **			3.0
LAIS/EBGN	H&SS Restricted Elective II	3.0		3.0
TECH ELECT	Technical Elective *	3.0		3.0

FREE	Free Elective	3.0	3.0
			<b>15.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>
LAIS/EBGN	H&SS Restricted Elective III	3.0	3.0
CHGN401	THEORETICAL INORGANIC CHEMISTRY	3.0	3
CHGN ELECT	Chemistry Elective**		2.0
FREE	Free Elective	3.0	3.0
FREE	Free Elective	3.0	3.0
			<b>14.0</b>

Total Hours: 132.5

\* Possible technical electives that will be recommended to students are:

CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY	3.0
CHGN462	MICROBIOLOGY AND THE ENVIRONMENT	3.0
BELS321	INTRO TO GENETICS	4.0
BELS402	CELL BIOLOGY AND PHYSIOLOGY	3.0
BELS404	ANATOMY AND PHYSIOLOGY	3.0

\*\* Chemistry Electives are non-required courses taught within the Chemistry Department. In addition, graduate level Chemistry and Geochemistry courses taught within the Department are acceptable.

CHGN495 SENIOR UNDERGRADUATE RESEARCH is taught as a possible chemistry elective. Those aspiring to enter Ph.D. programs in Chemistry or related fields are encouraged to include undergraduate research in their curricula. The objective of CHGN495 is that students successfully perform an open-ended research project under the direction of a CSM faculty member. Students must demonstrate through the preparation of a proposal, prepared in consultation with the potential faculty research advisor and the CHGN495 instructor, that they qualify for enrollment in CHGN495. Up to 5 credit hours of CHGN495 can be taken.

**Students are strongly encouraged to go to <http://chemistry.mines.edu> for the most up-to-date curriculum flowcharts and degree requirements.**

General CSM Minor/ASI requirements can be found [here](#).

## Chemistry Minor and ASI Programs

No specific course sequences are suggested for students wishing to include chemistry minors or areas of special interest in their programs. Rather, those students should consult with the Chemistry department head (or designated faculty member) to design appropriate sequences. For the purpose of completing a minor in Chemistry, the Organic Chemistry sequence is exempt from the 100-200 level limit.

ASI programs include Chemistry, Polymer Chemistry, Environmental Chemistry, and Biochemistry. Refer to the main ASI section of the Bulletin for applicable rules for Areas of Special Interest ([bulletin.mines.edu/undergraduate/sectionundergraduateinformation/specialprograms](http://bulletin.mines.edu/undergraduate/sectionundergraduateinformation/specialprograms)).

## Courses

### CHGN111. INTRODUCTORY CHEMISTRY. 3.0 Hours.

(S) Introductory college chemistry. Elementary atomic structure and the periodic chart, chemical bonding, chemical reactions and stoichiometry of chemical reactions, chemical equilibrium, thermochemistry, and properties of gases. Must not be used for elective credit. Does not apply toward undergraduate degree or g.p.a. 3 hours lecture and 3 hours lab; 3 semester hours.

### CHGN121. PRINCIPLES OF CHEMISTRY I. 4.0 Hours.

(I, II) Study of matter and energy based on atomic structure, correlation of properties of elements with position in periodic chart, chemical bonding, geometry of molecules, phase changes, stoichiometry, solution chemistry, gas laws, and thermochemistry. 3 hours lecture, 3 hours lab; 4 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-SC1.

### CHGN122. PRINCIPLES OF CHEMISTRY II (SC1). 4.0 Hours.

(I, II, S) Continuation of CHGN121 concentrating on chemical kinetics, gas laws, thermodynamics, electrochemistry and chemical equilibrium (acid-base, solubility, complexation, and redox). Laboratory experiments emphasizing quantitative chemical measurements. Prerequisite: Grade of C- or better in CHGN121. 3 hours lecture; 3 hours lab, 4 semester hours.

### CHGN198. SPECIAL TOPICS. 1-6 Hour.

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### CHGN221. ORGANIC CHEMISTRY I. 3.0 Hours.

(I, S) Structure, properties, and reactions of the important classes of organic compounds, introduction to reaction mechanisms. Prerequisites: Grade of C- or better in CHGN122. 3 hours lecture; 3 semester hours.

### CHGN222. ORGANIC CHEMISTRY II. 3.0 Hours.

(II, S) Continuation of CHGN221. Prerequisites: Grade of C- or better in CHGN221. 3 hours lecture; 3 semester hours.

### CHGN223. ORGANIC CHEMISTRY I LABORATORY. 1.0 Hour.

(I,II, S) Laboratory exercises including purification techniques, synthesis, and characterization. Experiments are designed to support concepts presented in the CHGN221. Students are introduced to Green Chemistry principles and methods of synthesis and the use of computational software. Prerequisites: CHGN221 or concurrent enrollment. 3 hours laboratory, 1 semester hour.

### CHGN224. ORGANIC CHEMISTRY II LABORATORY. 1.0 Hour.

(II, S) Laboratory exercises using more advanced synthesis techniques. Experiments are designed to support concepts presented in CHGN222. Prerequisites: CHGN221, CHGN223, and CHGN222 or concurrent enrollment. 3 hours laboratory, 1 semester hour.

### CHGN298. SPECIAL TOPICS. 1-6 Hour.

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**CHGN299. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**CHGN323. QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY. 2.0 Hours.**

(II) Identification, separation and purification of organic compounds including use of modern physical and instrumental methods. Prerequisite: Grade of C- or better in CHGN222, CHGN224. 1 hour lecture; 3 hours lab; 2 semester hours.

**CHGN335. INSTRUMENTAL ANALYSIS. 3.0 Hours.**

(II) Principles of AAS, AES, Visible-UV, IR, NMR, XRF, XRD, XPS, electron, and mass spectroscopy; gas and liquid chromatography; data interpretation. Prerequisite: Grade of C- or better in CHGN122. 3 hours lecture; 3 semester hours.

**CHGN336. ANALYTICAL CHEMISTRY. 3.0 Hours.**

(I) Theory and techniques of gravimetry, titrimetry (acid-base, complexometric, redox, precipitation), electrochemical analysis, chemical separations; statistical evaluation of data. Prerequisite: Grade of C- or better in both CHGN122 and DCGN209 or DCGN210. 3 hours lecture; 3 semester hours.

**CHGN337. ANALYTICAL CHEMISTRY LABORATORY. 1.0 Hour.**

(I) (WI) Laboratory exercises emphasizing sample preparation and instrumental methods of analysis. Prerequisite: CHGN336 or concurrent enrollment. 3 hours lab; 1 semester hour.

**CHGN340. COOPERATIVE EDUCATION. 3.0 Hours.**

(I, II, S) Supervised, full-time, chemistry-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions.

**CHGN341. DESCRIPTIVE INORGANIC CHEMISTRY. 3.0 Hours.**

(I) The chemistry of the elements and periodic trends in reactivity discussed in relation to the preparation and use of inorganic chemicals in industry and the environment. Prerequisite: Grade of C- or better in both CHGN222 and DCGN209 or DCGN210. 3 hours lecture; 3 semester hours.

**CHGN351. PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I. 4.0 Hours.**

(I) A study of chemical systems from a molecular physical chemistry perspective. Includes an introduction to quantum mechanics, atoms and molecules, spectroscopy, bonding and symmetry, and an introduction to modern computational chemistry. Prerequisite: MATH225; PHGN200; Grade of C- or better in both CHGN122 and DCGN209 or DCGN210. 3 hours lecture; 3 hours laboratory; 4 semester hours.

**CHGN353. PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II. 4.0 Hours.**

(II) A continuation of CHGN351. Includes statistical thermodynamics, chemical kinetics, chemical reaction mechanisms, electrochemistry, and selected additional topics. Prerequisite: CHGN351. 3 hours lecture; 3 hours laboratory; 4 semester hours.

**CHGN395. INTRODUCTION TO UNDERGRADUATE RESEARCH. 1.0 Hour.**

(I) (WI) Introduction to Undergraduate Research is designed to introduce students to the research endeavor. Topics include ethics, hypothesis testing, critical evaluation of the scientific literature, scientific writing, bibliographic software, and proposal preparation. Prerequisites: Completion of the chemistry curriculum through the Spring semester of the sophomore year or permission of the department head. Credit: 1 semester hour.

**CHGN396. UNDERGRADUATE RESEARCH. 1-5 Hour.**

(I,II,S) Individual research project for freshman, sophomores or juniors under direction of a member of the departmental faculty. Prerequisites: permission of instructor or department head. Variable credit; 1 to 5 credit hours. Repeatable for credit. Seniors should take CHGN495 instead of CHGN396.

**CHGN398. SPECIAL TOPICS IN CHEMISTRY. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**CHGN398L. SPECIAL TOPICS LAB. 1-6 Hour.****CHGN399. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**CHGN401. THEORETICAL INORGANIC CHEMISTRY. 3.0 Hours.**

(II) Introduction to symmetry and group theory; application of group theory to molecular orbitals and spectroscopy; molecular orbital theory; coordination chemistry; electronic structure of solids and quantum confinement; introduction to preparation and characterization of nanostructured materials. Prerequisite: CHGN341 or consent of instructor. 3 hours lecture; 3 semester hours.

**CHGN403. INTRODUCTION TO ENVIRONMENTAL CHEMISTRY. 3.0 Hours.**

(II) Processes by which natural and anthropogenic chemicals interact, react and are transformed and redistributed in various environmental compartments. Air, soil and aqueous (fresh and saline surface and groundwaters) environments are covered, along with specialized environments such as waste treatment facilities and the upper atmosphere. Prerequisites: CHGN222, DCGN209 or DCGN210 or consent of instructor. 3 hours lecture; 3 semester hours.

**CHGN410. SURFACE CHEMISTRY. 3.0 Hours.**

(II) Introduction to colloid systems, capillarity, surface tension and contact angle, adsorption from solution, micelles and micro-emulsions, the solid/gas interface, surface analytical techniques, van der Waal forces, electrical properties and colloid stability, some specific colloid systems (clays, foams and emulsions). Students enrolled for graduate credit in MLGN510 must complete a special project. Prerequisite: DCGN209 or consent of instructor. 3 hours lecture; 3 semester hours.

**CHGN422. POLYMER CHEMISTRY LABORATORY. 1.0 Hour.**

(I) Prerequisites: CHGN221, CHGN223. 3 hours lab; 1 semester hour.

**CHGN428. BIOCHEMISTRY. 3.0 Hours.**

(I) Introductory study of the major molecules of biochemistry: amino acids, proteins, enzymes, nucleic acids, lipids, and saccharides- their structure, chemistry, biological function, and biosynthesis. Stresses bioenergetics and the cell as a biological unit of organization. Discussion of classical genetics, molecular genetics, and protein synthesis. Prerequisite: CHGN222 or permission of instructor. 3 hours lecture; 3 semester hours.

**CHGN429. BIOCHEMISTRY II. 3.0 Hours.**

(I) A continuation of CHGN428. Topics include: nucleotide synthesis; DNA repair, replication and recombination; transcription, translation and regulation; proteomics; lipid and amino acid synthesis; protein target and degradation; membranes; receptors and signal transduction. Prerequisites: CHGN428 or permission of instructor. 3 hours lecture; 3 semester hours.

**CHGN430. INTRODUCTION TO POLYMER SCIENCE. 3.0 Hours.**

(I) An introduction to the chemistry and physics of macromolecules. Topics include the properties and statistics of polymer solutions, measurements of molecular weights, molecular weight distributions, properties of bulk polymers, mechanisms of polymer formation, and properties of thermosets and thermoplastics including elastomers. Pre requisite: CHGN222 or permission of instructor. 3 hour lecture, 3 semester hours.

**CHGN462. MICROBIOLOGY AND THE ENVIRONMENT. 3.0 Hours.**

This course will cover the basic fundamentals of microbiology, such as structure and function of prokaryotic versus eukaryotic cells; viruses; classification of microorganisms; microbial metabolism, energetics, genetics, growth and diversity, microbial interactions with plants, animals, and other microbes. Additional topics covered will include various aspects of environmental microbiology such as global biogeochemical cycles, bioleaching, bioremediation, and wastewater treatment. Prerequisite: Consent of instructor 3 hours lecture, 3 semester hours. Offered in alternate years.

**CHGN475. COMPUTATIONAL CHEMISTRY. 3.0 Hours.**

(II) This class provides a survey of techniques of computational chemistry, including quantum mechanics (both Hartree-Fock and density functional approaches) and molecular dynamics. Emphasis is given to the integration of these techniques with experimental programs of molecular design and development. Prerequisites: CHGN351, CHGN401. 3 hours lecture; 3 semester hours.

**CHGN490. SYNTHESIS AND CHARACTERIZATION. 6.0 Hours.**

(S) (WI) Advanced methods of organic and inorganic synthesis; high-temperature, high-pressure, inert-atmosphere, vacuumline, and electrolytic methods. Prerequisites: CHGN323, CHGN341. 6-week summer session; 6 semester hours.

**CHGN495. UNDERGRADUATE RESEARCH. 1-5 Hour.**

(I, II, S) (WI) Individual research project under direction of a member of the Departmental faculty. Prerequisites: selection of a research topic and advisor, preparation and approval of a research proposal, completion of chemistry curriculum through the junior year or permission of the department head. Variable credit; 1 to 5 credit hours. Repeatable for credit.

**CHGN496. SPECIAL SUMMER COURSE. 16.0 Hours.****CHGN497. INTERNSHIP. 1-6 Hour.**

(I, II, S) Individual internship experience with an industrial, academic, or governmental host supervised by a Departmental faculty member. Prerequisites: Completion of chemistry curriculum through the junior year or permission of the department head. Variable credit; 1 to 6 credit hours.

**CHGN498. SPECIAL TOPICS IN CHEMISTRY. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**CHGN499. INDEPENDENT STUDY. 0.5-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**DCGN209. DIST CORE THERMO. 3.0 Hours.**

(I, II, S) Introduction to the fundamental principles of classical thermodynamics, with particular emphasis on chemical and phase equilibria. Volume-temperature-pressure relationships for solids, liquids, and gases; ideal and non-ideal gases. Introduction to kinetic molecular theory of ideal gases and the Maxwell-Boltzmann distributions. Work, heat, and application of the First Law to closed systems, including chemical reactions. Entropy and the Second and Third Laws; Gibbs Free Energy. Chemical equilibrium and the equilibrium constant; introduction to activities & fugacities. One- and two-component phase diagrams; Gibbs Phase Rule. Prerequisites: CHGN121, CHGN124, MATH111, MATH112, PHGN100. 3 hours lecture; 3 semester hours. Students with credit in DCGN210 may not also receive credit in DCGN209.

# Metallurgical and Materials Engineering

<http://metallurgy.mines.edu/>

## Program Description

Metallurgical and materials engineering plays a role in all manufacturing processes which convert raw materials into useful products adapted to human needs. The primary goal of the Metallurgical and Materials Engineering program is to provide undergraduates with a fundamental knowledge base associated with materials-processing, their properties, and their selection and application. Upon graduation, students will have acquired and developed the necessary background and skills for successful careers in materials related industries. Furthermore, the benefits of continued education toward graduate degrees and other avenues, and the pursuit of knowledge in other disciplines should be well inculcated.

The emphasis in the Department is on materials processing operations which encompass: the conversion of mineral and chemical resources into metallic, ceramic or polymeric materials; the synthesis of new materials; refining and processing to produce high performance materials for applications from consumer products to aerospace and electronics; the development of mechanical, chemical and physical properties of materials related to their processing and structure; and the selection of materials for specific applications.

The metallurgical and materials engineering discipline is founded on fundamentals in chemistry, mathematics and physics which contribute to building the knowledge base and developing the skills for the processing of materials so as to achieve specifications requested for a particular industrial or advanced product. The engineering principles in this discipline include: crystal structure and structural analysis, thermodynamics of materials, reaction kinetics, transport phenomena, phase equilibria, phase transformations, microstructural evolution, mechanical behavior, and properties of materials.

The core-discipline fundamentals are applied to a broad range of materials processes including extraction and refining of materials, alloy development, casting, mechanical working, joining and forming, ceramic particle processing, high temperature reactions and synthesis of engineered materials. In each stage of processing, the effects of resultant microstructures and morphologies on materials properties and performance are emphasized.

Laboratories, located in Nathaniel Hill Hall, are among the finest in the nation. The laboratories, in conjunction with classroom instruction, provide for a well-integrated education of the undergraduates working towards their baccalaureate degrees. These facilities are well equipped and dedicated to: particulate and chemical/extraction, metallurgical and materials processing, foundry science, corrosion and hydro/electro-metallurgical studies, physical and mechanical metallurgy, welding and joining, forming, processing and testing of ceramic materials. Mechanical testing facilities include computerized machines for tension, compression, torsion, toughness, fatigue and thermo-mechanical testing.

There are also other highly specialized research laboratories dedicated to: vapor deposition, and both plasma and high-temperature reaction systems. Supporting analytical laboratories also exist for surface analysis, emission spectrometry, X-ray analysis, optical microscopy and image analysis, scanning and transmission electron microscopy, and micro-thermal-analysis/mass spectrometry. Metallurgical and materials engineering involves all of the processes that transform precursor materials into final engineered products adapted to human

needs. The objective of the metallurgical and materials engineering program is to impart a fundamental knowledge of materials processing, properties, selection and application in order to provide graduates with the background and skills needed for successful careers in materials-related industries, for continued education toward graduate degrees and for the pursuit of knowledge in other disciplines.

The Engineering Accreditation Commission of ABET  
111 Market Place, Suite 1050  
Baltimore, MD 21202-4012  
Telephone (410) 347-7700

The Departments of Metallurgical and Materials Engineering and Physics collaborate to offer a five-year program designed to meet the needs of the electronics and similar high-tech industries. Students who satisfy the requirements of the program obtain an undergraduate degree in either Engineering Physics or in Metallurgical and Materials Engineering in four years and a Master of Engineering degree in Metallurgical and Materials Engineering at the end of the fifth year. The program is designed to provide a strong background in science fundamentals, as well as specialized training in the materials-science and processing needs of these industries. Thus, the educational objective of the program is to provide students with the specific educational requirements to begin a career in microelectronics and, at the same time, a broad and flexible background necessary to remain competitive in this exciting and rapidly changing industry. The undergraduate electives which satisfy the requirements of the program and an overall curriculum need to be discussed with the student's advisor and approved by the Physics or Metallurgical and Materials Engineering Departments. A Program Mentor in each Department can also provide counseling on the program.

## Metallurgical and Materials Engineering (MME) Program Educational Objectives

The Metallurgical and Materials Engineering (MME) program emphasizes the structure, properties, processing and performance of materials. Program educational objectives are broad statements that describe what graduates are expected to attain within a few years of graduation. The Metallurgical and Materials Engineering program at CSM prepares graduates who:

1. obtain a range of positions in industry or positions in government facilities or pursue graduate education in engineering, science, or other fields;
2. demonstrate advancement in their chosen careers;
3. engage in appropriate professional societies and continuing education activities.

The three MME program educational objectives were determined by using inputs from program constituencies (faculty, students, visiting committee, industry recruiters and alumni). These objectives are consistent with those of the Colorado School of Mines (CSM). CSM is an engineering and applied science institution, dedicated to the education and training of students who will be stewards of the earth's resources.

## Curriculum

The Metallurgical and Materials Engineering (MME) curriculum is organized to educate students in the fundamentals of materials (MME Basics) and their applications (MME Applications) with the option of pursuing a track in one of four focus areas.

**A. MME Basics:** The basic curriculum in the Metallurgical and Materials Engineering program will provide a background in the following topic areas:

1. Crystal Structures and Structural Analysis: crystal systems; symmetry elements and Miller indices; atomic bonding; metallic, ceramic and polymeric structures; x-ray and electron diffraction; stereographic projection and crystal orientation; long range order; defects in materials.
2. Thermodynamics of Materials: heat and mass balances; thermodynamic laws; chemical potential and chemical equilibrium; solution thermodynamics & solution models; partial molar and excess quantities; solid state thermodynamics; thermodynamics of surfaces; electrochemistry.
3. Transport Phenomena and Kinetics: Heat, mass and momentum transport; transport properties of fluids; diffusion mechanisms; reaction kinetics; nucleation and growth kinetics.
4. Phase Equilibria: phase rule; binary and ternary systems; microstructural evolution; defects in crystals; surface phenomena; phase transformations: eutectic, eutectoid, martensitic, nucleation and growth, recovery; microstructural evolution; strengthening mechanisms; quantitative stereology; heat treatment.
5. Properties of Materials: mechanical properties; chemical properties (oxidation and corrosion); electrical, magnetic and optical properties: failure analysis.

**B. MME Applications:** The course content in the Metallurgical and Materials Engineering program emphasizes the following applications:

1. Materials Processing: particulate processing; thermo- and electro-chemical materials processing; hydrometallurgical processing; synthesis of materials; deformation processing; solidification and casting; welding and joining.
2. Design and Application of Materials: materials selection; ferrous and nonferrous metals; ceramics; polymers; composites; electronic materials.
3. Statistical Process Control and Design of Experiments: statistical process control; process capability analysis; design of experiments.

**C. MME Curriculum Requirements:** The Metallurgical and Materials Engineering course sequence is designed to fulfill the program educational objectives. In addition, there are four focus areas within the Metallurgical and Materials Engineering curriculum. Students have the option to select one of these focus areas by pursuing one of four tracks. A track is not required to obtain a degree in Metallurgical and Materials Engineering. Only a single track can be taken as part of the degree. The track designation will only appear on the transcript and it does not appear on the diploma. To pursue a track, the student must file appropriate paper work with the registrar and the student will need to fulfill the curricular requirements for that track as listed below. Once a track has been declared the student can change their track or return to the basic curriculum by submitting appropriate paperwork to the registrar.

The four focus areas (tracks) in MME are:

1. Physical and Manufacturing Metallurgy
2. Ceramic and Electronic Materials
3. Physicochemical Processing of Materials
4. Biomaterials

**D. MME Curriculum Requirements:** The Metallurgical and Materials Engineering course sequence is designed to fulfill the program goals and

to satisfy the curriculum requirements. The time sequence of courses organized by degree program, year and semester, is listed below.

## Degree Requirements (Metallurgical and Materials Engineering)

The B.S. curricula in metallurgical and materials engineering are outlined below:

### Freshman

	lec	lab	sem.hrs
Common Core			33.0
			<b>33.0</b>

### Sophomore

	lec	lab	sem.hrs
DCGN209			3
MATH213			4
PHGN200			4.5
MTGN202			3
PAGN2XX			0.5
			<b>15.0</b>

### Spring

	lec	lab	sem.hrs
MATH225			3
TECH ELECT			3.0
DCGN241			3
EPIC251			3
EBGN201			3
SYGN200			3
PAGN2XX			0.5
			<b>18.5</b>

### Summer

	lec	lab	sem.hrs
MTGN272			3
			<b>3.0</b>

### Junior

	lec	lab	sem.hrs
MTGN311			4
MTGN381			2
MTGN351			3
EGGN320			3
LAIS/EBGN			3.0
FREE			3.0
			<b>18.0</b>

### Spring

	lec	lab	sem.hrs
MTGN334			4
MTGN348			4



MTGN352	METALLURGICAL AND MATERIALS KINETICS	3
LAIS/EBGN	H&SS Cluster Elective II	3.0
FREE	Free Elective	3.0
		<b>17.0</b>

**Senior**

<b>Fall</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MTGN445	MECHANICAL PROPERTIES OF MATERIALS	4			
MTGN461	TRANSPORT PHENOMENA AND REACTOR DESIGN FOR METALLURGICAL-AND-MATERIALS ENGINEERS	3			
MTGN450	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS	3			
MTGN	MTGN Elective	3.0			
LAIS/EBGN	H&SS Cluster Elective III	3.0			
		<b>16.0</b>			

**Spring**

<b>Spring</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MTGN466	MATERIALS DESIGN: SYNTHESIS, CHARACTERIZATION AND SELECTION	3			
MTGN415	ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS	3			
MTGN	MTGN Elective	3.0			
MTGN	MTGN Elective	3.0			
MTGN	MTGN Elective	3.0			
FREE	Free Elective	3.0			
		<b>18.0</b>			

Total Hours: 138.5

**\*\* Restricted Electives:**

BELS301	GENERAL BIOLOGY I	3
CSCI261	PROGRAMMING CONCEPTS	3
CHGN221	ORGANIC CHEMISTRY I	3
CHGN335	INSTRUMENTAL ANALYSIS	3
CHGN336	ANALYTICAL CHEMISTRY	3
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	4
EGGN281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER	3
ENGY200	INTRODUCTION TO ENERGY	3
ESGN353	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I	3
MATH323	PROBABILITY AND STATISTICS FOR ENGINEERS	3
MATH332	LINEAR ALGEBRA	3
MATH348	ADVANCED ENGINEERING MATHEMATICS	3
PHGN215	ANALOG ELECTRONICS	4
PHGN300	PHYSICS III-MODERN PHYSICS I	3

**Physical and Manufacturing Metallurgy Track requires:**

Sophomore and Junior Year is the same as the MME degree

**Freshman**

	<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
Common Core			33.0
			<b>33.0</b>

**Sophomore**

	<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
Sophomore Year			36.5
			<b>36.5</b>

**Junior**

	<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
Junior Year			35.0
			<b>35.0</b>

**Senior**

<b>Fall</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MTGN445	MECHANICAL PROPERTIES OF MATERIALS	4			
MTGN461	TRANSPORT PHENOMENA AND REACTOR DESIGN FOR METALLURGICAL-AND-MATERIALS ENGINEERS	3			
MTGN450	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS	3			
MTGN	Track MTGN Elective <sup>#</sup>	3.0			
LAIS/EBGN	H&SS Cluster Elective	3.0			
		<b>16.0</b>			
<b>Spring</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MTGN466	MATERIALS DESIGN: SYNTHESIS, CHARACTERIZATION AND SELECTION	3			
MTGN415	ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS	3			
MTGN442	ENGINEERING ALLOYS	3			
MTGN	Track MTGN Elective <sup>#</sup>	3.0			
MTGN	Track MTGN Elective <sup>#</sup>	3.0			
FREE	Free Elective	3.0			
		<b>18.0</b>			

Total Hours: 138.5

# Track MTGN Electives must be selected from the following courses:

MTGN300	FOUNDRY METALLURGY	2
MTGN302	FOUNDRY METALLURGY LABORATORY	1
MTGN456	ELECTRON MICROSCOPY	2
MTGN458	ELECTRON MICROSCOPY LABORATORY	1
MTGN464	FORGING AND FORMING	3
MTGN475	METALLURGY OF WELDING	2
MTGN477	METALLURGY OF WELDING LABORATORY	1

**Ceramic and Electronic Materials Track requires:**

Sophomore and Junior Year is the same as the MME degree

<b>Freshman</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
Common Core					33.0
					<b>33.0</b>
<b>Sophomore</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
Sophomore Year					36.5
					<b>36.5</b>
<b>Junior</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
Junior Year					35.0
					<b>35.0</b>
<b>Senior</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
<b>Fall</b>					
MTGN445	MECHANICAL PROPERTIES OF MATERIALS				4
MTGN461	TRANSPORT PHENOMENA AND REACTOR DESIGN FOR METALLURGICAL-AND-MATERIALS ENGINEERS				3
MTGN450	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS				3
MTGN412	CERAMIC ENGINEERING				3
MTGN	Restricted Track MTGN Elective <sup>##</sup>				3.0
					<b>16.0</b>
<b>Spring</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MTGN466	MATERIALS DESIGN: SYNTHESIS, CHARACTERIZATION AND SELECTION				3
MTGN415	ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS				3
MTGN	Track MTGN Elective <sup>#</sup>				3.0
MTGN	MTGN Elective				3.0
FREE	Free Elective				3.0
LAIS/EBGN	H&SS Cluster Elective				3.0
					<b>18.0</b>

Total Hours: 138.5

# Track MTGN Electives must be selected from the following courses:

MTGN414	PROCESSING OF CERAMICS	3
MTGN456	ELECTRON MICROSCOPY	2
MTGN458	ELECTRON MICROSCOPY LABORATORY	1
MTGN465	MECHANICAL PROPERTIES OF CERAMICS	3
MTGN469	FUEL CELL SCIENCE AND TECHNOLOGY	3
CHGN410	SURFACE CHEMISTRY	3
PHGN419	PRINCIPLES OF SOLAR ENERGY SYSTEMS	3
PHGN435	INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY	3

## Restricted Track MTGN Elective must be selected from the following courses:

MTGN414	PROCESSING OF CERAMICS	3
PHGN435	INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY	3

**Physicochemical Processing of Materials Track requires:**

Sophomore and Junior Year is the same as the MME degree

<b>Freshman</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
Common Core					33.0
					<b>33.0</b>
<b>Sophomore</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
Sophomore Year					36.5
					<b>36.5</b>
<b>Junior</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
Junior Year					35.0
					<b>35.0</b>
<b>Senior</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
<b>Fall</b>					
MTGN445	MECHANICAL PROPERTIES OF MATERIALS				4
MTGN461	TRANSPORT PHENOMENA AND REACTOR DESIGN FOR METALLURGICAL-AND-MATERIALS ENGINEERS				3
MTGN450	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS				3
MTGN	Track MTGN Elective <sup>#</sup>				3.0
MTGN	Track MTGN Elective <sup>#</sup>				3.0
					<b>16.0</b>
<b>Spring</b>			<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MTGN466	MATERIALS DESIGN: SYNTHESIS, CHARACTERIZATION AND SELECTION				3
MTGN415	ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS				3
MTGN	Track MTGN Elective <sup>#</sup>				3.0
MTGN	MTGN Elective				3.0
LAIS/EBGN	H&SS Restricted Elective				3.0
FREE	Free Elective				3.0
					<b>18.0</b>

Total Hours: 138.5

# Track MTGN Electives must be selected from the following courses:

MTGN430	PHYSICAL CHEMISTRY OF IRON AND STEELMAKING	3
MTGN431	HYDRO- AND ELECTRO-METALLURGY	3
MTGN432	PYROMETALLURGY	3
MTGN532	PARTICULATE MATERIAL PROCESSING I - COMMINUTION AND PHYSICAL SEPARATIONS	3

MTGN533 PARTICULATE MATERIAL PROCESSING II - APPLIED SEPARATIONS 3

**Biomaterials Track requires:**

Sophomore and Junior Year is the same as the MME degree

**Freshman**

	lec	lab	sem.hrs
Common Core			33.0
			<b>33.0</b>

**Sophomore**

	lec	lab	sem.hrs
Sophomore Year			36.5
			<b>36.5</b>

**Junior**

	lec	lab	sem.hrs
Junior Year			35.0
			<b>35.0</b>

**Senior**

	lec	lab	sem.hrs
MTGN445 MECHANICAL PROPERTIES OF MATERIALS			4
MTGN461 TRANSPORT PHENOMENA AND REACTOR DESIGN FOR METALLURGICAL-AND-MATERIALS ENGINEERS			3
MTGN450 STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS			3
MTGN472 BIOMATERIALS I			3.0
MTGN Track MTGN Elective <sup>#</sup>			3.0
			<b>16.0</b>

**Spring**

	lec	lab	sem.hrs
MTGN466 MATERIALS DESIGN: SYNTHESIS, CHARACTERIZATION AND SELECTION			3
MTGN415 ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS			3
MTGN463 POLYMER ENGINEERING			3
MTGN570 BIOCOMPATIBILITY OF MATERIALS			3
LAIS/EBGN H&SS Restricted Elective			3.0
FREE Free Elective			3.0
			<b>18.0</b>

Total Hours: 138.5

# Track MTGN Elective must be selected from the following courses:

MTGN412 CERAMIC ENGINEERING	3
MTGN451 CORROSION ENGINEERING	3

Five Year Combined Metallurgical and Materials Engineering Baccalaureate and Master of Engineering in Metallurgical and Materials Engineering, with an Electronic-Materials Emphasis.\*

The Departments of Metallurgical and Materials Engineering and Physics collaborate to offer a five-year program designed to meet the needs of the electronics and similar high-tech industries. Students who satisfy the requirements of the program obtain an undergraduate degree in either Engineering Physics or in Metallurgical and Materials Engineering in four years and a Master of Engineering degree in Metallurgical and Materials Engineering at the end of the fifth year. The program is designed to provide a strong background in science fundamentals, as well as specialized training in the materials-science and processing needs of these industries. Thus, the educational objective of the program is to provide students with the specific educational requirements to begin a career in microelectronics and, at the same time, a broad and flexible background necessary to remain competitive in this exciting and rapidly changing industry. The undergraduate electives which satisfy the requirements of the program and an overall curriculum need to be discussed with the student's advisor and approved by the Physics or Metallurgical and Materials Engineering Departments. A Program Mentor in each Department can also provide counseling on the program.

Application for admission to this program should be made during the first semester of the sophomore year (in special cases, later entry may be approved, upon review, by one of the program mentors). Undergraduate students admitted to the program must maintain a 3.0 grade-point average or better. The graduate segment of the program requires a case study report, submitted to the student's graduate advisor. Additional details on the Master of Engineering can be found in the Graduate Degree and Requirements section of the Graduate Bulletin. The case study is started during the student's senior design-project and completed during the year of graduate study. A student admitted to the program is expected to select a graduate advisor, in advance of the graduate-studies final year, and prior to the start of their senior year. The case-study topic is then identified and selected in consultation with the graduate advisor. A formal application, during the senior year, for admission to the graduate program in Metallurgical and Materials Engineering must be submitted to the Graduate School. Students who have maintained all the standards of the program requirements leading up to this step, can expect to be admitted.

\* Additional "Emphasis" areas are being developed in conjunction with other Departments on Campus.

General CSM Minor/ASI requirements can be found [here](#).

## Minor in Metallurgical and Materials Engineering

General Requirements: A minor program in metallurgical and materials engineering consists of a minimum of 18 credit hours of a logical sequence of courses. Only three of these hours may be taken in the student's degree-granting department and no more than three of these hours may be at the 100- or 200- level. Students majoring in metallurgical and material engineering are not eligible to earn a minor in the department.

A minor program declaration (available in the Registrar's Office) must be submitted for approval prior to the student's completion of half of the hours proposed to constitute the program. Approvals are required from the department head of metallurgical and materials engineering, the student's advisor, and the department head or division director in the department or division in which the student is enrolled.

Recommended Courses: The following courses are recommended for students seeking to earn a minor in metallurgical and materials engineering:

MTGN202	ENGINEERED MATERIALS	3.0
MTGN311	STRUCTURE OF MATERIALS	4.0
MTGN348	MICROSTRUCTURAL DEVELOPMENT	4.0
MTGN445	MECHANICAL PROPERTIES OF MATERIALS	4.0
300- or 400- level course in metallurgical and materials engineering		3.0
Total Hours		18.0

Other sequences are permissible to suit the special interests of individual students. These other sequences need to be discussed and approved by the department head in metallurgical and materials engineering.

## Explosive Processing of Materials Minor

Program Advisor: Dr. Stephen Liu

There are very few academic explosive engineering-related programs in the United States of America and around the world. In fact, Colorado School of Mines is the only educational institution that offers an explosive processing of materials minor program in the U.S.A. Built to the tradition of combining academic education with hands-on experience of CSM, this minor program will prepare the students for new and developing applications in materials joining, forming and synthesis that involve the use of explosives.

Under proper development of courses and background in explosives, students enrolled in this program will apply these energetic materials to the processing of traditional and advanced materials. The program focuses on the microstructural and property development in materials as a function of deformation rate. Selection of suitable explosives and proper parameters, selection of specific materials for explosive processing and application, and optimization of post-processing properties are the three major attributes acquired at the completion of this minor program. With the help of the program advisor, the students will design and select the proper course sequence and complete a hands-on research project under the supervision of a faculty advisor.

## Courses

### MTGN198. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING. 1-3 Hour.

(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). The course topic is generally offered only once. Prerequisite: consent of instructor. 1 to 3 semester hours. Repeatable for credit under different titles.

### MTGN199. INDEPENDENT STUDY. 1-3 Hour.

(I, II, S) Independent work leading to a comprehensive report. This work may take the form of conferences, library, and laboratory work. Choice of problem is arranged between student and a specific department faculty-member. Prerequisite: Selection of topic with consent of faculty supervisor; "Independent Study Form" must be completed and submitted to Registrar. 1 to 3 semester hours. Repeatable for credit.

### MTGN202. ENGINEERED MATERIALS. 3.0 Hours.

(I,II) Introduction to the structure, properties, and processing of materials. The historical role that engineered and natural materials have made on the advance of civilization. Engineered materials and their life cycles through processing, use, disposal, and recycle. The impact that engineered materials have on selected systems to show the breadth of properties that are important and how they can be controlled by proper material processing. Recent trends in materials development mimicking natural materials in the context of the structure and functionality of material in living systems. Corequisites: CHGN122, MATH112, PHGN100. 3 hours lecture; 3 semester hours.

### MTGN272. PARTICULATE MATERIALS PROCESSING. 3.0 Hours.

(S) Summer session. Characterization and production of particles. Physical and interfacial phenomena associated with particulate processes. Applications to metal and ceramic powder processing. Laboratory projects and plant visits. Prerequisites: DCGN209 and PHGN200. 3 weeks; 3 semester hours.

### MTGN298. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING. 1-3 Hour.

(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). The course topic is generally offered only once. Prerequisite: consent of instructor. 1 to 3 semester hours. Repeatable for credit under different titles.

### MTGN299. INDEPENDENT STUDY. 1-3 Hour.

(I, II, S) Independent work leading to a comprehensive report. This work may take the form of conferences, library, and laboratory work. Choice of problem is arranged between student and a specific department faculty-member. Prerequisite: Selection of topic with consent of faculty supervisor; "Independent Study Form" must be completed and submitted to Registrar. 1 to 3 semester hours. Repeatable for credit.

### MTGN300. FOUNDRY METALLURGY. 2.0 Hours.

(II) Design and metallurgical aspects of casting, patterns, molding materials and processes, solidification processes, risers and gating concepts, casting defects and inspection, melting practice, cast alloy selection. Prerequisite: PHGN200/PHGN210. Co-requisite: MTGN302 or consent of instructor. 2 hours lecture; 2 semester hours.

### MTGN302. FOUNDRY METALLURGY LABORATORY. 1.0 Hour.

(II) Experiments in the foundry designed to supplement the lectures of MTGN300. Co-requisite: MTGN300. 3 hours lab; 1 semester hour.

### MTGN311. STRUCTURE OF MATERIALS. 4.0 Hours.

(I) (WI) Principles of crystallography and crystal chemistry. Characterization of crystalline materials using X-ray diffraction techniques. Applications to include compound identification, lattice parameter measurement, orientation of single crystals, and crystal structure determination. Laboratory experiments to supplement the lectures. Prerequisites: PHGN200 or PHGN210 and MTGN202. 3 hours lecture, 3 hours lab; 4 semester hours.

**MTGN334. CHEMICAL PROCESSING OF MATERIALS. 4.0 Hours.**

(II) Development and application of fundamental principles related to the processing of metals and materials by thermochemical and aqueous and fused salt electrochemical/chemical routes. The course material is presented within the framework of a formalism that examines the physical chemistry, thermodynamics, reaction mechanisms and kinetics inherent to a wide selection of chemical processing systems. The general formalism provides for a transferable knowledge-base to other systems not specifically covered in the course. Prerequisite: MTGN272, MTGN351 and EPIC251, 3 hours lecture, 3 hours lab, 4 semester hours.

**MTGN340. COOPERATIVE EDUCATION. 1-3 Hour.**

(I, II, S) Supervised, full-time, engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 1 to 3 semester hours. Cooperative education credit does not count toward graduation except under special conditions. Repeatable.

**MTGN348. MICROSTRUCTURAL DEVELOPMENT. 4.0 Hours.**

(II) (WI) An introduction to the relationships between microstructure and properties of materials, with emphasis on metallic and ceramic systems; Fundamentals of imperfections in crystalline materials on material behavior; recrystallization and grain growth; strengthening mechanisms: grain refinement, solid solution strengthening, precipitation strengthening, and microstructural strengthening; and phase transformations. Prerequisite: MTGN311 and MTGN351. 3 hours lecture, 3 hours lab; 4 semester hours.

**MTGN351. METALLURGICAL AND MATERIALS THERMODYNAMICS. 3.0 Hours.**

(I) Applications of thermodynamics in extractive and physical metallurgy and materials science. Thermodynamics of solutions including solution models, calculation of activities from phase diagrams, and measurements of thermodynamic properties of alloys and slags. Reaction equilibria with examples in alloy systems and slags. Phase stability analysis. Thermodynamic properties of phase diagrams in material systems, defect equilibrium and interactions. Prerequisite DCGN209. 3 hours lecture, 3 semester hours.

**MTGN352. METALLURGICAL AND MATERIALS KINETICS. 3.0 Hours.**

(II) Introduction to reaction kinetics: chemical kinetics, atomic and molecular diffusion, surface thermodynamics and kinetics of interfaces and nucleation-and-growth. Applications to materials processing and performance aspects associated with gas/solid reactions, precipitation and dissolution behavior, oxidation and corrosion, purification of semiconductors, carburizing of steel, formation of p-n junctions and other important materials systems. Prerequisite: MTGN351. 3 hours lecture; 3 semester hours.

**MTGN381. INTRODUCTION TO PHASE EQUILIBRIA IN MATERIALS SYSTEMS. 2.0 Hours.**

(I) Review of the concepts of chemical equilibrium and derivation of the Gibbs phase rule. Application of the Gibbs phase rule to interpreting one, two and three component phase equilibrium diagrams. Application to alloy and ceramic materials systems. Emphasis on the evolution of phases and their amounts and the resulting microstructural development. Prerequisite/Co-requisite: MTGN351. 2 hours lecture; 2 semester hours.

**MTGN398. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING. 1-3 Hour.**

(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). The course topic is generally offered only once. Prerequisite: consent of instructor. 1 to 3 semester hours. Repeatable for credit under different titles.

**MTGN399. INDEPENDENT STUDY. 1-3 Hour.**

(I, II, S) Independent work leading to a comprehensive report. This work may take the form of conferences, library, and laboratory work. Choice of problem is arranged between student and a specific department faculty-member. Prerequisite: Selection of topic with consent of faculty supervisor; "Independent Study Form" must be completed and submitted to Registrar. 1 to 3 semester hours. Repeatable for credit.

**MTGN403. SENIOR THESIS. 3.0 Hours.**

(I, II) Two semester individual research under the direction of members of the Metallurgical and Materials Engineering faculty. Work may include library and laboratory research on topics of relevance. Oral presentation will be given at the end of the second semester and written thesis submitted to the committee for evaluation. Prerequisites: Senior standing in the Department of Metallurgical and Materials Engineering and consent of department head. 3 hours per semester. Repeatable for credit to a maximum of 6 hours.

**MTGN412. CERAMIC ENGINEERING. 3.0 Hours.**

(I) Application of engineering principles to nonmetallic and ceramic materials. Processing of raw materials and production of ceramic bodies, glazes, glasses, enamels, and cements. Firing processes and reactions in glass bonded as well as mechanically bonded systems. Prerequisite: MTGN348. 3 hours lecture; 3 semester hours.

**MTGN414. PROCESSING OF CERAMICS. 3.0 Hours.**

(II) Principles of ceramic processing and the relationship between processing and microstructure. Raw materials and raw materials preparation, forming and fabrication, thermal processing, and finishing of ceramic materials will be covered. Principles will be illustrated by case studies on specific ceramic materials. A project to design a ceramic fabrication process is required. Field trips to local ceramic manufacturing operations. Prerequisite: MTGN311 or consent of the instructor. 3 hours lecture; 3 semester hours.

**MTGN415. ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS. 3.0 Hours.**

(II) Survey of the electrical properties of materials, and the applications of materials as electrical circuit components. The effects of chemistry, processing and microstructure on the electrical properties. Functions, performance requirements and testing methods of materials for each type of circuit component. General topics covered are conductors, resistors, insulators, capacitors, energy converters, magnetic materials and integrated circuits. Prerequisites: PHGN200, MTGN311 or MLGN501, or consent of instructor. 3 hours lecture; 3 semester hours.

**MTGN419. NON-CRYSTALLINE MATERIALS. 3.0 Hours.**

(II) Introduction to the principles of glass science-and-engineering and non-crystalline materials in general. Glass formation, structure, crystallization and properties will be covered, along with a survey of commercial glass compositions, manufacturing processes and applications. Prerequisites: MTGN311 or MLGN501, MLGN512/MTGN412, or consent of instructor. 3 hours lecture; 3 semester hours.

**MTGN429. METALLURGICAL ENVIRONMENT. 3.0 Hours.**

(I) Examination of the interface between metallurgical process engineering and environmental engineering. Wastes, effluents and their point sources in metallurgical processes such as mineral concentration, value extraction and process metallurgy are studied in context. Fundamentals of metallurgical unit operations and unit processes with those applicable to waste and effluent control, disposal and materials recycling are covered. Engineering design and engineering cost components are also included for selected examples. Fundamentals and applications receive equal coverage. Prerequisites: MTGN334 or consent of Instructor. 3 hours lecture; 3 semester hours.

**MTGN430. PHYSICAL CHEMISTRY OF IRON AND STEELMAKING. 3.0 Hours.**

(I) Physical chemistry principles of blast furnace and direct reduction production of iron and refining of iron to steel. Discussion of raw materials, productivity, impurity removal, deoxidation, alloy additions, and ladle metallurgy. Prerequisite: MTGN334. 3 hours lecture; 3 semester hours.

**MTGN431. HYDRO- AND ELECTRO-METALLURGY. 3.0 Hours.**

(I) Physicochemical principles associated with the extraction and refining of metals by hydro- and electrometallurgical techniques. Discussion of unit processes in hydrometallurgy, electrowinning, and electrorefining. Analysis of integrated flowsheets for the recovery of nonferrous metals. Prerequisites: MTGN334, MTGN351 and MTGN352. Co-requisite: MTGN461, or consent of instructor. 3 hours lecture; 3 semester hours.

**MTGN432. PYROMETALLURGY. 3.0 Hours.**

(II) Extraction and refining of metals including emerging practices. Modifications driven by environmental regulations and by energy minimization. Analysis and design of processes and the impact of economic constraints. Prerequisite: MTGN334. 3 hours lecture; 3 semester hours.

**MTGN442. ENGINEERING ALLOYS. 3.0 Hours.**

(II) This course is intended to be an important component of the physical metallurgy sequence, to reinforce and integrate principles from earlier courses, and enhance the breadth and depth of understanding of concepts in a wide variety of alloy systems. Metallic systems considered include iron and steels, copper, aluminum, titanium, superalloys, etc. Phase stability, microstructural evolution and structure/property relationships are emphasized. Prerequisite: MTGN348 or consent of instructor. 3 hours lecture; 3 semester hours.

**MTGN445. MECHANICAL PROPERTIES OF MATERIALS. 4.0 Hours.**

(I) (VI) Mechanical properties and relationships. Plastic deformation of crystalline materials. Relationships of microstructures to mechanical strength. Fracture, creep, and fatigue. Laboratory sessions devoted to advanced mechanical-testing techniques to illustrate the application of the fundamentals presented in the lectures. Prerequisite: MTGN348. 3 hours lecture, 3 hours lab; 4/3\* semester hours. \*This is a 3 semester-hours graduate-course in the Materials Science Program (ML) and a 4 semester-hours undergraduate- course in the Metallurgical and Materials Engineering program.

**MTGN450. STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS. 3.0 Hours.**

(I) Introduction to statistical process control, process capability analysis and experimental design techniques. Statistical process control theory and techniques developed and applied to control charts for variables and attributes involved in process control and evaluation. Process capability concepts developed and applied to the evaluation of manufacturing processes. Theory of designed experiments developed and applied to full factorial experiments, fractional factorial experiments, screening experiments, multilevel experiments and mixture experiments. Analysis of designed experiments by graphical and statistical techniques. Introduction to computer software for statistical process control and for the design and analysis of experiments. Prerequisite: Consent of Instructor. 3 hours lecture, 3 semester hours.

**MTGN451. CORROSION ENGINEERING. 3.0 Hours.**

(II) Principles of electrochemistry. Corrosion mechanisms. Methods of corrosion control including cathodic and anodic protection and coatings. Examples, from various industries, of corrosion problems and solutions. Prerequisite: DCGN209. 3 hours lecture; 3 semester hours.

**MTGN456. ELECTRON MICROSCOPY. 2.0 Hours.**

(II) Introduction to electron optics and the design and application of transmission and scanning electron microscopes. Interpretation of images produced by various contrast mechanisms. Electron diffraction analysis and the indexing of electron diffraction patterns. Prerequisite: MTGN311 or Consent of Instructor. Co-requisite: MTGN458. 2 hours lecture; 2 semester hours.

**MTGN458. ELECTRON MICROSCOPY LABORATORY. 1.0 Hour.**

(II) Laboratory exercises to illustrate specimen preparation techniques, microscope operation, and the interpretation of images produced from a variety of specimens, and to supplement the lectures in MTGN456. Co-requisite: MTGN456. 3 hours lab; 1 semester hour.

**MTGN461. TRANSPORT PHENOMENA AND REACTOR DESIGN FOR METALLURGICAL-AND-MATERIALS ENGINEERS. 3.0 Hours.**

(I) Introduction to the conserved-quantities: momentum, heat, and mass transfer, and application of chemical kinetics to elementary reactor-design. Examples from materials processing and process metallurgy. Molecular transport properties: viscosity, thermal conductivity, and mass diffusivity of materials encountered during processing operations. Uni-directional transport: problem formulation based on the required balance of the conserved-quantity applied to a control-volume. Prediction of velocity, temperature and concentration profiles. Equations of change: continuity, motion, and energy. Transport with two independent variables (unsteady-state behavior). Interphase transport: dimensionless correlations friction factor, heat, and mass transfer coefficients. Elementary concepts of radiation heat-transfer. Flow behavior in packed beds. Design equations for: continuous- flow/batch reactors with uniform dispersion and plug flow reactors. Digital computer methods for the design of metallurgical systems. Laboratory sessions devoted to: tutorials/ demonstrations to facilitate the understanding of concepts related to selected topics; and, Projects with the primary focus on the operating principles and use of modern electronic- instrumentation for measurements on lab-scale systems in conjunction with correlation and prediction strategies for analysis of results. Prerequisites: MATH225, MTGN334 and MTGN352. 2 hours lecture, 3 hours lab; 3 semester hours.

**MTGN462. SOLID WASTE MINIMIZATION AND RECYCLING. 3.0 Hours.**

(I) This course will examine, using case studies, how industry applies engineering principles to minimize waste formation and to meet solid waste recycling challenges. Both proven and emerging solutions to solid waste environmental problems, especially those associated with metals, will be discussed. Prerequisites: EGGN353/ESGN353, EGGN354/ESGN354, and ESGN302/CHGN403 or consent of instructor. 3 hours lecture; 3 semester hours.

**MTGN463. POLYMER ENGINEERING. 3.0 Hours.**

(II) Introduction to the structure and properties of polymeric materials, their deformation and failure mechanisms, and the design and fabrication of polymeric end items. Molecular and crystallographic structures of polymers will be developed and related to the elastic, viscoelastic, yield and fracture properties of polymeric solids and reinforced polymer composites. Emphasis on forming and joining techniques for end-item fabrication including: extrusion, injection molding, reaction injection molding, thermoforming, and blow molding. The design of end-items in relation to: materials selection, manufacturing engineering, properties, and applications. Prerequisite: consent of instructor. 3 hours lecture; 3 semester hours.

**MTGN464. FORGING AND FORMING. 3.0 Hours.**

(II) Introduction to plasticity. Survey and analysis of working operations of forging, extrusion, rolling, wire drawing and sheet-metal forming. Metallurgical structure evolution during working. Prerequisites: EGGN320 and MTGN348 or EGGN350. 2 hours lecture; 3 hours lab, 3 semester hours.

**MTGN465. MECHANICAL PROPERTIES OF CERAMICS. 3.0 Hours.**

(II) Mechanical properties of ceramics and ceramic-based composites; brittle fracture of solids; toughening mechanisms in composites; fatigue, high temperature mechanical behavior, including fracture, creep deformation. Prerequisites: MTGN445, MTGN412 or consent of instructor. 3 hours lecture; 3 semester hours.

**MTGN466. MATERIALS DESIGN: SYNTHESIS, CHARACTERIZATION AND SELECTION. 3.0 Hours.**

(II) (WI) Application of fundamental materials-engineering principles to the design of systems for extraction and synthesis, and to the selection of materials. Systems covered range from those used for metallurgical processing to those used for processing of emergent materials. Microstructural design, characterization and properties evaluation provide the basis for linking synthesis to applications. Selection criteria tied to specific requirements such as corrosion resistance, wear and abrasion resistance, high temperature service, cryogenic service, vacuum systems, automotive systems, electronic and optical systems, high strength/weight ratios, recycling, economics and safety issues. Materials investigated include mature and emergent metallic, ceramic and composite systems used in the manufacturing and fabrication industries. Student-team designactivities including oral- and written-reports. Prerequisite: MTGN351, MTGN352, MTGN445 and MTGN461 or consent of instructor. 1 hour lecture, 6 hours lab; 3 semester hours.

**MTGN469. FUEL CELL SCIENCE AND TECHNOLOGY. 3.0 Hours.**

(I) Investigate fundamentals of fuel-cell operation and electrochemistry from a chemical-thermodynamics and materials- science perspective. Review types of fuel cells, fuel-processing requirements and approaches, and fuel-cell system integration. Examine current topics in fuel-cell science and technology. Fabricate and test operational fuel cells in the Colorado Fuel Cell Center. Prerequisites: EGGN371 or ChEN357 or MTGN351, or consent of instructor. 3 hours lecture; 3 semester hours.

**MTGN472. BIOMATERIALS I. 3.0 Hours.**

(I) This course covers a broad overview on materials science and engineering principles for biomedical applications, and is organized around three main topics: 1) The fundamental properties of biomaterials; 2) The fundamental concepts in biology; 3) The interactions between biological systems with exogenous materials. Particular emphasis will be put on understanding surface energy and surface modification; protein adsorption; cell adhesion, spreading and migration; Biomaterials implantation and acute inflammation; blood-materials interactions and thrombosis; biofilm and biomaterials-related pathological reactions. In addition to the reign of biomedical materials, this course also introduces the basic principles of bio-mimetic materials synthesis and assembly. Prerequisites: MTGN202 3 hours lecture; 3 semester hours.

**MTGN475. METALLURGY OF WELDING. 2.0 Hours.**

(I) Introduction to welding processes; thermal aspects; selection of filler metals; stresses; stress relief and annealing; pre- and postweld heat treating; weld defects; welding ferrous and nonferrous alloys; weld metal phase transformations; metallurgical evaluation of resulting weld microstructures and properties; and welding tests. Prerequisite: MTGN348. Co-requisite: MTGN477. 2 hours lecture; 2 semester hours.

**MTGN477. METALLURGY OF WELDING LABORATORY. 1.0 Hour.**

(I) Experiments designed to supplement the lectures in MTGN475. Co-requisite: MTGN475. 3 hours lab; 1 semester hour.

**MTGN497. SUMMER PROGRAMS. 6.0 Hours.**

**MTGN498. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING. 1-3 Hour.**

(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). The course topic is generally offered only once. Prerequisite: consent of instructor. 1 to 3 semester hours. Repeatable for credit under different titles.

**MTGN499. INDEPENDENT STUDY. 1-3 Hour.**

(I, II, S) Independent advanced-work leading to a comprehensive report. This work may take the form of conferences, library, and laboratory work. Selection of problem is arranged between student and a specific Department faculty-member. Prerequisite: Selection of topic with consent of faculty supervisor; "Independent Study Form" must be completed and submitted to Registrar. 1 to 3 semester hours. Repeatable for credit to a maximum of 6 hours.



# Physics

## Program Description Engineering Physics

Physics is the most basic of all sciences and the foundation of most of the science and engineering disciplines. As such, it has always attracted those who want to understand nature at its most fundamental level. Engineering Physics is not a specialized branch of physics, but an interdisciplinary area wherein the basic physics subject matter, which forms the backbone of any undergraduate physics degree, is taken further toward application to engineering. The degree is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET). At CSM, the required engineering physics curriculum includes all of the undergraduate physics courses that would form the physics curriculum at any good university, but in addition to these basic courses, the CSM requirements include pre-engineering and engineering courses, which physics majors at other universities would not ordinarily take. These courses include engineering science, design, systems, summer field session, and a capstone senior design sequence culminating in a senior thesis.

This unique blend of physics and engineering makes it possible for the engineering physics graduate to work at the interface between science and technology, where new discoveries are continually being put to practice. While the engineering physicist is at home applying existing technologies, he or she is also capable of striking out in different directions to develop new technologies. It is the excitement of being able to work at this cutting edge that makes the engineering physics degree attractive to many students.

Career paths of CSM engineering physics graduates vary widely, illustrating the flexibility inherent in the program. More than half of the graduating seniors go on to graduate school in physics or a closely related field of engineering. Some go to medical, law, or other professional post-graduate schools. Others find employment in fields as diverse as electronics, semiconductor processing, aerospace, materials development, biomedical applications, nuclear energy, solar energy, and geophysical exploration.

The Physics Department maintains modern well-equipped laboratories for general physics, modern physics, electronics, and advanced experimentation. There are research laboratories for the study of condensed matter physics, surface physics, materials science, optics, and nuclear physics, including an NSF-funded laboratory for solar and electronic materials processing. The department also maintains electronic and machine shops.

## Program Educational Objectives (Bachelor of Science in Engineering Physics)

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile, the Physics Department is dedicated to additional educational objectives.

The program prepares graduates who, based on factual knowledge and other skills necessary to construct an appropriate understanding of physical phenomena in applied contexts, will:

1. Obtain a range of positions in industry or positions in government facilities or pursue graduate education in engineering, science or related fields;

2. Communicate and perform effectively within the criteria of their chosen careers;
3. Engage in appropriate professional societies and continuing education activities;
4. Participate ethically as members of the global society.

## Degree Requirements (Engineering Physics)

		lec	lab	sem.hrs
<b>Freshman</b>				
CORE	Common Core			33.0
				<b>33.0</b>
<b>Sophomore</b>				
<b>Fall</b>		lec	lab	sem.hrs
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS			4.5
EPIC251	DESIGN (EPICS) II			3
SYGN200	HUMAN SYSTEMS			3
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>15.0</b>
<b>Spring</b>		lec	lab	sem.hrs
MATH225	DIFFERENTIAL EQUATIONS			3
MATH332	LINEAR ALGEBRA			3
DCGN210	INTRO TO ENG THERMODYNAMICS			3
PHGN300	PHYSICS III-MODERN PHYSICS I			3
PHGN215	ANALOG ELECTRONICS			4
PAGN2XX	PHYSICAL EDUCATION			0.5
				<b>16.5</b>
<b>Summer</b>		lec	lab	sem.hrs
PHGN384	FIELD SESSION TECHNIQUES IN PHYSICS			6.0
				<b>6.0</b>
<b>Junior</b>				
<b>Fall</b>		lec	lab	sem.hrs
PHGN315	ADVANCED PHYSICS LAB I			2
PHGN311	INTRODUCTION TO MATHEMATICAL PHYSICS			3
LAIS/EBGN	H&SS GenEd Restricted Elective I			3.0
PHGN317	SEMICONDUCTOR CIRCUITS- DIGITAL			3
PHGN350	INTERMEDIATE MECHANICS			4
				<b>15.0</b>
<b>Spring</b>		lec	lab	sem.hrs
PHGN361	INTERMEDIATE ELECTROMAGNETISM			3
PHGN320	MODERN PHYSICS II: BASICS OF QUANTUM MECHANICS			4
PHGN326	ADVANCED PHYSICS LAB II			2
PHGN341	THERMAL PHYSICS			3

EBGN201	PRINCIPLES OF ECONOMICS			3
				<b>15.0</b>
<b>Senior</b>				
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
PHGN471	SENIOR DESIGN PRINCIPLES I			0.5
PHGN481	SENIOR DESIGN PRACTICE			2.5
PHGN462	ELECTROMAGNETIC WAVES AND OPTICAL PHYSICS			3
LAIS/EBGN	H&SS GenEd Restricted Elective II			3.0
FREE	Free Elective I			3.0
FREE	Free Elective II			3.0
				<b>15.0</b>
<b>Spring</b>				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
PHGN472	SENIOR DESIGN PRINCIPLES II			0.5
PHGN482	SENIOR DESIGN PRACTICE			2.5
LAIS/EBGN	H&SS GenEd Restricted Elective III			3.0
ENG SCI	Engineering Science Elective			3.0
FREE	Free Elective III			3.0
FREE	Free Elective IV			3.0
				<b>15.0</b>

Total Hours: 130.5

## Combined Baccalaureate / Masters and Baccalaureate / Doctoral Degree Programs

The Physics Department, independently, and in collaboration with the Department of Metallurgical and Materials Engineering, the Department of Applied Mathematics and Statistics, the Department of Mechanical Engineering, the Department of Electrical Engineering and Computer Science, and the Nuclear Science and Engineering Program offers programs in which students obtain an undergraduate degree in Engineering Physics in four years as well as a Masters Degree in Applied Physics, an Engineering discipline, or Mathematics after an additional year of study. There are four engineering tracks, three physics tracks, and one mathematics track. These programs emphasize a strong background in fundamentals of science, in addition to practical experience within an applied physics, engineering, or mathematics discipline. Many of the undergraduate electives of students involved in each track are specified. For this reason, students are expected to apply to the program during the first semester of their sophomore year (in special cases late entry can be approved by the program mentors). A 3.0 grade point average must be maintained to guarantee admission into the engineering and physics graduate programs. A 3.3 grade point average must be maintained to guarantee admission into the mathematics graduate program.

Students in the engineering tracks must complete a report or case study during the last year. Students in the physics and mathematics tracks must complete a master's thesis. Students in the nuclear engineering program can choose between thesis and non-thesis options. The case study or thesis should begin during the senior year as part of the Senior Design experience. Participants must identify an engineering or physics advisor as appropriate prior to their senior year who will assist in choosing an

appropriate project and help coordinate the senior design project with the case study or thesis completed in the last year.

It is also possible for undergraduate students to begin work on a Doctoral Degree in Applied Physics while completing the requirements for their Bachelor's Degree. Students in this Combined Baccalaureate/Doctoral Program may fulfill part of the requirements of their doctoral degree by including up to six hours of specified course credits that are also used to fulfill the requirements of their undergraduate degree. These courses may only be applied toward fulfilling Doctoral Degree requirements. Courses must meet all requirements for graduate credit, but their grades are not included in calculating the graduate GPA.

Interested students can obtain additional information and detailed curricula from the Physics Department or from the participating Engineering Departments.

General CSM Minor/ASI requirements can be found [here](#).

## Minor and Area of Special Interest

The department offers a Minor and Area of Special Interest for students not majoring in physics. The requirements are as follows:

### Area of Special Interest (12 semester hours minimum)

PHGN100	PHYSICS I - MECHANICS	4.5
or PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	

### Minor (18 semester hours minimum)

PHGN100	PHYSICS I - MECHANICS	4.5
or PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	
PHGN300/310	PHYSICS III-MODERN PHYSICS I	3.0
PHGN320	MODERN PHYSICS II: BASICS OF QUANTUM MECHANICS	4.0

Select one of the following: 3-4

PHGN341	THERMAL PHYSICS	
PHGN350	INTERMEDIATE MECHANICS	
PHGN361	INTERMEDIATE ELECTROMAGNETISM	

Total Hours 19-20

Selected courses to complete the Minor: Upper division (400-level) and/or graduate (500-level) courses which form a logical sequence in a specific field of study as determined in consultation with the Physics Department and the student's option department.

## Courses

### PHGN100. PHYSICS I - MECHANICS. 4.5 Hours.

(I, II, S) A first course in physics covering the basic principles of mechanics using vectors and calculus. The course consists of a fundamental treatment of the concepts and applications of kinematics and dynamics of particles and systems of particles, including Newton's laws, energy and momentum, rotation, oscillations, and waves. Prerequisite: MATH111 and concurrent enrollment in MATH112/ MATH122 or consent of instructor. 2 hours lecture; 4 hours studio; 4.5 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-SC1.

**PHGN198. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Prerequisite: Consent of Department. Credit to be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

**PHGN199. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**PHGN200. PHYSICS II-ELECTROMAGNETISM AND OPTICS. 4.5 Hours.**

(I, II, S) Continuation of PHGN100. Introduction to the fundamental laws and concepts of electricity and magnetism, electromagnetic devices, electromagnetic behavior of materials, applications to simple circuits, electromagnetic radiation, and an introduction to optical phenomena. Prerequisite: Grade of C- or higher in PHGN100, concurrent enrollment in MATH213/MATH223. 2 hours lecture; 4 hours studio; 4.5 semester hours.

**PHGN215. ANALOG ELECTRONICS. 4.0 Hours.**

(II) Introduction to analog devices used in modern electronics and basic topics in electrical engineering. Introduction to methods of electronics measurements, particularly the application of oscilloscopes and computer based data acquisition. Topics covered include circuit analysis, electrical power, diodes, transistors (FET and BJT), operational amplifiers, filters, transducers, and integrated circuits. Laboratory experiments in the use of basic electronics for physical measurements. Emphasis is on practical knowledge gained in the laboratory, including prototyping, troubleshooting, and laboratory notebook style. Prerequisite: PHGN200. 3 hours lecture, 3 hours lab; 4 semester hours.

**PHGN298. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Prerequisite: Consent of Department. Credit to be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

**PHGN299. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**PHGN300. PHYSICS III-MODERN PHYSICS I. 3.0 Hours.**

(I, II, S) Our technical world is filled with countless examples of modern physics. This course will discuss some historic experiments that led to the key discoveries, and the basic concepts, theories, and models behind some of our present day technologies. Topics may include special relativity, quantum physics, atomic and molecular physics, solid-state physics, semiconductor theory and devices, nuclear physics, particle physics and cosmology. Prerequisite: PHGN200; Concurrent enrollment in MATH225 or consent of instructor. 3 hours lecture; 3 semester hours.

**PHGN310. HONORS PHYSICS III-MODERN PHYSICS. 3.0 Hours.**

(II) The third course in introductory physics with in depth discussion on special relativity, wave-particle duality, the Schroedinger equation, electrons in solids, quantum tunneling, nuclear structure and transmutations. Registration is strongly recommended for declared physics majors and those considering majoring or minoring in physics. Prerequisite: PHGN200; Concurrent enrollment in MATH225 or consent of instructor. 3 hours lecture; 3 semester hours.

**PHGN311. INTRODUCTION TO MATHEMATICAL PHYSICS. 3.0 Hours.**

Demonstration of the unity of diverse topics such as mechanics, quantum mechanics, optics, and electricity and magnetism via the techniques of linear algebra, complex variables, Fourier transforms, and vector calculus. Prerequisite: PHGN300/PHGN310, MATH225, and MATH332 or consent of instructor. 3 hours lecture; 3 semester hours.

**PHGN315. ADVANCED PHYSICS LAB I. 2.0 Hours.**

(I) (WI) Introduction to laboratory measurement techniques as applied to modern physics experiments. Experiments from optics and atomic physics. A writing-intensive course with laboratory and computer design projects based on applications of modern physics. Prerequisite: PHGN300/PHGN310, PHGN384 or consent of instructor. 1 hour lecture, 3 hours lab; 2 semester hours.

**PHGN317. SEMICONDUCTOR CIRCUITS- DIGITAL. 3.0 Hours.**

(I) Introduction to digital devices used in modern electronics. Topics covered include logic gates, flip-flops, timers, counters, multiplexing, analog-to-digital and digital-to-analog devices. Emphasis is on practical circuit design and assembly. Prerequisite: PHGN215. 2 hours lecture, 3 hours lab; 3 semester hours.

**PHGN320. MODERN PHYSICS II: BASICS OF QUANTUM MECHANICS. 4.0 Hours.**

(II) Introduction to the Schroedinger theory of quantum mechanics. Topics include Schroedinger's equation, quantum theory of measurement, the uncertainty principle, eigenfunctions and energy spectra, angular momentum, perturbation theory, and the treatment of identical particles. Example applications taken from atomic, molecular, solid state or nuclear systems. Prerequisites: PHGN300/PHGN310 and PHGN311. 4 hours lecture; 4 semester hours.

**PHGN324. INTRODUCTION TO ASTRONOMY AND ASTROPHYSICS. 3.0 Hours.**

(II) Celestial mechanics; Kepler's laws and gravitation; solar system and its contents; electromagnetic radiation and matter; stars: distances, magnitudes, spectral classification, structure, and evolution. Variable and unusual stars, pulsars and neutron stars, supernovae, black holes, and models of the origin and evolution of the universe. Prerequisite: PHGN200. 3 hours lecture; 3 semester hours.

**PHGN326. ADVANCED PHYSICS LAB II. 2.0 Hours.**

(II) (WI) Continuation of PHGN315. A writing-intensive course which expands laboratory experiments to include nuclear and solid state physics. Prerequisite: PHGN315. 1 hour lecture, 3 hours lab; 2 semester hours.

**PHGN333. INTRODUCTION TO BIOPHYSICS. 3.0 Hours.**

(II) This course is designed to show the application of physics to biology. It will assess the relationships between sequence structure and function in complex biological networks and the interfaces between physics, chemistry, biology and medicine. Topics include: biological membranes, biological mechanics and movement, neural networks, medical imaging basics including optical methods, MRI, isotopic tracers and CT, biomagnetism and pharmacokinetics. Prerequisites: PHGN200 and BELS301/ESGN301, or permission of the instructor, 3 hours lecture, 3 semester hours.

**PHGN340. COOPERATIVE EDUCATION. 1-3 Hour.**

(I, II, S) Supervised, full-time, engineering-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 1 to 3 semester hours. Repeatable up to 3 credit hours.

**PHGN341. THERMAL PHYSICS. 3.0 Hours.**

(II) An introduction to statistical physics from the quantum mechanical point of view. The microcanonical and canonical ensembles. Heat, work and the laws of thermodynamics. Thermodynamic potentials; Maxwell relations; phase transformations. Elementary kinetic theory. An introduction to quantum statistics. Prerequisite: DCGN209 or 210 and PHGN311. 3 hours lecture; 3 semester hours.

**PHGN350. INTERMEDIATE MECHANICS. 4.0 Hours.**

(I) Begins with an intermediate treatment of Newtonian mechanics and continues through an introduction to Hamilton's principle and Hamiltonian and Lagrangian dynamics. Includes systems of particles, linear and driven oscillators, motion under a central force, two-particle collisions and scattering, motion in non-inertial reference frames and dynamics of rigid bodies. Prerequisite: PHGN200. Corequisite: PHGN311. 4 hours lecture; 4 semester hours.

**PHGN361. INTERMEDIATE ELECTROMAGNETISM. 3.0 Hours.**

(II) Theory and application of the following: static electric and magnetic fields in free space, dielectric materials, and magnetic materials; steady currents; scalar and vector potentials; Gauss' law and Laplace's equation applied to boundary value problems; Ampere's and Faraday's laws. Prerequisite: PHGN200 and PHGN311. 3 hours lecture; 3 semester hours.

**PHGN384. FIELD SESSION TECHNIQUES IN PHYSICS. 1-6 Hour.**

(S1) Introduction to the design and fabrication of engineering physics apparatus. Intensive individual participation in the design of machined system components, vacuum systems, electronics, optics, and application of computer interfacing systems and computational tools. Supplementary lectures on safety, laboratory techniques and professional development. Visits to regional research facilities and industrial plants. Prerequisite: PHGN300/PHGN310, PHGN215. (6 credit hours).

**PHGN398. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Prerequisite: Consent of Department. Credit to be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

**PHGN399. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**PHGN401. THEORETICAL PHYSICS SEMINAR. 1.0 Hour.**

(I,II) Students will attend the weekly theoretical physics seminar. Students will be responsible for presentation and discussion. Corequisite: PHGN300/PHGN310. 1 hour lecture; 1 semester hour.

**PHGN419. PRINCIPLES OF SOLAR ENERGY SYSTEMS. 3.0 Hours.**

Review of the solar resource and components of solar irradiance; principles of photovoltaic devices and photovoltaic system design; photovoltaic electrical energy production and cost analysis of photovoltaic systems relative to fossil fuel alternatives; introduction to concentrated photovoltaic systems and manufacturing methods for wafer-based and thin film photovoltaic panels. Prerequisite: PHGN200 and MATH225. 3 hours lecture; 3 semester hours.

**PHGN422. NUCLEAR PHYSICS. 3.0 Hours.**

Introduction to subatomic (particle and nuclear) phenomena. Characterization and systematics of particle and nuclear states; symmetries; introduction and systematics of the electromagnetic, weak, and strong interactions; systematics of radioactivity; liquid drop and shell models; nuclear technology. Prerequisite: PHGN300/PHGN310. 3 hours lecture; 3 semester hours.

**PHGN424. ASTROPHYSICS. 3.0 Hours.**

(II) A survey of fundamental aspects of astrophysical phenomena, concentrating on measurements of basic stellar properties such as distance, luminosity, spectral classification, mass, and radii. Simple models of stellar structure evolution and the associated nuclear processes as sources of energy and nucleosynthesis. Introduction to cosmology and physics of standard big-bang models. Prerequisite: PHGN300/PHGN310. 3 hours lecture; 3 semester hours.

**PHGN435. INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY. 3.0 Hours.**

Application of science and engineering principles to the design, fabrication, and testing of microelectronic devices. Emphasis on specific unit operations and the interrelation among processing steps. Prerequisites: Senior standing in PHGN, CHGN, MTGN, or EGGN. Consent of instructor. 1.5 hours lecture, 4 hours lab; 3 semester hours.

**PHGN440. SOLID STATE PHYSICS. 3.0 Hours.**

An elementary study of the properties of solids including crystalline structure and its determination, lattice vibrations, electrons in metals, and semiconductors. (Graduate students in physics may register only for PHGN440.) Prerequisite: PHGN320. 3 hours lecture; 3 semester hours.

**PHGN441. SOLID STATE PHYSICS APPLICATIONS AND PHENOMENA. 3.0 Hours.**

Continuation of PHGN440/MLGN502 with an emphasis on applications of the principles of solid state physics to practical properties of materials including: optical properties, superconductivity, dielectric properties, magnetism, noncrystalline structure, and interfaces. (Graduate students in physics may register only for PHGN441.) Prerequisite: PHGN440 or MLGN502, or equivalent by instructor's permission. 3 hours lecture; 3 semester hours.

**PHGN450. COMPUTATIONAL PHYSICS. 3.0 Hours.**

Introduction to numerical methods for analyzing advanced physics problems. Topics covered include finite element methods, analysis of scaling, efficiency, errors, and stability, as well as a survey of numerical algorithms and packages for analyzing algebraic, differential, and matrix systems. The numerical methods are introduced and developed in the analysis of advanced physics problems taken from classical physics, astrophysics, electromagnetism, solid state, and nuclear physics. Prerequisites: Introductory-level knowledge of C, Fortran, or Basic; and PHGN311. 3 hours lecture; 3 semester hours.

**PHGN462. ELECTROMAGNETIC WAVES AND OPTICAL PHYSICS. 3.0 Hours.**

(I) Solutions to the electromagnetic wave equation are studied, including plane waves, guided waves, refraction, interference, diffraction and polarization; applications in optics; imaging, lasers, resonators and wave guides. Prerequisite: PHGN361. 3 hours lecture; 3 semester hours.

**PHGN466. MODERN OPTICAL ENGINEERING. 3.0 Hours.**

Provides students with a comprehensive working knowledge of optical system design that is sufficient to address optical problems found in their respective disciplines. Topics include paraxial optics, imaging, aberration analysis, use of commercial ray tracing and optimization, diffraction, linear systems and optical transfer functions, detectors and optical system examples. Prerequisite: PHGN462 or consent of instructor. 3 hours lecture; 3 semester hours.

**PHGN471. SENIOR DESIGN PRINCIPLES I. 0.5 Hours.**

(I) (WI) The first of a two semester sequence covering the principles of project design. Class sessions cover effective team organization, project planning, time management, literature research methods, record keeping, fundamentals of technical writing, professional ethics, project funding and intellectual property. Prerequisites: PHGN384 and PHGN326. Co-requisites: PHGN481 or PHGN491. 1 hour lecture in 7 class sessions; 0.5 semester hours.

**PHGN472. SENIOR DESIGN PRINCIPLES II. 0.5 Hours.**

(II) (WI) Continuation of PHGN471. Prerequisite: PHGN384 and PHGN326. Co-requisite: PHGN482 or PHGN492. 1 hour lecture in 7 class sessions; 0.5 semester hours.

**PHGN480. LASER PHYSICS. 3.0 Hours.**

(I) Theory and application of the following: Gaussian beams, optical cavities and wave guides, atomic radiation, detection of radiation, laser oscillation, nonlinear optics and ultrafast pulses. Prerequisite: PHGN320. Co-requisite: PHGN462. 3 hours lecture; 3 semester hours.

**PHGN481. SENIOR DESIGN PRACTICE. 2.5 Hours.**

(I) (WI) The first of a two semester program covering the full spectrum of project design, drawing on all of the student's previous course work. At the beginning of the first semester, the student selects a research project in consultation with the Senior Design Oversight Committee (SDOC) and the Project Mentor. The objectives of the project are given to the student in broad outline form. The student then designs the entire project, including any or all of the following elements as appropriate: literature search, specialized apparatus or algorithms, block-diagram electronics, computer data acquisition and/or analysis, sample materials, and measurement and/or analysis sequences. The course culminates in a formal interim written report. Prerequisite: PHGN384 and PHGN326. Co-requisite: PHGN471. 6 hour lab; 2.5 semester hours.

**PHGN482. SENIOR DESIGN PRACTICE. 2.5 Hours.**

(II) (WI) Continuation of PHGN481. The course culminates in a formal written report and poster. Prerequisite: PHGN384 and PHGN326. Co-requisite: PHGN472. 6 hour lab; 2.5 semester hours.

**PHGN491. HONORS SENIOR DESIGN PRACTICE. 2.5 Hours.**

(I) (WI) Individual work on an advanced research topic that involves more challenging demands than a regular senior design project. Honors students will devote more time to their project, and will produce an intermediate report in a more advanced format. Prerequisite: PHGN384 and PHGN326. Corequisite: PHGN471. 7.5 hour lab; 2.5 semester hours.

**PHGN492. HONORS SENIOR DESIGN PRACTICE. 2.5 Hours.**

(II) (WI) Continuation of PHGN481 or PHGN491. The course culminates in a formal written report and poster. The report may be in the form of a manuscript suitable for submission to a professional journal. Prerequisite: PHGN481 or PHGN491. Corequisite: PHGN472. 7.5 hour lab; 2.5 semester hours.

**PHGN497. SUMMER PROGRAMS. 6.0 Hours.****PHGN498. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Prerequisite: Consent of Department. Credit to be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

**PHGN499. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

## Aerospace Studies

### Air Force ROTC (AFROTC)

The Department of Aerospace Studies offers programs leading to an officer's commission in the Air Force in conjunction with an undergraduate or graduate degree.

Aerospace science courses are designed to supplement a regular degree program by offering practical leadership and management experience. The Aerospace Studies Program at the Colorado School of Mines (CSM) is offered in conjunction with the University of Colorado at Boulder (CUB).

### Four-Year Program

The four-year program consists of two phases: the general military course (freshman and sophomore years) and the professional officer course (junior and senior years). This program is designed for incoming freshmen or any student with four years remaining until degree completion. It consists of three parts: the General Military Course (GMC) for lower division (normally freshmen and sophomore) students; the Professional Officer Course (POC) for upper division students (normally juniors and seniors); and Leadership Laboratory (LLAB-attended by all cadets). Completion of a four-week summer training course is required prior to commissioning.

### Leadership Lab

All AFROTC cadets must attend Leadership Lab (2 hours per week). The laboratory involves a study of Air Force customs and courtesies, drill and ceremonies, career opportunities, and the life and work of an Air Force officer.

### General Military Course (GMC)

The basic course covers Air Force history and organization as well as military leadership and management. Laboratory sessions provide the opportunity to apply leadership skills while learning basic military skills. Enrollment in the basic course incurs no military obligation except for Air Force scholarship recipients.

### Professional Officer Course (POC)

The advanced course covers military officership, leadership and unit operations, training techniques, military law, and professional ethics, and includes a leadership practicum each semester. A Field Training encampment provides challenging leadership training and is a prerequisite for commissioning. Advanced course students must have completed the basic course and obtain permission from the Professor of Aerospace Studies (PAS) to enroll in the POC.

### Three-Year Program

The three-year program consists of the first two years of GMC courses taken concurrently in one year. The student then attends a Field Training encampment, and completes two years of advanced POC courses.

### Scholarship Programs

Four-year college scholarships are available to high school seniors, who apply before December 1 of their senior year. Competition for two- and three- year scholarships is open to all university students, regardless of academic major and whether or not they are currently enrolled in ROTC. Scholarship students receive tuition assistance and mandatory laboratory fees, a book allowance, and a monthly stipend. Students interested in the scholarship program should contact the AFROTC Unit Admissions Officer at [www.afrotc.colorado.edu](http://www.afrotc.colorado.edu) ([bulletin.mines.edu/undergraduate/programs/additionalprograms/aerospacestudies/http://www.afrotc.colorado.edu](http://bulletin.mines.edu/undergraduate/programs/additionalprograms/aerospacestudies/http://www.afrotc.colorado.edu)) no

later than the beginning of the spring semester to apply for the following academic year. A complete listing of all available AFROTC scholarships is available at [www.afrotc.com](http://www.afrotc.com) ([bulletin.mines.edu/undergraduate/programs/additionalprograms/aerospacestudies/http://www.afrotc.com](http://bulletin.mines.edu/undergraduate/programs/additionalprograms/aerospacestudies/http://www.afrotc.com)).

### Registration and Credits

Air Force ROTC serves as elective credit in most departments. Elective course credit toward your degree for AFROTC classes will be determined by your individual academic advisor. Students who wish to register for Air Force ROTC classes do so through the normal course registration process at CSM. AFROTC classes begin with the AFGN prefix. For more information about AFROTC, contact the Air Force ROTC Unit Admissions Officer at [www.afrotc.colorado.edu](http://www.afrotc.colorado.edu) ([bulletin.mines.edu/undergraduate/programs/additionalprograms/aerospacestudies/http://www.afrotc.colorado.edu](http://bulletin.mines.edu/undergraduate/programs/additionalprograms/aerospacestudies/http://www.afrotc.colorado.edu)), or the department on campus directly at 303-273-3380. The department is located in the Military Science building on West Campus Road. For information about CSM, call 303-273-3380.

### Aerospace Studies Minor

Air Force ROTC cadets desiring to receive a minor in Aerospace Studies must complete at least 20 hours of Aerospace Studies courses as follows:

AFGN101	FOUNDATIONS OF THE UNITED STATES AIR FORCE	1.5
AFGN102	FOUNDATIONS OF THE UNITED STATES AIR FORCE	1.5
AFGN201	THE EVOLUTION OF USAF AIR AND SPACE POWER	1.5
AFGN202	THE EVOLUTION OF USAF AIR AND SPACE POWER	1.5
AFGN301	AIR FORCE LEADERSHIP STUDIES	3.5
AFGN302	AIR FORCE LEADERSHIP STUDIES	3.5
AFGN401	NATIONAL SECURITY AFFAIRS AND PREPARATION FOR ACTIVE DUTY	3.5
AFGN402	NATIONAL SECURITY AFFAIRS AND PREPARATION FOR ACTIVE DUTY	3.5
Total Hours		20.0

### General CSM Minor/ASI requirements can be found at

<https://nextbulletin.mines.edu/undergraduate/undergraduateinformation/specialprograms/minorasi/>

### Other AFROTC Programs

Other programs are frequently available based on current Air Force needs. Contact a Det 105 representative at [afrotc.colorado.edu](http://afrotc.colorado.edu) ([bulletin.mines.edu/undergraduate/programs/additionalprograms/aerospacestudies/http://afrotc.colorado.edu](http://bulletin.mines.edu/undergraduate/programs/additionalprograms/aerospacestudies/http://afrotc.colorado.edu)).

## Courses

### **AFGN101. FOUNDATIONS OF THE UNITED STATES AIR FORCE. 1.5 Hour.**

Two semesters, 1.5 hours per semester. This survey course briefly covers topics relating to the Air Force and defense. It focuses on the structure and missions of Air Force organizations, officership and professionalism. It is also a good introduction into the use of communication skills. Weekly Leadership Lab for this course (to be taken in conjunction with AS 101 and 102) is a weekly laboratory that touches on the topics of Air Force customs and courtesies, health and physical fitness, and drill and ceremonies.

### **AFGN102. FOUNDATIONS OF THE UNITED STATES AIR FORCE. 1.5 Hour.**

Two semesters, 1.5 hours per semester. This survey course briefly covers topics relating to the Air Force and defense. It focuses on the structure and missions of Air Force organizations, officership and professionalism. It is also a good introduction into the use of communication skills. Weekly Leadership Lab for this course (to be taken in conjunction with AS 101 and 102) is a weekly laboratory that touches on the topics of Air Force customs and courtesies, health and physical fitness, and drill and ceremonies.

### **AFGN201. THE EVOLUTION OF USAF AIR AND SPACE POWER. 1.5 Hour.**

Two semesters, 1.5 hours per semester. This survey course is concerned with the beginnings of manned flight and the development of aerospace power in the United States, including the employment of air power in WWI, WWII, Korea, Vietnam, the Gulf War and the peaceful employment of U.S. air power in civic actions, scientific missions and support of space exploration. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AS 201 and 202) provides you with the opportunity to demonstrate fundamental management skills and prepares you for Field Training.

### **AFGN202. THE EVOLUTION OF USAF AIR AND SPACE POWER. 1.5 Hour.**

Two semesters, 1.5 hours per semester. This survey course is concerned with the beginnings of manned flight and the development of aerospace power in the United States, including the employment of air power in WWI, WWII, Korea, Vietnam, the Gulf War and the peaceful employment of U.S. air power in civic actions, scientific missions and support of space exploration. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AS 201 and 202) provides you with the opportunity to demonstrate fundamental management skills and prepares you for Field Training.

### **AFGN301. AIR FORCE LEADERSHIP STUDIES. 3.5 Hours.**

Two semesters, 3.5 hours per semester. This course is a study in the anatomy of leadership, the need for quality and management leadership, the role of discipline in leadership situations and the variables affecting leadership. Case studies are used to examine Air Force leadership and management situations as a means of demonstrating and exercising practical application of the concepts. Deal with actual problems and complete projects associated with planning and managing the Leadership Laboratory. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AS 301 and 302) provides you the opportunity to develop your fundamental management skills while planning and conducting cadet activities.

### **AFGN302. AIR FORCE LEADERSHIP STUDIES. 3.5 Hours.**

Two semesters, 3.5 hours per semester. This course is a study in the anatomy of leadership, the need for quality and management leadership, the role of discipline in leadership situations and the variables affecting leadership. Case studies are used to examine Air Force leadership and management situations as a means of demonstrating and exercising practical application of the concepts. Deal with actual problems and complete projects associated with planning and managing the Leadership Laboratory. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AS 301 and 302) provides you the opportunity to develop your fundamental management skills while planning and conducting cadet activities.

### **AFGN401. NATIONAL SECURITY AFFAIRS AND PREPARATION FOR ACTIVE DUTY. 3.5 Hours.**

Two semesters, 3.5 hours per semester. Learn about the role of the professional military leader in a democratic society; societal attitudes toward the armed forces; the requisites for maintaining adequate national defense structure; the impact of technological and international developments on strategic preparedness and the overall policy-making process; and military law. In addition, you will study topics that will prepare you for your first active-duty assignment as an officer in the Air Force. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AS 401 and 402) provides you with the opportunity to use your leadership skills in planning and conducting cadet activities. It prepares you for commissioning and entry into the active-duty Air Force.

### **AFGN402. NATIONAL SECURITY AFFAIRS AND PREPARATION FOR ACTIVE DUTY. 3.5 Hours.**

Two semesters, 3.5 hours per semester. Learn about the role of the professional military leader in a democratic society; societal attitudes toward the armed forces; the requisites for maintaining adequate national defense structure; the impact of technological and international developments on strategic preparedness and the overall policy-making process; and military law. In addition, you will study topics that will prepare you for your first active-duty assignment as an officer in the Air Force. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AS 401 and 402) provides you with the opportunity to use your leadership skills in planning and conducting cadet activities. It prepares you for commissioning and entry into the active-duty Air Force.

### **MSGN103. ADVENTURES IN LEADERSHIP I. 2.0 Hours.**

(I) Introduces fundamentals of leadership and the United States Army. Examines its organization, customs, and history as well as its current relevance and purpose. Students also investigate basic leadership and management skills necessary to be successful in both military and civilian settings. Includes fundamentals of Army leadership doctrine, teambuilding concepts, time and stress management, an introduction to cartography and land navigation, marksmanship, briefing techniques, and some basic military tactics. Lab fee. 1 hour lecture, 2 hours lab, 3 hours PT, and 80 hours field training; 2 semester hours. (Fall).

**MSGN104. ADVENTURES IN LEADERSHIP II. 2.0 Hours.**

(II) Continues the investigation of leadership in small organizations. Covers selected topics such as basic troop leading procedures, military first aid and casualty evacuation concepts, creating ethical work climates, an introduction to Army organizations and installations, and a further examination of basic military tactics. Introduces students to effective military writing styles. Lab fee. 1 hour lecture, 2 hours lab, 3 hours PT, and 80 hours field training; 2 semester hours. (Spring).

**MSGN198. SPECIAL TOPICS IN MILITARY SCIENCE. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MSGN199. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**MSGN203. METHODS OF LEADERSHIP. 2.0 Hours.**

(I) Comprehensively reviews advanced leadership and management concepts including motivation, attitudes, communication skills, problem solving, human needs and behavior, and leadership self development. Students continue to refine effective written and oral communications skills and to explore topics such as the basic branches of the Army, and officer and NCO duties. Students conduct classroom and practical exercises in small unit light infantry tactics and are prepared to perform as midlevel leaders in the cadet organization. Lab fee: 1 hour lecture, 2 hours lab, 3 hours PT, and 80 hours field training; 2 semester hours. (Fall).

**MSGN204. METHODS OF LEADERSHIP AND MANAGEMENT II. 2.0 Hours.**

(II) Focuses on leadership and management functions in military and corporate environments. Studies various components of Army leadership doctrine to include the four elements of leadership, leadership principles, risk management and planning theory, the be-know-do framework, and the Army leadership evaluation program. Continue to refine communication skills. Lab fee. 1 hour lecture, 2 hours lab, 3 hours PT, and 80 hours field training; 2 semester hours. (Spring).

**MSGN298. SPECIAL TOPICS IN MILITARY SCIENCE. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MSGN299. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**MSGN301. MILITARY OPERATIONS AND TRAINING I. 3.0 Hours.**

(I) Further explores the theory of managing and leading small military units with an emphasis on practical applications at the squad and platoon levels. Students examine various leadership styles and techniques as they relate to advanced small unit tactics. Familiarizes students with a variety of topics such as cartography, land navigation, field craft, and weapons systems. Involves multiple, evaluated leadership opportunities in field settings and hands-on experience with actual military equipment. Students are given maximum leadership opportunities in weekly labs. Prerequisite: Consent of the Professor of Military Science. Lab Fee. 3 hours lecture; 3 semester hours. (Fall).

**MSGN302. MILITARY OPERATIONS AND TRAINING II. 3.0 Hours.**

(II) Studies theoretical and practical applications of small unit leadership principles. Focuses on managing personnel and resources, the military decision making process, the operations order, and oral communications. Exposes the student to tactical unit leadership in a variety of environments with a focus on preparation for the summer advance camp experience. Prerequisite: Consent of the Professor of Military Science. Lab Fee. 3 hours lecture; 3 semester hours. (Spring).

**MSGN303. LEADERSHIP LABORATORY. 0.5 Hours.**

(I) Development of military leadership techniques to include preparation of operation plans, presentation of instruction, and supervision of underclass military cadets. Instruction in military drill, ceremonies, and customs and courtesies of the Army. Must be taken in conjunction with MSGN301. Prerequisite: Consent of department. Lab Fee. 2 hours lab, 3 hours PT, 80 hours field training; .5 semester hour. (Fall).

**MSGN304. LEADERSHIP LABORATORY. 0.5 Hours.**

(II) Continued development of military leadership techniques with the major emphasis on leading an Infantry Squad. Training is "hands-on." Practical exercises are used to increase understanding of the principles of leadership learned in MSGN302. Must be taken in conjunction with MSGN302. Prerequisite: Consent of department. Lab Fee. 2 hours lab, 3 hours PT, 80 hours field training; .5 semester hour. (Spring).

**MSGN398. SPECIAL TOPICS IN MILITARY SCIENCE. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MSGN399. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.



**MSGN401. OFFICER LEADERSHIP AND DEVELOPMENT I. 3.0 Hours.**

(I) Examines management and leadership concepts and techniques associated with planning and executing military training and operations at company and higher echelons. Includes analyses of professional ethics and values, effective training principles and procedures, subordinate counseling, and effective staff officer briefing techniques. Also investigates other subjects such as counter terrorism, modern peacekeeping missions, and the impact of the information revolution on the art of land warfare. Conducted both in and out of classroom setting and with multiple practical leadership opportunities to organize cadet training and activities.

Prerequisite: Consent of the Professor of Military Science. Lab Fee. 3 hours lecture; 3 semester hours. (Fall).

**MSGN402. OFFICER LEADERSHIP AND DEVELOPMENT II. 3.0 Hours.**

(II) Continues MSGN401 study of management and leadership concepts and techniques, providing practical leadership experiences in the classroom and during multiple cadet-run activities. Also examines varied topics such as theory and practice of the military justice system, law of war, military-media relations, support mechanisms for soldiers and their families, operational security considerations, and historical case studies in military leadership in the context of

21st century land warfare. Prerequisite: Consent of the Professor of Military Science. Lab Fee. 3 hours lecture; 3 semester hours. (Spring).

**MSGN403. LEADERSHIP LABORATORY. 0.5 Hours.**

(I) Continued development of leadership techniques by assignment in the command and staff positions in the Cadet Battalion. Cadets are expected to plan and execute much of the training associated with the day-to-day operations within the cadet battalion. Utilizing the troop leading and management principles

learned in previous classes, cadets analyze the problems which the battalion faces, develop strategies, brief recommendations, and execute the approved plan. Prerequisite: Consent of department. Lab Fee. 2 hours lab, 3 hours PT, and 80 hours field training; .5 semester hour. (Fall).

**MSGN404. LEADERSHIP LABORATORY. 0.5 Hours.**

(II) Continued leadership development by serving in the command and staff positions in the Cadet Battalion. Cadets take a large role in determining the goals and direction of the cadet organization, under supervision of the cadre. Cadets are required to plan and organize cadet outings and much of the training of underclassmen. Lab Fee.

Prerequisite: Consent of department. Lab Fee. 2 hours lab, 3 hours PT, and 80 hours field training; .5 semester hour. (Spring).

**MSGN497. SPEC STDY LDRSHIP/SMALL GRP. 3.0 Hours.**

(I) The course is specifically geared to the unique leadership challenges faced by individuals involved in CSM student government and other campus leadership positions. Instruction emphasis is on forces and dynamics which shape and define leader/manager's job in the campus environment. Prerequisite: Currently appointed or elected leader of a recognized student organization or consent of the department head. 1 hour lecture and 5 hours lab; 3 semester hours.

**MSGN498. SPECIAL TOPICS IN MILITARY SCIENCE. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MSGN499. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

## Design -- EPICS (Engineering Practices Introductory Course Sequence)

Design EPICS is designed to prepare students for their upper-division courses and to develop some of the key skills of the professional engineer: the ability to solve complex, open-ended problems, the ability to work in teams, the ability to select a solution from competing alternatives, and the ability to communicate effectively. The first semester course, EPIC151, is required by all undergraduate options. The second semester course, EPIC251, is required by all undergraduate engineering options according to ABET requirements. EPIC251 is not required for majors in Chemistry, Mathematical and Computer Sciences, and Economics and Business.

An award-winning program, Design EPICS replaces the traditional core courses in introductory computing skills, graphics, and technical communication. Whenever possible, instruction in these subjects is "hands-on" and experimental, with the instructor serving primarily as mentor rather than lecturer.

Problem-solving skills are developed through open-ended design problems organized as semester-long "projects," which the students solve in teams. Projects grow in content and complexity as the program applies a guided methodology to projects submitted by an external client. The projects require extensive library research and self-education in appropriate technical areas; they also require students to consider non-technical constraints (economic, ethical, political, societal, etc.) and incorporate them into their solutions.

Written and oral communications skills are studied and practiced as an integral part of the project work. Specific graphics and computing skills are integrated within projects wherever applicable.

### Courses

#### EPIC151. DESIGN (EPICS) I. 3.0 Hours.

(I,II,S). Design EPICS I introduces students to a design process that includes open-ended problem solving and teamwork integrated with the use of computer software as tools to solve engineering problems. Computer applications emphasize graphical visualization and production of clear and coherent graphical images, charts, and drawings. Teams assess engineering ethics, group dynamics and time management with respect to decisionmaking. The course emphasizes written technical communications and introduces oral presentations. 3 semester hours.

#### EPIC155. EPICS I GRAPHICS. 1.0 Hour.

(I,II). Instruction and practice in mechanical sketching and computer-aided drafting methods. Specific lessons include perspective sketching, geometric construction, isometric and orthographic views, dimensions, and sections. Homework is assigned weekly. Each unit culminates in one in-class proficiency examination or extended written assignment, plus one capstone design portfolio. Prerequisites: permission of the EPICS Program Director. 1 hour lecture, 1 hour laboratory, 1 semester hour.

#### EPIC199. INDEPENDENT STUDY. 1-6 Hour.

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

#### EPIC251. DESIGN (EPICS) II. 3.0 Hours.

(I,II,S). Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communications with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. Teams analyze team dynamics through weekly team meetings and progress reports. The course emphasizes oral presentations and builds on written communications techniques introduced in Design EPICS I. Prerequisite: EPIC151. 3 semester hours.

#### EPIC252. LEADERSHIP DESIGN II. 4.0 Hours.

(I,II). EPIC252 can be taken in place of EPIC251. Students integrate teamwork, communications, computer software applications and project management skills to solve engineering problems, and the deliverables are equivalent to those for EPICS 251. In addition, students examine the global nature of modern engineering design by combining a project of global interest with an emphasis on leadership and communications skills across a variety of cultures. To support these objectives, students conduct research in the effect of international influences and cultural diversity on the acceptance and implementation of their design solutions. Prerequisite: EPIC151. 4 semester hours.

#### EPIC261. EPICS II: GIS. 3.0 Hours.

(I,II): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. EPICS 261 – GIS incorporates instruction and practice in ArcView, a geographic information system software package, to enable students to capture, manage, analyze and display geographic information in maps, charts or tables, with projects that depend on GIS for their design solutions. Recent projects involving the use of GIS include campus emergency management and room usage maps, groundwater testing well analysis and reporting for the Colorado Department of Agriculture and trail maps for the Foothills Recreation District. Students interested in Petroleum Engineering, or another major where GIS is used, should consider registering for this section. Geology and Geological Engineering students are directed to register for Geology GIS EPICS251, which is a different course. Prerequisite: EPIC151. 3 semester hours.

**EPIC262. EPICS II: AUTO CAD. 3.0 Hours.**

(I,II): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. EPICS 262-AutoCAD incorporates semester-long instruction and practice in AutoCAD computer-aided drawing, with projects involving the use of AutoCAD in design solutions. Recent projects include remodeling plans for the Ford Building, a solar tree house education center, an environmentally sustainable house, and new structural designs for use in Haiti following the January 2010 earthquake in Haiti. Students in the Civil Engineering specialty in Engineering, the Environmental Engineering specialty in Engineering, or in Mining Engineering, should consider registering for this course. Prerequisite: EPIC151. 3 semester hours.

**EPIC263. EPICS II: DRILLING ENGINEERING. 3.0 Hours.**

(S): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. This course implements the design process with drilling technology and automated drilling processes to solve multidisciplinary drilling project issues. Based on the project conditions set by the client, various alternatives and configurations are possible to meet the project objectives. Teams select and build a body of evidence to market their most desirable alternatives. Prerequisite: EPIC151. 3 semester hours.

**EPIC264. EPICS II: GEOLOGY GIS. 3.0 Hours.**

(II): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. There are typically eight geology-based projects in the course, based on the needs of multiple outside clients. Many of the course deliverables are maps with associated data sets. Prerequisite: EPIC151. 3 semester hours.

**EPIC265. EPIC II: BIOCHEMICAL PROCESSES. 3.0 Hours.**

(I,II): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. This course emphasizes steady-state design in biochemical production processes and provides exposure to information about various manufacturing and research segments. Projects are selected to represent real-world biochemical engineering problems in biofuels, food sciences and pharmaceuticals, wherein creative and critical thinking skills are necessary. These projects may often involve computer-based optimization to obtain a solution. Students are exposed to the range of core engineering computation skills that are utilized in both the chemical and biochemical engineering disciplines, and subsequently employ these skills to their design projects. This approach also integrates the content of future courses with the application of engineering design. Prerequisite: EPIC151. 3 semester hours.

**EPIC266. EPICS II: CHEMICAL PROCESSES. 3.0 Hours.**

(I, II): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. This course emphasizes steady-state design in chemical production processes and provides exposure to information about various manufacturing and research segments. Projects are selected to represent realworld chemical engineering problems in the energy sectors, chemicals and environmental stewardship, wherein creative and critical thinking skills are necessary. These projects may often involve computer-based optimization to obtain a solution. Students are exposed to the range of core engineering computation skills that are utilized in both the chemical and biochemical engineering disciplines, and subsequently employ these skills to their design projects. This approach also integrates the content of future courses with the application of engineering design. Prerequisite: EPIC151. 3 semester hours.

**EPIC267. EPICS II: CIVIL ENGINEERING. 3.0 Hours.**

(II): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. Prerequisite: EPIC151. 3 semester hours.

**EPIC268. EPIC II: FOR GEOPHYSICS. 3.0 Hours.**

(II): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. Students work on projects from the geophysical engineering practice in which they analyze (process, model, visualize) data. In their projects, students encounter limitations and uncertainties in data and learn quantitative means for handling them. They learn how to analyze errors in data, and their effects on data interpretation and decision making. Prerequisite: EPIC151. 3 semester hours.

**EPIC298. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**EPIC299. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**EPIC398. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**EPIC399. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**EPIC497. SPECIAL SUMMER COURSE. 6.0 Hours.****EPIC498. SPECIAL TOPICS. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

## Military Science

### (Army ROTC-AROTC)

The Department of Military Science offers programs leading to an officer's commission in the active Army, Army Reserve, or National Guard in conjunction with an undergraduate or graduate degree. Military science courses are designed to supplement a regular degree program by offering practical leadership and management experience. The Military Science Program at the Colorado School of Mines (CSM) is offered in conjunction with the University of Colorado at Boulder (CU-B). Students attend classes at the Colorado School of Mines in Golden.

### Four-Year Program

The four-year program consists of two phases: the basic course (freshman and sophomore years) and the advanced course (junior and senior years).

#### Basic course

The basic course offers a 2- or 3-credit course each semester, covering Army history and organization as well as military leadership and management. Laboratory sessions provide the opportunity to apply leadership skills while learning basic military skills. Enrollment in the basic course incurs no military obligation except for Army scholarship recipients.

#### Advanced course

The advanced course covers leadership, tactics and unit operations, training techniques, military law, and professional ethics, and includes a leadership practicum each semester. A 33-day summer advanced camp at Fort Lewis, Washington, provides challenging leadership training and is a prerequisite for commissioning. Advanced course students must have completed the basic course and obtain permission from the Professor of Military Science (PMS).

### Two-Year Program

The two-year program consists of the advanced course, preceded by attending the Leaders Training course (a four-week summer ROTC basic course at Ft. Knox, Kentucky). Veterans, or Active Army Reserve/Army National Guard Soldiers, or students who have participated in three years of Junior ROTC or Civil Air Patrol, may be eligible to enroll in the advanced course without attendance at basic camp or completion of the basic course. Advanced course students must obtain permission from the Professor of Military Science (PMS) at 303-492-6495.

### Scholarship Programs

Four-year college scholarships are available to high school seniors, who apply before December 1 of their senior year. Competition for two- and three- year scholarships is open to all university students, regardless of academic major and whether or not they are currently enrolled in ROTC. Scholarship students receive full tuition and mandatory laboratory fees, a book allowance, and an allowance of \$300- \$500 per month during the academic year. Students interested in the scholarship program should contact the AROTC Enrollment and Scholarship Officer at 303-492-3549 no later than the beginning of the spring semester to apply for the following academic year.

### Simultaneous Membership Program

Students currently in the Army Reserves or Army National Guard and entering either the second year of the basic course or the advanced course may participate in the Simultaneous Membership Program (SMP). Students participating in this program will receive \$450 to \$500 monthly

stipend plus their unit pay at the E-5 grade. SMP participants may be eligible for Army Reserve or Army National Guard tuition assistance benefits.

### Leadership Laboratories

Leadership labs provide cadets with practical leadership experience and performance-oriented, hands-on instruction outside the classroom.. Diagnostic evaluations of cadets in leadership roles are frequently administered. Leadership labs are compulsory for enrolled cadets. Physical training is conducted three times a week with the purpose of developing muscular strength, endurance, and cardio-respiratory endurance.

### Veterans

Veterans who have served on active duty or in the Army Reserve/ National Guard are also eligible for the ROTC program. Although veterans are not required to take the Basic Course, they are encouraged to do so. A minimum of 60 credit hours are required prior to enrolling in the Advanced Course.

### Registration and Credits

Army ROTC serves as elective credit in most departments. Elective course credit toward your degree for AROTC classes will be determined by your individual academic advisor. Students who wish to register for Army ROTC classes do so through the normal course registration process at CSM. AROTC classes begin with the MSGN prefix.

For more information about AROTC, contact:

the Army ROTC Enrollment and Scholarship Officer at:  
303-492-3549 or 303-492-6495

or the department on campus directly at:  
303-273-3380

The department is located in the Military Science building, 1232 West Campus Road.

You can also go to <http://www.colorado.edu/AROTC>.

For information about ROTC at CSM, call 303-273-3398 or 303-273-3380.

General CSM Minor/ASI requirements can be found [here](#).

### Military Science Minor

Army ROTC cadets desiring to receive a minor in Military Science must complete at least 22 hours of Military Science courses as follows:

MSGN103	ADVENTURES IN LEADERSHIP I	2
MSGN104	ADVENTURES IN LEADERSHIP II	2
MSGN203	METHODS OF LEADERSHIP	2
MSGN204	METHODS OF LEADERSHIP AND MANAGEMENT II	2
MSGN301	MILITARY OPERATIONS AND TRAINING I	3.0
MSGN302	MILITARY OPERATIONS AND TRAINING II	3.0
MSGN303	LEADERSHIP LABORATORY	0.5
MSGN304	LEADERSHIP LABORATORY	0.5
MSGN401	OFFICER LEADERSHIP AND DEVELOPMENT I	3.0
MSGN402	OFFICER LEADERSHIP AND DEVELOPMENT II	3.0
MSGN403	LEADERSHIP LABORATORY	0.5

MSGN404	LEADERSHIP LABORATORY	0.5
Total Hours		22.0

Note: In order to Commission as a 2nd Lieutenant in the US Army, completion of a Military History Course (LAIS365) is also required.

## Courses

### **AFGN101. FOUNDATIONS OF THE UNITED STATES AIR FORCE. 1.5 Hour.**

Two semesters, 1.5 hours per semester. This survey course briefly covers topics relating to the Air Force and defense. It focuses on the structure and missions of Air Force organizations, officership and professionalism. It is also a good introduction into the use of communication skills. Weekly Leadership Lab for this course (to be taken in conjunction with AS 101 and 102) is a weekly laboratory that touches on the topics of Air Force customs and courtesies, health and physical fitness, and drill and ceremonies.

### **AFGN102. FOUNDATIONS OF THE UNITED STATES AIR FORCE. 1.5 Hour.**

Two semesters, 1.5 hours per semester. This survey course briefly covers topics relating to the Air Force and defense. It focuses on the structure and missions of Air Force organizations, officership and professionalism. It is also a good introduction into the use of communication skills. Weekly Leadership Lab for this course (to be taken in conjunction with AS 101 and 102) is a weekly laboratory that touches on the topics of Air Force customs and courtesies, health and physical fitness, and drill and ceremonies.

### **AFGN201. THE EVOLUTION OF USAF AIR AND SPACE POWER. 1.5 Hour.**

Two semesters, 1.5 hours per semester. This survey course is concerned with the beginnings of manned flight and the development of aerospace power in the United States, including the employment of air power in WWI, WWII, Korea, Vietnam, the Gulf War and the peaceful employment of U.S. air power in civic actions, scientific missions and support of space exploration. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AS 201 and 202) provides you with the opportunity to demonstrate fundamental management skills and prepares you for Field Training.

### **AFGN202. THE EVOLUTION OF USAF AIR AND SPACE POWER. 1.5 Hour.**

Two semesters, 1.5 hours per semester. This survey course is concerned with the beginnings of manned flight and the development of aerospace power in the United States, including the employment of air power in WWI, WWII, Korea, Vietnam, the Gulf War and the peaceful employment of U.S. air power in civic actions, scientific missions and support of space exploration. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AS 201 and 202) provides you with the opportunity to demonstrate fundamental management skills and prepares you for Field Training.

### **AFGN301. AIR FORCE LEADERHIP STUDIES. 3.5 Hours.**

Two semesters, 3.5 hours per semester. This course is a study in the anatomy of leadership, the need for quality and management leadership, the role of discipline in leadership situations and the variables affecting leadership. Case studies are used to examine Air Force leadership and management situations as a means of demonstrating and exercising practical application of the concepts. Deal with actual problems and complete projects associated with planning and managing the Leadership Laboratory. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AS 301 and 302) provides you the opportunity to develop your fundamental management skills while planning and conducting cadet activities.

### **AFGN302. AIR FORCE LEADERHIP STUDIES. 3.5 Hours.**

Two semesters, 3.5 hours per semester. This course is a study in the anatomy of leadership, the need for quality and management leadership, the role of discipline in leadership situations and the variables affecting leadership. Case studies are used to examine Air Force leadership and management situations as a means of demonstrating and exercising practical application of the concepts. Deal with actual problems and complete projects associated with planning and managing the Leadership Laboratory. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AS 301 and 302) provides you the opportunity to develop your fundamental management skills while planning and conducting cadet activities.

### **AFGN401. NATIONAL SECURITY AFFAIRS AND PREPARATION FOR ACTIVE DUTY. 3.5 Hours.**

Two semesters, 3.5 hours per semester. Learn about the role of the professional military leader in a democratic society; societal attitudes toward the armed forces; the requisites for maintaining adequate national defense structure; the impact of technological and international developments on strategic preparedness and the overall policy-making process; and military law. In addition, you will study topics that will prepare you for your first active-duty assignment as an officer in the Air Force. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AS 401 and 402) provides you with the opportunity to use your leadership skills in planning and conducting cadet activities. It prepares you for commissioning and entry into the active-duty Air Force.

### **AFGN402. NATIONAL SECURITY AFFAIRS AND PREPARATION FOR ACTIVE DUTY. 3.5 Hours.**

Two semesters, 3.5 hours per semester. Learn about the role of the professional military leader in a democratic society; societal attitudes toward the armed forces; the requisites for maintaining adequate national defense structure; the impact of technological and international developments on strategic preparedness and the overall policy-making process; and military law. In addition, you will study topics that will prepare you for your first active-duty assignment as an officer in the Air Force. Weekly Leadership Laboratory (LLAB) for this course (to be taken in conjunction with AS 401 and 402) provides you with the opportunity to use your leadership skills in planning and conducting cadet activities. It prepares you for commissioning and entry into the active-duty Air Force.

**MSGN103. ADVENTURES IN LEADERSHIP I. 2.0 Hours.**

(I) Introduces fundamentals of leadership and the United States Army. Examines its organization, customs, and history as well as its current relevance and purpose. Students also investigate basic leadership and management skills necessary to be successful in both military and civilian settings. Includes fundamentals of Army leadership doctrine, teambuilding concepts, time and stress management, an introduction to cartography and land navigation, marksmanship, briefing techniques, and some basic military tactics. Lab fee. 1 hour lecture, 2 hours lab, 3 hours PT, and 80 hours field training; 2 semester hours. (Fall).

**MSGN104. ADVENTURES IN LEADERSHIP II. 2.0 Hours.**

(II) Continues the investigation of leadership in small organizations. Covers selected topics such as basic troop leading procedures, military first aid and casualty evacuation concepts, creating ethical work climates, an introduction to Army organizations and installations, and a further examination of basic military tactics. Introduces students to effective military writing styles. Lab fee. 1 hour lecture, 2 hours lab, 3 hours PT, and 80 hours field training; 2 semester hours. (Spring).

**MSGN198. SPECIAL TOPICS IN MILITARY SCIENCE. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MSGN199. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**MSGN203. METHODS OF LEADERSHIP. 2.0 Hours.**

(I) Comprehensively reviews advanced leadership and management concepts including motivation, attitudes, communication skills, problem solving, human needs and behavior, and leadership self development. Students continue to refine effective written and oral communications skills and to explore topics such as the basic branches of the Army, and officer and NCO duties. Students conduct classroom and practical exercises in small unit light infantry tactics and are prepared to perform as midlevel leaders in the cadet organization. Lab fee: 1 hour lecture, 2 hours lab, 3 hours PT, and 80 hours field training; 2 semester hours. (Fall).

**MSGN204. METHODS OF LEADERSHIP AND MANAGEMENT II. 2.0 Hours.**

(II) Focuses on leadership and management functions in military and corporate environments. Studies various components of Army leadership doctrine to include the four elements of leadership, leadership principles, risk management and planning theory, the be-know-do framework, and the Army leadership evaluation program. Continue to refine communication skills. Lab fee. 1 hour lecture, 2 hours lab, 3 hours PT, and 80 hours field training; 2 semester hours. (Spring).

**MSGN298. SPECIAL TOPICS IN MILITARY SCIENCE. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MSGN299. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**MSGN301. MILITARY OPERATIONS AND TRAINING I. 3.0 Hours.**

(I) Further explores the theory of managing and leading small military units with an emphasis on practical applications at the squad and platoon levels. Students examine various leadership styles and techniques as they relate to advanced small unit tactics. Familiarizes students with a variety of topics such as cartography, land navigation, field craft, and weapons systems. Involves multiple, evaluated leadership opportunities in field settings and hands-on experience with actual military equipment. Students are given maximum leadership opportunities in weekly labs. Prerequisite: Consent of the Professor of Military Science. Lab Fee. 3 hours lecture; 3 semester hours. (Fall).

**MSGN302. MILITARY OPERATIONS AND TRAINING II. 3.0 Hours.**

(II) Studies theoretical and practical applications of small unit leadership principles. Focuses on managing personnel and resources, the military decision making process, the operations order, and oral communications. Exposes the student to tactical unit leadership in a variety of environments with a focus on preparation for the summer advance camp experience. Prerequisite: Consent of the Professor of Military Science. Lab Fee. 3 hours lecture; 3 semester hours. (Spring).

**MSGN303. LEADERSHIP LABORATORY. 0.5 Hours.**

(I) Development of military leadership techniques to include preparation of operation plans, presentation of instruction, and supervision of underclass military cadets. Instruction in military drill, ceremonies, and customs and courtesies of the Army. Must be taken in conjunction with MSGN301. Prerequisite: Consent of department. Lab Fee. 2 hours lab, 3 hours PT, 80 hours field training; .5 semester hour. (Fall).

**MSGN304. LEADERSHIP LABORATORY. 0.5 Hours.**

(II) Continued development of military leadership techniques with the major emphasis on leading an Infantry Squad. Training is "hands-on." Practical exercises are used to increase understanding of the principles of leadership learned in MSGN302. Must be taken in conjunction with MSGN302. Prerequisite: Consent of department. Lab Fee. 2 hours lab, 3 hours PT, 80 hours field training; .5 semester hour. (Spring).

**MSGN398. SPECIAL TOPICS IN MILITARY SCIENCE. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MSGN399. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

**MSGN401. OFFICER LEADERSHIP AND DEVELOPMENT I. 3.0 Hours.**

(I) Examines management and leadership concepts and techniques associated with planning and executing military training and operations at company and higher echelons. Includes analyses of professional ethics and values, effective training principles and procedures, subordinate counseling, and effective staff officer briefing techniques. Also investigates other subjects such as counter terrorism, modern peacekeeping missions, and the impact of the information revolution on the art of land warfare. Conducted both in and out of classroom setting and with multiple practical leadership opportunities to organize cadet training and activities.

Prerequisite: Consent of the Professor of Military Science. Lab Fee. 3 hours lecture; 3 semester hours. (Fall).

**MSGN402. OFFICER LEADERSHIP AND DEVELOPMENT II. 3.0 Hours.**

(II) Continues MSGN401 study of management and leadership concepts and techniques, providing practical leadership experiences in the classroom and during multiple cadet-run activities. Also examines varied topics such as theory and practice of the military justice system, law of war, military-media relations, support mechanisms for soldiers and their families, operational security considerations, and historical case studies in military leadership in the context of

21st century land warfare. Prerequisite: Consent of the Professor of Military Science. Lab Fee. 3 hours lecture; 3 semester hours. (Spring).

**MSGN403. LEADERSHIP LABORATORY. 0.5 Hours.**

(I) Continued development of leadership techniques by assignment in the command and staff positions in the Cadet Battalion. Cadets are expected to plan and execute much of the training associated with the day-to-day operations within the cadet battalion. Utilizing the troop leading and management principles

learned in previous classes, cadets analyze the problems which the battalion faces, develop strategies, brief recommendations, and execute the approved plan. Prerequisite: Consent of department. Lab Fee. 2 hours lab, 3 hours PT, and 80 hours field training; .5 semester hour. (Fall).

**MSGN404. LEADERSHIP LABORATORY. 0.5 Hours.**

(II) Continued leadership development by serving in the command and staff positions in the Cadet Battalion. Cadets take a large role in determining the goals and direction of the cadet organization, under supervision of the cadre. Cadets are required to plan and organize cadet outings and much of the training of underclassmen. Lab Fee.

Prerequisite: Consent of department. Lab Fee. 2 hours lab, 3 hours PT, and 80 hours field training; .5 semester hour. (Spring).

**MSGN497. SPEC STDY LDRSHIP/SMALL GRP. 3.0 Hours.**

(I) The course is specifically geared to the unique leadership challenges faced by individuals involved in CSM student government and other campus leadership positions. Instruction emphasis is on forces and dynamics which shape and define leader/manager's job in the campus environment. Prerequisite: Currently appointed or elected leader of a recognized student organization or consent of the department head. 1 hour lecture and 5 hours lab; 3 semester hours.

**MSGN498. SPECIAL TOPICS IN MILITARY SCIENCE. 1-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MSGN499. INDEPENDENT STUDY. 1-6 Hour.**

(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.



## Physical Education and Athletics

<http://www.csmorediggers.com>

The Department of Physical Education and Athletics offers a four-fold physical education and athletics program which includes:

1. Required physical education classes;
2. Intercollegiate athletics;
3. Intramural athletics and club sports; and
4. Recreational athletics.

A large number of students use the institution's facilities for recreational purposes, including swimming, tennis, soccer, basketball, volleyball, weight lifting, softball, and racquetball.

### Russell H. Volk Gymnasium

A tri-level complex containing a NCAA regulation basketball arena, two racquetball/handball courts, wrestling room, weight training facility, locker space, and offices for the Physical Education Department.

### Steinhauer Field House

A facility of 35,000-sq. ft., which provides for the needs of intercollegiate athletics and physical education classes.

### Darden Baseball Field

Newly renovated with dugouts, fencing, 10 inning score-board, netted backstop, press-box and lights for night games. Located west of Brooks Field and has seating accommodations for 500 spectators.

### Softball Field

Newly constructed dugouts, batting cage, perimeter fencing, sound system and new irrigation system. Located west of Darden Field seating for 200 people.

### Harry D. Campbell Field

Includes a synthetic surface named in honor of Harry D. Campbell, Class of 1939. This is equipped with lights and a steel-concrete grandstand and bleachers which seat 3,500 spectators.

### Tennis Courts

The Department maintains four tennis courts.

### Student Recreation Center

A three-level, 108,000 square foot facility that features an 8 lane, 25 yard swimming pool with 2 diving boards and a 14 person hot tub. There are men's and women's locker rooms, a 4,000 square foot climbing wall, a full service juice bar, an elevated jogging track, a 5,500 square foot fitness area, 2 multi-purpose rooms, a recreational gym and an arena that seats 3,000 for varsity athletic contests.

### Swenson Intramural Complex

Two fields are available for intramural/recreation sports.

### Stermole Track and Field Complex

Nine lane metric track with all field event components necessary to host NCAA, RMAC sanctioned events. Seating for 800 spectators.

### CSM Soccer Stadium

Synthetic surface which provides opportunities for Men's and Women's NCAA, RMAC sanctioned events. Seating for 500 spectators.

## Required Physical Education

Each student at Colorado School of Mines is required to complete four separate semesters of Physical Education classes (PAGN):

PAGN101	PHYSICAL EDUCATION (prerequisite)	0.5
PAGN102	PHYSICAL EDUCATION (prerequisite)	0.5
PAGN2XX	PHYSICAL EDUCATION	0.5
PAGN2XX	PHYSICAL EDUCATION	0.5
Total Hours		2.0

Exceptions:

1. A medical excuse verified by a physician;
2. Veterans, honorably or generally discharged from the armed forces;
3. New students entering CSM for the first time who are 26 years or older prior to the first day of class;
4. Students holding a bachelor's degree.

Normally, it is fulfilled during the first two years of attendance. Transfer students should check with the Admissions Office regarding advanced standing in physical education. Participation in intercollegiate athletics may be substituted for required semesters and hours of physical education. ROTC students can waive the physical education requirement when a similar four-semester physical activity is required in their respective ROTC Programs.

Upper-class students who wish to continue taking physical education after completing graduation requirements may re-enroll in any of the 200-level courses.

Some of the 200-level courses may require off campus transportation, please check with Department of Athletics. All students enrolled in physical education shall provide their own gym uniform, athletic shoes, or swimming suit. Students are encouraged to rent a locker and lock in Volk for a \$10 rental fee.

## Intercollegiate Athletics

The School is a charter member of the Rocky Mountain Athletic Conference (RMAC) and the National Collegiate Athletic Association (NCAA). Sports offered include: football, men's and women's basketball, wrestling, men's and women's track, men's and women's cross country, baseball, men's golf, men's and women's swimming and diving, men's and women's soccer, and women's volleyball and softball. An athlete can register each semester for one hour physical activity credit to meet their graduation requirements.

Through a required athletic fee, all full-time students attending CSM become members of the CSM Athletic Association, which financially supports the intercollegiate athletic program. With this fee, each CSM student receives free admission to all home athletic events. The Director of Athletics administers this program.

## Intramural and Club Sports

The intramural program features a variety of activities ranging from those offered in the intercollegiate athletic program to more recreational type activities. They are governed by the CSM Rec. Sports Department. All activities are offered in the following categories: men, women and co-ed.

The club sport program is governed by the CSM Sport Club Council. There are 14 competitive groups currently under this umbrella. Some teams engage in intercollegiate competition at the non-varsity level, some serve as instructional/recreational entities, and some as strictly recreational interest groups. They are funded through ASCSM. Some of the current organizations are Cycling, Ice Hockey, Lacrosse, Men's

Rugby, Women's Rugby, Ski Team, Men's Soccer, Women's Soccer, Men's Ultimate Frisbee, Women's Ultimate Frisbee, Men's Volleyball, Women's Volleyball, Water Polo, Bowling and In-Line Hockey.

## Courses

### **PAGN101. PHYSICAL EDUCATION. 0.5 Hours.**

(I) (Required and not repeatable for credit) A general overview of life fitness basics which includes exposure to educational units of Nutrition, Stress Management, Drug and Alcohol Awareness. Instruction in Fitness units provides the student an opportunity for learning and the beginning basics for a healthy life style.

### **PAGN102. PHYSICAL EDUCATION. 0.5 Hours.**

(II) (Required and not repeatable for credit) Sections in physical fitness and team sports, relating to personal health and wellness activities. Prerequisite: PAGN101 or consent of the Department Head.

### **PAGN151. VARSITY BASEBALL. 1.0 Hour.**

Instruction and practice in fundamentals and mechanics of baseball in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. Prerequisite: Consent of department. 1 semester hour.

### **PAGN153. VARSITY MEN'S BASKETBALL. 1.0 Hour.**

Instruction and practice in fundamentals and mechanics of men's basketball in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. Prerequisite: Consent of department. 1 semester hour.

### **PAGN154. VARSITY WOMEN'S BASKETBALL. 1.0 Hour.**

Instruction and practice in fundamentals and mechanics of women's basketball in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. Prerequisite: Consent of department. 1 semester hour.

### **PAGN157. VARSITY CROSS COUNTRY. 1.0 Hour.**

Instruction and practice in fundamentals and mechanics of cross country in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. Prerequisite: Consent of department. 1 semester hour.

### **PAGN159. VARSITY FOOTBALL. 1.0 Hour.**

Instruction and practice in fundamentals and mechanics of football in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. Prerequisite: Consent of department. 1 semester hour.

### **PAGN161. VARSITY GOLF. 1.0 Hour.**

Instruction and practice in fundamentals and mechanics of golf in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. Prerequisite: Consent of department. 1 semester hour.

### **PAGN167. VARSITY MEN'S SOCCER. 1.0 Hour.**

Instruction and practice in fundamentals and mechanics of men's soccer in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. Prerequisite: Consent of department. 1 semester hour.

### **PAGN168. VARSITY WOMEN'S SOCCER. 1.0 Hour.**

Instruction and practice in fundamentals and mechanics of women's soccer in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. Prerequisite: Consent of department. 1 semester hour.

### **PAGN169. VARSITY SWIMMING AND DIVING. 1.0 Hour.**

Instruction and practice in fundamentals and mechanics of swimming and diving in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. Prerequisite: Consent of department. 1 semester hour.

### **PAGN173. VARSITY TRACK AND FIELD. 1.0 Hour.**

Instruction and practice in fundamentals and mechanics of track and field in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. Prerequisite: Consent of department. 1 semester hour.

### **PAGN175. VARSITY WRESTLING. 1.0 Hour.**

Instruction and practice in fundamentals and mechanics of wrestling in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. Prerequisite: Consent of department. 1 semester hour.

### **PAGN177. VARSITY VOLLEYBALL. 1.0 Hour.**

Instruction and practice in fundamentals and mechanics of volleyball in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. Prerequisite: Consent of department. 1 semester hour.

### **PAGN179. VARSITY SOFTBALL. 1.0 Hour.**

Instruction and practice in fundamentals and mechanics of softball in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements. Prerequisite: Consent of department. 1 semester hour.

### **PAGN201. PERSONAL WELLNESS. 1.0 Hour.**

(Not repeatable for credit) Provides an overview of the 5 Dimensions of Wellness: Physical, Social, Emotional, Intellectual and Spiritual. Students will take a proactive approach to developing strategies for optimum wellness including goal setting and application of wellness principles through assignments and group in-class work. Prerequisites: PAGN101 and PAGN102 or consent of Department Head. 2 hours lecturer; 1 semester hour. Repeatable for credit.

### **PAGN202. INDOOR SOCCER. 0.5 Hours.**

(Students enrolling in these courses may be required to furnish their own equipment.) Classes will be offered on Monday and Wednesday for 50 minutes each day or on Tuesday or Thursday for 1.5 hours. Prerequisite: PAGN101 or PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour. Repeatable for credit.

### **PAGN203. TECHNIQUES OF RELAXATION. 0.5 Hours.**

(Students enrolling in these courses may be required to furnish their own equipment.) Classes will be offered on Monday and Wednesday for 50 minutes each day or on Tuesday or Thursday for 1.5 hours. Prerequisite: PAGN101 or PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour. Repeatable for credit.



**PAGN255. MOUNTAIN BIKING. 0.5 Hours.**

(Students enrolling in these courses may be required to furnish their own equipment.) Classes will be offered on Monday and Wednesday for 50 minutes each day or on Tuesday or Thursday for 1.5 hours. Prerequisite: PAGN101 or PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour. Repeatable for credit.

**PAGN257. INTRODUCTION TO ROCK CLIMBING. 0.5 Hours.**

(Students enrolling in these courses may be required to furnish their own equipment.) Classes will be offered on Monday and Wednesday for 50 minutes each day or on Tuesday or Thursday for 1.5 hours. Prerequisite: PAGN101 or PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour. Repeatable for credit.

**PAGN258. WOMEN'S ROCK CLIMBING. 0.5 Hours.**

(Students enrolling in these courses may be required to furnish their own equipment.) Classes will be offered on Monday and Wednesday for 50 minutes each day or on Tuesday or Thursday for 1.5 hours. Prerequisite: PAGN101 or PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour. Repeatable for credit.

**PAGN271. BEGINNING BADMINTON. 0.5 Hours.**

(Students enrolling in these courses may be required to furnish their own equipment.) Classes will be offered on Monday and Wednesday for 50 minutes each day or on Tuesday or Thursday for 1.5 hours. Prerequisite: PAGN101 or PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour. Repeatable for credit.

**PAGN272. ADVANCED BADMINTON. 0.5 Hours.**

(Students enrolling in these courses may be required to furnish their own equipment.) Classes will be offered on Monday and Wednesday for 50 minutes each day or on Tuesday or Thursday for 1.5 hours. Prerequisite: PAGN101 or PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour. Repeatable for credit.

**PAGN273. BEGINNING BASKETBALL. 0.5 Hours.**

(Students enrolling in these courses may be required to furnish their own equipment.) Classes will be offered on Monday and Wednesday for 50 minutes each day or on Tuesday or Thursday for 1.5 hours. Prerequisite: PAGN101 or PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour. Repeatable for credit.

**PAGN274. ADVANCED BASKETBALL. 0.5 Hours.**

(Students enrolling in these courses may be required to furnish their own equipment.) Classes will be offered on Monday and Wednesday for 50 minutes each day or on Tuesday or Thursday for 1.5 hours. Prerequisite: PAGN101 or PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour. Repeatable for credit.

**PAGN275. VOLLEYBALL. 0.5 Hours.**

(Students enrolling in these courses may be required to furnish their own equipment.) Classes will be offered on Monday and Wednesday for 50 minutes each day or on Tuesday or Thursday for 1.5 hours. Prerequisite: PAGN101 or PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour. Repeatable for credit.

**PAGN277. BEGINNING RACQUETBALL. 0.5 Hours.**

(Students enrolling in these courses may be required to furnish their own equipment.) Classes will be offered on Monday and Wednesday for 50 minutes each day or on Tuesday or Thursday for 1.5 hours. Prerequisite: PAGN101 or PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour. Repeatable for credit.

**PAGN279. HANDBALL. 0.5 Hours.**

(Students enrolling in these courses may be required to furnish their own equipment.) Classes will be offered on Monday and Wednesday for 50 minutes each day or on Tuesday or Thursday for 1.5 hours. Prerequisite: PAGN101 or PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour. Repeatable for credit.

**PAGN280. CLUB SPORTS. 0.5 Hours.**

(Students enrolling in these courses may be required to furnish their own equipment.) Classes will be offered on Monday and Wednesday for 50 minutes each day or on Tuesday or Thursday for 1.5 hours. Prerequisite: PAGN101 or PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour. Repeatable for credit.

**PAGN281. ADVANCED HANDBALL. 0.5 Hours.**

(I, II) PAGN202 through PAGN280. (Students enrolling in these courses may be required to furnish their own equipment.) Classes will be offered on Monday and Wednesday for 50 minutes each day or on Tuesday, Thursday or Saturday for 1.5 hours. Prerequisite: PAGN101 and PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour. Repeatable for credit.

**PAGN298. SPECIAL TOPICS. 0.5-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**PAGN398. SPECIAL TOPICS. 0.5-6 Hour.**

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

# Bioengineering and Life Sciences

## Programs Offered

- Minor in Bioengineering and Life Sciences
- Area of Special Interest in Bioengineering and Life Sciences

## Program Description

The interdisciplinary program in Bioengineering and Life Sciences (BELS) is administered by the Chemical and Biological Engineering Department. Participating departments are listed below:

- Chemical and Biological Engineering
- Chemistry and Geochemistry
- Civil and Environmental Engineering
- Liberal Arts and International Studies
- Mathematical and Computer Science
- Metallurgical and Materials Engineering
- Physics

All departments are represented on the Curriculum and Research Committee, which is responsible for the delivery and new course development for the program.

The mission of the BELS program is to offer Minors and Areas of Special Interest (ASI) at the undergraduate level, and support areas of specialization at the graduate level, as well as to enable research opportunities for CSM students in bioengineering and the life sciences.

Bioengineering and the Life Sciences (BELS) are becoming increasingly significant in fulfilling the role and mission of the Colorado School of Mines. Many intellectual frontiers within the fields of environment, energy, materials, and their associated fields of science and engineering, are being driven by advances in the biosciences and the application of engineering to living processes.

## Program Requirements

### Required Curriculum:

Both the Minor and the ASI require one core course (3 semester hours). The minor requires at least 6 additional credit hours from the Basic Life Science course list, and additional BELS approved courses to make up a total of at least 18 credit hours. The ASI requires at least 3 additional credit hours from the Life Science course list, and additional BELS approved courses to make up a total of at least 12 credit hours.

### Premedical Students

While medical college admissions requirements vary, most require a minimum of:

- two semesters of General Chemistry with lab
- two semesters of Organic Chemistry with lab
- two semesters of Calculus
- two semesters of Calculus-based Physics
- two semesters of English Literature and Composition
- two semesters of General Biology with lab.

CSM currently offers all of these requirements. CSM also has a premedical student society. See <http://stulife.mines.edu/premed> for more information.

General CSM Minor/ASI requirements can be found at:

<https://nextbulletin.mines.edu/undergraduate/undergraduateinformation/specialprograms/minorasi/>

## Minor in Bioengineering and Life Sciences

The Minor in BELS requires a minimum of 18 semester hours of acceptable coursework, as outlined under the Required Curriculum section that follows.

The Area of Special Interest (ASI) in BELS requires a minimum of 12 semester hours of acceptable coursework, as outlined under the Required Curriculum section that follows.

Enrollments in the BELS Minor and ASI are approved by the Director or Associate Director, who monitor progress and completion.

## Required Curriculum

Both the Minor and the ASI require one core course (3 semester hours). The minor requires at least 6 additional credit hours from the Basic Life Science course list, and additional BELS-approved courses to make up a total of at least 18 credit hours. The ASI requires at least 3 additional credit hours from the Life Science course list, and additional BELS-approved courses to make up a total of at least 12 credit hours.

### Core course

BELS301	GENERAL BIOLOGY I	3.0
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### Basic Life Science courses

BELS303	GENERAL BIOLOGY II	3.0
BELS311	GENERAL BIOLOGY I LABORATORY	1.0
BELS313	GENERAL BIOLOGY II LABORATORY	1.0
BELS321	INTRO TO GENETICS	4.0
BELS402	CELL BIOLOGY AND PHYSIOLOGY	3.0
BELS404	ANATOMY AND PHYSIOLOGY	3.0
BELS405	ANATOMY AND PHYSIOLOGY LAB	1.0
CHGN428	BIOCHEMISTRY	3.0
CHGN462/ CHGC562	MICROBIOLOGY AND THE ENVIRONMENT	3.0
CHGC563/ ESGN582	ENVIRONMENTAL MICROBIOLOGY	2

### BELS-approved Elective courses (including, but not limited to)

BELS/LAIS320	INTRODUCTION TO ETHICS	3.0
BELS/PHGN333	INTRODUCTION TO BIOPHYSICS	3.0
BELS350	HONORS UNDERGRADUATE RESEARCH	1-3
BELS351	HONORS UNDERGRADUATE RESEARCH	1-3
BELS/CHEN415	POLYMER SCIENCE AND TECHNOLOGY	3.0
BELS/CHEN432	TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS	3.0
BELS450	HONORS UNDERGRADUATE RESEARCH	1-3
BELS451	HONORS UNDERGRADUATE RESEARCH	1-3
BELS325	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3.0
BELS425	MUSCULOSKELETAL BIOMECHANICS	3.0
BELS428	COMPUTATIONAL BIOMECHANICS	3.0
BELS453	WASTEWATER ENGINEERING	3.0
BELS470	INTRODUCTION TO MICROFLUIDICS	3.0
BELS/EGGN525	MUSCULOSKELETAL BIOMECHANICS	3.0
BELS527	PROSTHETIC AND IMPLANT ENGINEERING	3.0
BELS528	COMPUTATIONAL BIOMECHANICS	1-3
BELS530	BIOMEDICAL	3.0

BELS541	BIOCHEMICAL TREATMENT PROCESSES	3.0
CHGN422	POLYMER CHEMISTRY LABORATORY	1.0
CHGN508	ANALYTICAL SPECTROSCOPY	3.0
MLGN523	APPLIED SURFACE AND SOLUTION CHEMISTRY	3.0
ESGN401	FUNDAMENTALS OF ECOLOGY	3.0
BELS/ESGN544	AQUATIC TOXICOLOGY	3.0
BELS545	ENVIRONMENTAL TOXICOLOGY	3.0
BELS596	MOLECULAR ENVIRONMENTAL BIOTECHNOLOGY	3.0
ESGN586	MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT	3.0
CHGN221	ORGANIC CHEMISTRY I	3.0
CHGN222	ORGANIC CHEMISTRY II	3.0
BELS/MTGN/MLGN570	INTRO TO BIOCOMPATIBILITY	3.0

\* Note: Only 3 hours of Organic Chemistry course credit may be applied toward the BELS minor or ASI. See General rules for Minor Programs and Areas of Special Interest ([bulletin.mines.edu/undergraduate/sectionundergraduateinformation/specialprograms](http://bulletin.mines.edu/undergraduate/sectionundergraduateinformation/specialprograms)). Note, however, that due to the interdisciplinary nature of the BELS minor and ASI programs, there is no restriction on the number of credit hours that may be taken in the student's degree granting department, provided that the course carries a BELS course number and is not required by the degree program for graduation.

BELS101	BIOLOGICAL AND ENVIRONMENTAL SYSTEMS	4
BELS301	GENERAL BIOLOGY I	3
BELS303	GENERAL BIOLOGY II	3
BELS311	GENERAL BIOLOGY I LABORATORY	1
BELS313	GENERAL BIOLOGY II LABORATORY	1
BELS/LAIS320	INTRODUCTION TO ETHICS	3
BELS321	INTRO TO GENETICS	4
BELS/EGGN325	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3
BELS331	MATHEMATICAL BIOLOGY	3
BELS/PHGN333	INTRODUCTION TO BIOPHYSICS	3
BELS350	HONORS UNDERGRADUATE RESEARCH	1-3
BELS351	HONORS UNDERGRADUATE RESEARCH	1-3
BELS398	SPECIAL TOPICS IN BIOENGINEERING AND LIFE SCIENCES	1-6
BELS402	CELL BIOLOGY AND PHYSIOLOGY	3
BELS404	ANATOMY AND PHYSIOLOGY	3
BELS405	ANATOMY AND PHYSIOLOGY LAB	1
BELS406	ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN	3
BELS407	ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN LABORATORY	1
BELS/CHEN415	POLYMER SCIENCE AND TECHNOLOGY	3
BELS/EGGN425	MUSCULOSKELETAL BIOMECHANICS	3
BELS426	MODELING AND SIMULATION OF HUMAN MOVEMENT	3
BELS/EGGN428	COMPUTATIONAL BIOMECHANICS	3

BELS431	IMMUNOLOGY FOR ENGINEERS AND SCIENTISTS	3
BELS432	TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS	3
BELS450	HONORS UNDERGRADUATE RESEARCH	1-3
BELS451	HONORS UNDERGRADUATE RESEARCH	1-3
BELS/ESGN453	WASTEWATER ENGINEERING	3
BELS454	APPLIED BIOINFORMATICS	3
BELS/CHEN470	INTRODUCTION TO MICROFLUIDICS	3
BELS498	SPECIAL TOPICS IN BIOENGINEERING AND LIFE SCIENCES	1-6
BELS/EGGN525	MUSCULOSKELETAL BIOMECHANICS	3
BELS526	MODELING AND SIMULATION OF HUMAN MOVEMENT	3
BELS/EGGN527	PROSTHETIC AND IMPLANT ENGINEERING	3
BELS528	COMPUTATIONAL BIOMECHANICS	1-3
BELS/EGGN530	BIOMEDICAL	3
BELS531	IMMUNOLOGY FOR SCIENTISTS AND ENGINEERS	3
BELS/EGGN541	BIOCHEMICAL TREATMENT PROCESSES	3
BELS/ESGN544	AQUATIC TOXICOLOGY	3
BELS/ESGN545	ENVIRONMENTAL TOXICOLOGY	3
BELS554	APPLIED BIOINFORMATICS	3
BELS555	POLYMER AND COMPLEX FLUIDS COLLOQUIUM	1
BELS/MTGN/MLGN570	INTRO TO BIOCOMPATIBILITY	3
BELS/ESGN596	MOLECULAR ENVIRONMENTAL BIOTECHNOLOGY	3
BELS598	SPECIAL TOPICS	1-6
CHGN422	POLYMER CHEMISTRY LABORATORY	1
CHGN428	BIOCHEMISTRY	3
CHGN462/CHGC562	MICROBIOLOGY AND THE ENVIRONMENT	3
CHGN508	ANALYTICAL SPECTROSCOPY	3
ESGN401	FUNDAMENTALS OF ECOLOGY	3
ESGN586	MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT	3
CHGN221	ORGANIC CHEMISTRY I	3
CHGN222	ORGANIC CHEMISTRY II	3
CHGN223	ORGANIC CHEMISTRY I LABORATORY	1
CHGN224	ORGANIC CHEMISTRY II LABORATORY	1

## Energy

<http://energyminor.mines.edu>

## Programs Offered

- Minor in Energy
- Area of Special Interest in Energy

## Program Educational Objectives

The discovery, production, and use of energy in modern societies has profound and far-reaching economic, political, and environmental effects. As energy is one of CSM's core statutory missions, it is appropriate

that CSM offer a program of study that not only addresses the scientific and technical aspects of energy production and use but its broader social impacts as well. The Energy Minor program is intended to provide engineering students with a deeper understanding of the complex role energy technology plays in modern societies by meeting the following learning objectives:

1. Students will gain a broad understanding of the scientific, engineering, environmental, economic and social aspects of the production, delivery, and utilization of energy as it relates to the support of current and future civilization both regional and worldwide.
2. Students will develop depth or breadth in their scientific and engineering understanding of energy technology.
3. Students will be able to apply their knowledge of energy science and technology to societal problems requiring economic, scientific, and technical analysis and innovation, while working in a multidisciplinary environment and be able to communicate effectively the outcomes of their analyses in written and oral form.

General CSM Minor/ASI requirements can be found at:

<https://nextbulletin.mines.edu/undergraduate/undergraduateinformation/specialprograms/minorasi/>

## Program Requirements

### Minor in Energy:

The Minor in Energy requires a minimum of 18 credit hours of acceptable course work. There are three curricular tracks:

- Fossil Energy,
- Renewable Energy, and
- General.

All Energy Minors must take:

ENGY200	INTRODUCTION TO ENERGY	3.0
EBGN/ENGY330	ENERGY ECONOMICS	3.0
ENGY490	ENERGY AND SOCIETY	3.0
Total Hours		9.0

In addition to the required courses, students in the Fossil Energy track must take:

ENGY310	FOSSIL ENERGY	3.0
Two approved fossil energy-related electives		6.0
Total Hours		9.0

In addition to the required courses, students in the Renewable Energy track must take:

ENGY320	RENEWABLE ENERGY	3.0
Two approved renewable energy-related electives		6.0
Total Hours		9.0

In addition to the required courses, students in the General track must take:

Select at least two of the following energy topic survey courses:		6.0
ENGY310	FOSSIL ENERGY	
ENGY320	RENEWABLE ENERGY	
ENGY340	NUCLEAR ENERGY	
ENGY350	INTRODUCTION TO GEOTHERMAL ENERGY	

One additional energy-related elective from any category	3.0
Total Hours	9.0

Up to 3 hours of coursework may be taken in the student's degree-granting department.

The Area of Special Interest in Energy requires a minimum of 12 credit hours of acceptable course work:

ENGY200	INTRODUCTION TO ENERGY	3.0
EBGN/ENGY330	ENERGY ECONOMICS	3.0
Two additional energy-related courses		6.0
Total Hours		12.0

### Introductory Courses

ENGY200	INTRODUCTION TO ENERGY	3.0
EBGN/ENGY330	ENERGY ECONOMICS	3.0
Total Hours		6.0

### Energy-related Courses: Fossil Energy Track

Select three of the following:		9.0
ENGY310	FOSSIL ENERGY	
CHEN408	NATURAL GAS PROCESSING	
CHEN409	PETROLEUM PROCESSES	
GEGN438	PETROLEUM GEOLOGY	
PEGN251	FLUID MECHANICS	
PEGN305	COMPUTATIONAL METHODS IN PETROLEUM ENGINEERING	
PEGN308	RESERVOIR ROCK PROPERTIES	
PEGN311	DRILLING ENGINEERING	
PEGN361	COMPLETION ENGINEERING	
PEGN411	MECHANICS OF PETROLEUM PRODUCTION	
PEGN419	WELL LOG ANALYSIS AND FORMATION EVALUATION	
PEGN422	ECONOMICS AND EVALUATION OF OIL AND GAS PROJECTS	
PEGN/ MNGN438	GEOSTATISTICS	
Total Hours		9.0

### Energy-related Courses: Renewable Energy Track

Select three of the following:		9.0
ENGY320	RENEWABLE ENERGY	
MTGN469	FUEL CELL SCIENCE AND TECHNOLOGY	
EGGN486	PRACTICAL DESIGN OF SMALL RENEWABLE ENERGY SYSTEMS	
PHGN419	PRINCIPLES OF SOLAR ENERGY SYSTEMS	
Total Hours		9.0

### General Track

Select two of the following:		6.0
ENGY310	FOSSIL ENERGY	
ENGY320	RENEWABLE ENERGY	
ENGY340	NUCLEAR ENERGY	
ENGY350	INTRODUCTION TO GEOTHERMAL ENERGY	

### Elective courses

Select one additional course from either the Fossil Energy or Renewable Energy tracks or from the following additional energy-related courses:

CHEN472	INTRODUCTION TO ENERGY TECHNOLOGIES	3.0
EGGN389	FUNDAMENTALS OF ELECTRIC MACHINERY	
EGGN403	THERMODYNAMICS II	
EGGN589	DESIGN AND CONTROL OF WIND ENERGY SYSTEMS	
EBGN340	ENERGY AND ENVIRONMENTAL POLICY	
LAIS419	MEDIA AND THE ENVIRONMENT	
LAIS423	ADVANCED SCIENCE COMMUNICATION	
LAIS424	RHETORIC, ENERGY AND PUBLIC POLICY	
LAIS477	ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT	
LAIS489	NUCLEAR POWER AND PUBLIC POLICY	
LAIS486	SCIENCE AND TECHNOLOGY POLICY	
Total Hours		9.0

#### Policy course (required for all Energy minors)

ENGY/LAIS490	ENERGY AND SOCIETY	3.0
Total Hours		3.0

ENGY200	INTRODUCTION TO ENERGY	3
ENGY310	FOSSIL ENERGY	3
ENGY320	RENEWABLE ENERGY	3
ENGY330	ENERGY ECONOMICS	3
ENGY340	NUCLEAR ENERGY	3
ENGY350	INTRODUCTION TO GEOTHERMAL ENERGY	3
ENGY490	ENERGY AND SOCIETY	3
ENGY497	SUMMER PROGRAMS	6

## Humanitarian Engineering

General CSM Minor/ASI requirements can be found at:

<https://nextbulletin.mines.edu/undergraduate/undergraduateinformation/specialprograms/minorasi/>

### Programs Offered

- Certificate Minor in Humanitarian Engineering (27 credit hours)
- Minor in Humanitarian Engineering (18 credit hours)
- Area of Special Interest in Humanitarian Engineering (12 credit hours)
- Minor in Humanitarian Studies (for non-engineering majors) (18 credit hours)
- Area of Special Interest in Humanitarian Studies (12 credit hours)

### Program Educational Objectives

The Humanitarian Engineering and Humanitarian Studies Minors (HE & HS) are designed to prepare students to better understand the complexities of and develop a strong appreciation for society, culture, and environment in sustainable humanitarian engineering design projects. Humanitarian engineering projects are intended to provide fundamental needs (food, water, shelter, and clothing), or higher-level needs when these are specifically requested by the local people. The preparatory courses are offered through the Division of Liberal Arts and International

Studies (LAIS) with additional technical electives offered by engineering departments across campus. Interested students are encouraged to investigate the many options previously listed and described in more detail below that range from a 12 credit hour area of special interest (ASI) to a 27-credit hour certificate minor in Humanitarian Engineering.

## Program Requirements

### 1. Nature and Human Values (Gateway Course)

This is part of all CSM degree programs but the credit hours are not included as a part of the HE minor. Transfer students must show an equivalent course.

### 2. Humanitarian engineering minor

#### HE Core

LAIS/BELS320	ETHICS (required)	3.0
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Select two of the following:	6.0
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LAIS375	ENGINEERING CULTURES	
LAIS402	WRITING PROPOSALS FOR A BETTER WORLD	
LAIS412	LITERATURE AND THE ENVIRONMENT	
LAIS475	ENGINEERING CULTURES IN THE DEVELOPING WORLD	
LAIS477/577	ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT (strongly recommended)	

#### Global Studies track

Select one option:	6.0
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#### Option A:

Select two of the following:	
LAIS220	INTRODUCTION TO PHILOSOPHY *
LAIS221	INTRODUCTION TO RELIGIONS *
LAIS301	CREATIVE WRITING: POETRY I
LAIS309	LITERATURE AND SOCIETY
LAIS325	CULTURAL ANTHROPOLOGY *
LAIS335	INTERNATIONAL POLITICAL ECONOMY OF LATIN AMERICA
LAIS337	INTERNATIONAL POLITICAL ECONOMY OF ASIA
LAIS339	INTERNATIONAL POLITICAL ECONOMY OF THE MIDDLE EAST
LAIS341	INTERNATIONAL POLITICAL ECONOMY OF AFRICA
EBGN342	ECONOMIC DEVELOPMENT
LAIS345	INTERNATIONAL POLITICAL ECONOMY
LAIS411	LITERATURES OF THE AFRICAN WORLD
LAIS412	LITERATURE AND THE ENVIRONMENT *
LAIS421	ENVIRONMENTAL PHILOSOPHY AND POLICY
LAIS435	LATIN AMERICAN DEVELOPMENT
LAIS437	ASIAN DEVELOPMENT *
LAIS439	MIDDLE EAST DEVELOPMENT *
LAIS441	AFRICAN DEVELOPMENT
LAIS442	NATURAL RESOURCES AND WAR IN AFRICA
LAIS446	GLOBALIZATION
LAIS448	GLOBAL ENVIRONMENTAL ISSUES
LAIS452	CORRUPTION AND DEVELOPMENT



LAIS453	ETHNIC CONFLICT IN GLOBAL PERSPECTIVE	
LAIS485	CONSTITUTIONAL LAW AND POLITICS	
LAIS486	SCIENCE AND TECHNOLOGY POLICY	
LAIS487	ENVIRONMENTAL POLITICS AND POLICY	
LAIS488	WATER POLITICS AND POLICY	
<b>Option B:</b>		
Foreign Language courses (university level credits)		
McBride courses		
Select two of the following Economics and Business courses:		
EBGN310	ENVIRONMENTAL AND RESOURCE ECONOMICS	
EBGN321	ENGINEERING ECONOMICS	
EBGN330	ENERGY ECONOMICS	
<b>Technical Electives</b>		
Select one of the following:		3.0
EGGN447/547	TIMBER AND MASONRY DESIGN	
EGGN486	PRACTICAL DESIGN OF SMALL RENEWABLE ENERGY SYSTEMS	
EGGN490	SUSTAINABLE ENGINEERING DESIGN	
EGGN536	HILLSLOPE HYDROLOGY AND STABILITY	
Any Biomedical Engineering Course:		
EGGN325	INTRODUCTION TO BIOMECHANICAL ENGINEERING	
EGGN425	MUSCULOSKELETAL BIOMECHANICS	
ESGN460	ONSITE WATER RECLAMATION AND REUSE	
ESGN/	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I	
EGGN353		
ESGN/	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II	
EGGN354		
EGGN453	WASTEWATER ENGINEERING	
ESGN/	WATER SUPPLY ENGINEERING	
EGGN454		
Total Hours		18.0

### 3. Co-Curricular Activities

Co-curricular activities associated with the Humanitarian Engineering Program will include public lectures on campus and student clubs such as Engineers without Borders, Earth-works, Blue Key, Rotaract and Circle K.

### 4. Multidisciplinary Engineering Labs (MEL)

MEL will be adding labs with HE enhancements.

### 5. Senior Design (6 credit hours)

Senior design projects will preferably include students working directly with the population lacking some basic human need. Ideally, the local people will be involved with the development of the project objectives.

### 6. Internship within and/or Community Service

Strongly recommended and not necessarily for credit. The project is secured through McBride (if student is Honors student), EWB, Rotoract, Circle K, Career Center, or some other nonprofit or non-governmental organization (NGO). This project must be discussed with the Director of Humanitarian Engineering prior to its occurrence.

## Five Options for CSM Students

- 1. Area of Special Interest (ASI) in Humanitarian Studies (12 credit hours):** Mainly for students not enrolled in the Engineering Division and/or students not earning ABET accredited engineering degrees. Nine credits must be from the HE core in LAIS, with three more from associated LAIS or EB courses.
- 2. Minor in Humanitarian Studies (18 credit hours):** Mainly for students not enrolled in one of the ABET accredited Engineering programs on campus. Nine credits must be from the HE core in LAIS, with nine more credits from associated LAIS or EB courses.
- 3. Area of Special Interest (ASI) in Humanitarian Engineering (12 credit hours):** Mainly for students not enrolled in the Engineering Division but from an ABET accredited engineering program on campus wishing to deepen their knowledge in human development issues. Nine credits must be from the HE core in LAIS, with three more from LAIS, EB or associated HE technical elective courses.
- 4. Minor in Humanitarian Engineering (18 credit hours):** For those students enrolled in any CSM engineering degree program. Take 1. and 2. from the list above.
- 5. Certificate Minor in Humanitarian Engineering (27+ credit hours):** For students enrolled in the Engineering Division or who can incorporate a strong humanitarian component to their senior design project. Will include the minor (4.) plus program requirements 4, 5, and 6 above.

EBGN310	ENVIRONMENTAL AND RESOURCE ECONOMICS	3
EBGN321/ CHEN421	ENGINEERING ECONOMICS	3
EBGN330	ENERGY ECONOMICS	3
EBGN342	ECONOMIC DEVELOPMENT	3
EGGN/BELS325	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3
EGGN/ ESGN353	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I	3
EGGN/ ESGN354	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II	3
EGGN/BELS425	MUSCULOSKELETAL BIOMECHANICS	3
EGGN447	TIMBER AND MASONRY DESIGN	3
EGGN/ ESGN453	WASTEWATER ENGINEERING	3
EGGN/ ESGN454	WATER SUPPLY ENGINEERING	3
EGGN486	PRACTICAL DESIGN OF SMALL RENEWABLE ENERGY SYSTEMS	3
EGGN490	SUSTAINABLE ENGINEERING DESIGN	3
EGGN536	HILLSLOPE HYDROLOGY AND STABILITY	3
ESGN460	ONSITE WATER RECLAMATION AND REUSE	3
LAIS220	INTRODUCTION TO PHILOSOPHY	3
LAIS221	INTRODUCTION TO RELIGIONS	3
LAIS309	LITERATURE AND SOCIETY	3
LAIS/BELS320	ETHICS	3
LAIS325	CULTURAL ANTHROPOLOGY	3
LAIS335	INTERNATIONAL POLITICAL ECONOMY OF LATIN AMERICA	3

LAIS337	INTERNATIONAL POLITICAL ECONOMY OF ASIA	3
LAIS339	INTERNATIONAL POLITICAL ECONOMY OF THE MIDDLE EAST	3
LAIS341	INTERNATIONAL POLITICAL ECONOMY OF AFRICA	3
LAIS345	INTERNATIONAL POLITICAL ECONOMY	3
LAIS375	ENGINEERING CULTURES	3
LAIS402	WRITING PROPOSALS FOR A BETTER WORLD	3
LAIS411	LITERATURES OF THE AFRICAN WORLD	3
LAIS412	LITERATURE AND THE ENVIRONMENT	3
LAIS421	ENVIRONMENTAL PHILOSOPHY AND POLICY	3
LAIS435/535	LATIN AMERICAN DEVELOPMENT	3
LAIS437/537	ASIAN DEVELOPMENT	3
LAIS439	MIDDLE EAST DEVELOPMENT	3
LAIS441	AFRICAN DEVELOPMENT	3
LAIS442	NATURAL RESOURCES AND WAR IN AFRICA	3
LAIS446/546	GLOBALIZATION	3
LAIS448	GLOBAL ENVIRONMENTAL ISSUES	3
LAIS452/552	CORRUPTION AND DEVELOPMENT	3
LAIS453	ETHNIC CONFLICT IN GLOBAL PERSPECTIVE	3
LAIS475	ENGINEERING CULTURES IN THE DEVELOPING WORLD	3
LAIS477/577	ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT	3
LAIS485	CONSTITUTIONAL LAW AND POLITICS	3
LAIS486/586	SCIENCE AND TECHNOLOGY POLICY	3
LAIS487/587	ENVIRONMENTAL POLITICS AND POLICY	3
LAIS488/588	WATER POLITICS AND POLICY	3

## Guy T. McBride, Jr. Honors Program in Public Affairs

**General CSM Minor/ASI requirements can be found at:**

<https://nextbulletin.mines.edu/undergraduate/undergraduateinformation/specialprograms/minorasi/>

### Program Educational Objectives

The McBride Honors Program in Public Affairs offers an honors minor consisting of seminars, courses, and off-campus activities that has the primary goal of providing a select number of students the opportunity to cross the boundaries of their technical expertise into the ethical, cultural, socio-political, and environmental dimensions of human life. Students will develop their skills in communication, critical thinking, and leadership through seminar style classes that explore diverse aspects of the human experience. The seminars are designed to offer coherent perspectives across the curriculum, allowing for a maximum degree of discussion and debate on complex topics. Themes, approaches, and perspectives from the humanities and the social sciences are integrated with science and engineering perspectives to develop in students habits of thought necessary for a comprehensive understanding of societal and cultural issues that enhance critical thinking, social responsibility, and enlightened leadership.

### Program Description

The McBride Honors Program is administered by the Division of Liberal Arts and International Studies.

As of fall 2011, the new 21 credit hour curriculum of the McBride Honors Program in Public Affairs has been modified for all students admitted as freshmen in spring 2011 and starting the Program as sophomores in the fall term.

McBride students who began the Program prior to fall 2011 will continue with the 24-credit hour curriculum that is designated separately below.

The Program is delivered primarily in an interdisciplinary seminar format that maximizes discussion and debate and student engagement. Seminars are designed and taught by teams of faculty members from the humanities, social sciences, life sciences and physical sciences, and engineering. The curriculum of the McBride Honors Program includes the following features and educational experiences:

- Student-centered seminars guided by faculty moderators from various disciplines.
- An interdisciplinary approach that integrates domestic and global perspectives into the curriculum.
- One-to-one long-lasting intellectual relationships and camaraderie among students and between faculty and students.
- The Development and practice of oral/written communication, argumentation, and listening skills.
- The opportunity to develop an individualized educational experience involving study abroad, service learning, research, entrepreneurial projects, and/or professional internships.

An important experience in the Program is the opportunity to engage in a Practicum (an internship, overseas study, public service, undergraduate research experience, or thesis). Because engineers and scientists will continue to assume significant responsibilities as leaders in public and private sectors, it is essential that CSM students be prepared for more than their traditional "first jobs". Leadership and management demand an understanding of the accelerating pace of change that marks the social, political, economic, and environmental currents of society and a commitment to social and environmental responsibility. Regardless of their career goals, however, this same understanding is demanded of an educated person in the contemporary world. While the seminars in the Program are designed to nourish such an understanding, these Practicum experiences allow students to see firsthand the kinds of challenges that they will face in their professional and personal lives.

Foreign study is also possible either through CSM-sponsored trips or through individual plans arranged in consultation with the Director and CSM's Office of International Programs. The program offers some competitive scholarships to selected students to facilitate study abroad or other exceptional educational experiences. Please contact the Director or see the Program website for more information.

### Student Profile

The McBride Honors Program in Public Affairs seeks to enroll students who can benefit most from the learning experiences upon which the Program is based while significantly contributing to the broader learning objectives of the McBride community. Most honors programs admit students exclusively on the basis of academic record. Although the McBride Honors Program uses SAT and ACT test scores, and high school grade point average as important indicators of success in the McBride Program, they form only part of the criteria used in the admission process. The McBride Program also examines extracurricular activities,

interest in human affairs, and the willingness to engage actively in discussion and debate. Applicants must demonstrate their commitment to public service, their leadership potential, willingness to understand and respect perspectives other than their own, and writing, listening, and speaking abilities.

Once admitted into the Program, a McBride student commits to:

- completing the McBride curriculum as stated in the Bulletin;
- participating in the McBride seminars as an active and responsible member of the learning community, always completing reading and writing assignments on time in order to be ready to learn;
- engaging in the highest level of intellectual discourse in a civil and respectful manner with all members of the CSM community, particularly with those who hold different beliefs, values, and views;
- understanding that the McBride faculty are committed to provide the best education to help students become thoughtful and responsible persons, citizens, and professionals; and
- upholding the highest standards of ethical conduct and the CSM Honor Code, particularly those related to academic honesty and respect for peers, instructors, and Program administrators.

Although the educational experiences in the McBride Honors Program are rigorous and demand a high degree of dedication from the students, McBride graduates have gained positions of their choice in industry, business, government, and within non-governmental organizations, or in other professions more easily than others, and have been successful in winning admission to high-quality graduate, law, medicine and other professional schools.

## Admission

Interested students who will begin the Program in the fall of their sophomore year should apply to the McBride Program by the deadline set by the Program, by filling out an application, submitting an essay, and securing a letter of recommendation (see website for details: <http://mcbride.mines.edu/>). Applicants will be interviewed by a team of Honors faculty and students. Once a finalist accepts the responsibilities of being a member of the Program (see above), s/he begins taking Honors courses as prescribed by the Program.

Note: Students must complete LAIS100 Nature and Human Values prior to enrolling in the first course, HNRS200 Public Affairs: Global Responsibility & Sustainability.

## H & SS Core Curriculum Requirements

Students completing the McBride Honors Program are required to complete LAIS100, "Nature and Human Values," and EBG201, "Principles of Economics." McBride students are exempt from completing SYGN200, "Human Systems."

## Transfer and Graduation Policies

The McBride Program accepts applications from transfer students as follows:

Transfer students must complete and submit an application and participate in the interview process like other applicants under the time frame set by the Program. All transfer students should expect to take the entire McBride curriculum in residence, but under some circumstances, transfer students may petition the Director for course substitutions.

## Academic Standards

Students must perform to the highest levels of writing, reading, and discussion in preparation for and during McBride seminars. Participation

in class projects and discussions is essential. Students who do not maintain an appropriate level of participation and engagement may be asked to leave the Program.

Academic integrity and honesty are expected of all Mines students. Any infractions in these areas will be handled under the rules of CSM and the McBride Program and may result in dismissal from the Program. The Program demands a high level of achievement not only in Honors courses, but in all academic work attempted at CSM. To that end, a student must meet the following minimum requirements:

- A minimum cumulative GPA 2.9 is required for admission. Failure to meet the GPA requirement will result in voiding the invitation to join the McBride Program.
- A minimum cumulative GPA of 3.0 in Honors coursework is required to remain in good academic standing in the Program. Students who drop below the minimum in their McBride coursework will be placed on probation for one semester. If the required minimum GPA has not been met at the end of the probationary semester, or in any subsequent semester, the student may be withdrawn from the Program.
- A minimum *cumulative* GPA of 2.9 is required in all course work at CSM. Students who drop below a cumulative GPA of 2.9 will be placed on probation for one semester. If the required minimum GPA has not been met at the end of the probationary semester, or in any subsequent semester, the student will be withdrawn from the Program.
- The minimum *cumulative GPA* and the minimum *Honors GPA* at the time of graduation are required in order to receive the "Minor in the McBride Honors Program in Public Affairs." Graduating seniors who fall below these minima will receive a "Minor in Public Affairs" without the Honors designation if they choose to complete the Public Affairs minor instead of transferring their credits to the Division of Liberal Arts and International Studies.
- If students wish to appeal their withdrawal from the McBride Honors Program, they must write a letter of appeal to the Director, who will review the student's case and consult with McBride faculty colleagues.

## Curriculum

The Curriculum Effective for Students Beginning Fall 2011

### Curriculum Effective Fall 2011

#### Sophomore

Fall		lec	lab	sem.hrs
HNRS200	PUBLIC AFFAIRS: GLOBAL RESPONSIBILITY AND SUSTAINABILITY			3
				<b>3.0</b>

#### Spring

Spring		lec	lab	sem.hrs
HNRS210	COMPARATIVE ETHICS AND POLITICS			3
				<b>3.0</b>

#### Junior

Fall		lec	lab	sem.hrs
HNRS300	U.S. PUBLIC POLICY ANALYSIS			3
				<b>3.0</b>

<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
HNRS310	INTERNATIONAL SCIENCE & TECHNOLOGY POLICY			3
				<b>3.0</b>
<b>Senior</b>				
<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
HNRS410	LEADERSHIP AND POWER			3
				<b>3.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
HNRS420	SYNTHESIS SEMINAR <sup>+</sup>			3.0
				<b>3.0</b>
<b>Summer</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
HNRS400	FIELD RESEARCH or 405 <sup>*</sup>			3
				<b>3.0</b>

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Total Hours: 21.0

<sup>+</sup> Note that HNRS420 Science, Technology, & Ethics is part of the curriculum for students that began in the fall of 2010 or earlier. Due to identical course numbers, the course description for HNRS420 Synthesis Seminar, for students that began in the fall of 2011 or later, will not show up in the Bulletin until the 2013-2014 academic year.

<sup>\*</sup> Students who do not register for HNRS400 but undertake other work in summer must complete HNRS405 in semester eight, in addition to HNRS410.

#### Curriculum Effective for Students Who Began Fall 2010 or Earlier

##### Freshman

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
				<b>0.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
HNRS101	PARADOXES OF HUMAN CONDITION			3.0
				<b>3.0</b>

##### Sophomore

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
HNRS201	CULTURAL ANTHROPOLOGY: A STUDY OF DIVERSE CULTURES			3
				<b>3.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
HNRS202	COMPARATIVE POLITICAL AND ECONOMIC SYSTEMS			3
				<b>3.0</b>

##### Junior

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
HNRS301	INTERNATIONAL POLITICAL ECONOMY or 302			3
				<b>3.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
HNRS311	U.S. PUBLIC POLICY: DOMESTIC AND FOREIGN or 312			3
				<b>3.0</b>

<b>Senior</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
<b>Fall</b>				
HNRS401	MCBRIDE PRACTICUM: INTERNSHIP or 402			3
				<b>3.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
HNRS411	STUDY OF LEADERSHIP AND POWER or 412			3
HNRS420	SCIENCE, TECHNOLOGY, & ETHICS			3
				<b>6.0</b>

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Total Hours: 24.0

## Courses

### HNRS200. PUBLIC AFFAIRS: GLOBAL RESPONSIBILITY AND SUSTAINABILITY. 3.0 Hours.

An introduction to issues and cultural problems and the "public affairs" and "public policy" circumstances faced by scientists, engineers, and economists as they confront issues of global responsibility and sustainability in their professional and personal lives. The seminar focuses on culture and its core role in relationships among science, engineering, technology and the environment as interactive systems. Admission to McBride Honors Program and completion of LAIS100: Nature and Human Values.

### HNRS201. CULTURAL ANTHROPOLOGY: A STUDY OF DIVERSE CULTURES. 3.0 Hours.

A study of cultures within the United States and abroad and the behavior of people. The seminar will emphasize the roles of languages, religions, moral values, and legal and economic systems in the cultures selected for inquiry. Prerequisite: HNRS101 or consent of the Program Director. 3 hours seminar; 3 semester hours.

### HNRS202. COMPARATIVE POLITICAL AND ECONOMIC SYSTEMS. 3.0 Hours.

This course constitutes a comparative study of the interrelationships between political and economic systems in theory and practice. Totalitarianism, authoritarianism, democracy, anarchy, socialism, and communism will be examined in their historical and theoretical contexts and compared with baseline concepts of what constitutes a political system. Economics will be studied from a historical/developmental approach, examining classical and neo-classical economics and theories of major western economists, including Smith, Marx, and Keynes. Specific nation or area case studies will be used to integrate concepts and to explore possible new global conditions which define the roles of governments and other institutions in the development, planning, and control of economic activities and social policy. Prerequisite: HNRS201 or permission of the Program Director. 3 hours seminar; 3 semester hours.

**HNRS210. COMPARATIVE ETHICS AND POLITICS. 3.0 Hours.**

(II) Ethics and politics interact and diverge in subtle and overt ways. This seminar will introduce students to major schools of thought and important thinkers from a variety of time periods and perspectives. Upon completion, students will be able to articulate and critically evaluate a selection of major ethical and political systems, and understand how these systems have impacted the trajectory and growth in the physical and applied sciences, particularly with regard to issues related to global responsibility and sustainability. Prerequisite: HNRS200: Public Affairs: Global Responsibility & Sustainability. 3 hours seminar; 3 semester hours.

**HNRS300. U.S. PUBLIC POLICY ANALYSIS. 3.0 Hours.**

This seminar offers a micro-economics approach that explores rationales for public policy and develops tools for policy analysis especially in terms of the U.S. with attention to science and technology policies which are especially relevant to issues of global responsibility and sustainability. It includes perspectives from social sciences other than economics. Prerequisites: EBG201 Principles of Economics, HNRS200: Public Affairs: Global Responsibility & Sustainability, HNRS210 Comparative Ethics and Politics. 3 lecture hours, 3 credit hours.

**HNRS301. INTERNATIONAL POLITICAL ECONOMY. 3.0 Hours.**

International political economy is the study of the dynamic relationships between nation-states and the global marketplace. Topics include: international and world politics, money and international finance, international trade, multinational and global corporations, global development, transition economies and societies, and developing economies and societies. Prerequisite: HNRS202 or permission of Program Director. 3 hours seminar; 3 semester hours.

**HNRS302. TECHNOLOGY AND SOCIO-ECONOMIC CHANGE. 3.0 Hours.**

A critical analysis of the interactions among science, technology, and American values and institutions. The seminar will study the role of technology in American society and will debate the implications of technology transfer from developed to developing nations. Students will learn to relate technological issues to socio-economic and religious aspects of society and explore the moral and social consequences of technological innovations. Prerequisite: HNRS202 or permission of the Program Director. 3 hours seminar; 3 semester hours.

**HNRS310. INTERNATIONAL SCIENCE & TECHNOLOGY POLICY. 3.0 Hours.**

This course builds on HNRS300 by bringing a global perspective to policy-making and policies that relate to science and technology especially with relevance to global responsibility and sustainability. The student will learn about the international organizations that affect science and technology worldwide and compare the politics of science, engineering, and economics in one or more countries with those in the United States. Those who travel abroad for their summer Field Research will go to one of the countries evaluated in this class; those who travel to Washington, D.C. will investigate further the domestic perspectives examined in this course. Prerequisite: HNRS300: U.S. Public Policy Analysis. 3 lecture hours, 3 credit hours.

**HNRS311. U.S. PUBLIC POLICY: DOMESTIC AND FOREIGN. 3.0 Hours.**

Detailed examination of United States public policy, using a case study approach to guide students to understand the various aspects of policy making and the participants in the process. As an outcome of this seminar, students will have the ability to engage in informed, critical analysis of public policy, and will understand the process and how they may become involved in it. Students should expect to spend spring break in Washington, D.C., as part of this seminar. Prerequisite: HNRS301 or HNRS302 or permission of the Program Director. 3 hours seminar; 3 semester hours.

**HNRS312. FOREIGN AREA STUDY. 3.0 Hours.**

A survey of current public policy issues of a selected country or region, based on a broad survey of history and culture as well as contemporary social, technological, economic and political trends. The areas that might be studied in a three year rotation; Far East (China and Taiwan or Hong Kong, Indonesia and/or Malaysia), Latin America (Brazil or Chile), Middle East/Africa (Turkey or South Africa). Students taking this seminar in preparation for a McBride sponsored trip abroad might be able to take a brief intensive language course before departure. Prerequisite: HNRS301 or HNRS302 or permission of the Program Director. 3 hours seminar; 3 semester hours.

**HNRS398. SPECIAL TOPICS IN THE MCBRIDE HONORS PROGRAM IN PUBLIC AFFAIRS. 1-6 Hour.**

A Special Topics course will be a pilot course in the McBride curriculum or will be offered as an enhancement to regularly-scheduled McBride seminars. Special Topics courses in the McBride curriculum will not be offered more than twice. Variable credit: 1 - 6 semester hours. Repeatable for credit under different titles.

**HNRS400. FIELD RESEARCH. 3.0 Hours.**

An extended period, typically of three weeks duration, in a field location (either in the United States or abroad or in both settings) visiting and analyzing the work and policies of government agencies, international organizations, and non-governmental agencies in relation to central themes of focus in the McBride Program. This seminar builds upon the background and study undertaken in HNRS310: International Science & Technology Policy. Prerequisites: HNRS310: International Science & Technology Policy. 3 lecture hours, 3 credit hours.

**HNRS401. MCBRIDE PRACTICUM: INTERNSHIP. 3.0 Hours.**

An off-campus practicum which may include an internship in a company, government agency, or public service organization (domestic or foreign), or foreign study as a part of a McBride group or individually. The practicum must have prior approval of the Program Director. All students completing a practicum are expected to keep an extensive journal and write a professional report detailing, analyzing, and evaluating their experiences. Prerequisite: HNRS311. 3 hours seminar; 3 semester hours.

**HNRS402. MCBRIDE PRACTICUM: FOREIGN AREA. 3.0 Hours.**

After completing the HNRS312 Foreign Area Study seminar, students travel to the selected country or region. Students will gain first hand experience interacting and communicating with people from another culture. Students will complete a written research and analysis report using historic cultural, technological, political, or an economic theme. Prerequisite: HNRS312 or permission of the Program Director. 3 hours seminar, 3 semester hours.

**HNRS405. MCBRIDE PRACTICUM. 1-3 Hour.**

(I, II) With approval of the Program, a McBride student may enroll in an individualized study project which substitutes for or enhances the regularly-scheduled McBride curriculum seminars. This option may be used to pursue an approved foreign study program, service learning program, international internship, undergraduate research project, or other authorized experiential learning program of study. Students must also prepare a faculty-guided major research paper that integrates the experience with the goals, objectives, and focus of the Honors Program in Public Affairs. 1-3 semester hours. Repeatable up to 6 hours.

**HNRS410. LEADERSHIP AND POWER. 3.0 Hours.**

This seminar builds on summer field study and the other McBride seminars by examining leadership and its relation to power. It explores the potential leadership roles of applied scientists, engineers, and economists in their professional lives as well as in their other roles as members of various communities contributing to global responsibility and sustainability. Students will gain knowledge and understanding about the subject of the seminar and enhance their skills in leadership, communication, conflict management, and examine a theoretical a range of approaches and real world case studies to the same. Prerequisites: HNRS310: International Science & Technology Policy. 3 lecture hours, 3 credit hours.

**HNRS411. STUDY OF LEADERSHIP AND POWER. 3.0 Hours.**

An intellectual examination into the nature of leadership and power. Focuses on understanding and interpreting the leadership role, both its potential and its limitations, in various historical, literary, political, socio-economic, and cultural contexts. Exemplary leaders and their antitypes are analyzed. Characteristics of leaders are related to their cultural and temporal context. This course will ask questions regarding the morality of power and its uses. Leadership in technical and non-technical environments will be compared and contrasted. Additionally, power and empowerment, and the complications of becoming or of confronting a leader are scrutinized. Prerequisite: HNRS311 or HNRS312 or permission of the Program Director. 3 hours seminar; 3 semester hours.

**HNRS412. CONFLICT RESOLUTION. 3.0 Hours.**

An in-depth look at creative, non-violent, non-litigious, win-win ways to handle conflicts in personal, business, environmental and governmental settings. The class will learn concepts, theories and methods of conflict resolution, study past and present cases, and observe on-going conflict resolution efforts in the Denver area. Prerequisite: HNRS311 or HNRS312 or permission of the Program Director. 3 hour seminar. 3 semester hours.

**HNRS420. SCIENCE, TECHNOLOGY, & ETHICS. 3.0 Hours.**

A comprehensive inquiry into ethical and moral issues raised by modern science and technology. Issues covered include: the contention that science is value neutral; the particular sorts of ethical problems faced by engineers in their public and political roles in deciding uses of materials and energy; the personal problems faced in the development of a career in science and technology; the moral dilemmas inherent in using natural forms and energies for human purposes; and the technologically dominated modern civilization. The seminar will consist of readings and discussion of ethical issues in plays, works of fiction, and films. Prerequisite: HNRS411 or HNRS412 or permission of the Program Director. 3 hours seminar; 3 semester hours.

**HNRS498. SPECIAL TOPICS IN THE MCBRIDE HONORS PROGRAM IN PUBLIC AFFAIRS. 1-6 Hour.**

A Special Topics course will be a pilot course in the McBride curriculum or will be offered as an enhancement to regularly-scheduled McBride seminars. Special Topics courses in the McBride curriculum will not be offered more than twice. Variable credit: 1 - 6 semester hours. Repeatable for credit under different titles.

**HNRS499. INDEPENDENT STUDY. 1-6 Hour.**

Under special circumstances, a McBride student may use this course number to register for an independent study project which substitutes for or enhances the regularly-scheduled McBride curriculum seminars. Variable credit: 1 - 6 semester hours. Repeatable for credit.

## Space and Planetary Science and Engineering

### Programs Offered

Area of Special Interest in Space and Planetary Science and Engineering

### Program Description

Since the advent of the space age in the middle of the last century, the pace of human and robotic exploration of space has been ever increasing. This exploration is made possible by feats of engineering to allow long-term operation of robotic and human explorers in the harsh environment of space. The product of this exploration is a large and growing body of knowledge about our neighbors in the Solar System and our place in the universe. The mission of the Space and Planetary Science and Engineering (SPSE) program is to provide students with a pathway for studying extraterrestrial applications of science, engineering, and resource utilization through an Area of Special Interest. This ASI draws on courses from five CSM departments and programs, covering a broad spectrum of space and planetary topics including astronomy, planetary science, space exploration, and the design of missions and instruments.

General CSM Minor/ASI requirements can be found at:

<https://nextbulletin.mines.edu/undergraduate/undergraduateinformation/specialprograms/minorasi/>

### Program Requirements

#### Area of Special Interest in Space and Planetary Science and Engineering:

Enrollment in the Area of Special Interest is approved by the Director or Associate Director. Students will then be assigned to an SPSE ASI advisor from among the faculty listed above, who will monitor and advise their progress. The Area of Special Interest requires a total of 12 credits, up to 3 of which may be at the 200 level or below, up to 3 of which may overlap with the requirements of the degree-granting program. Students may choose their ASI courses from the list of approved courses below or from any additional courses approved by the students' ASI advisor. Application of EPICS or Senior Design credits towards the ASI requires choice of a space or planetary related project and approval by the students' SPSE ASI advisor.

#### SPSE-approved Courses

EPIC251	DESIGN (EPICS) II	3
EGGN408	INTRODUCTION TO SPACE EXPLORATION	1.0
EGGN491/492	SENIOR DESIGN I	4.0

GEGN469	ENGINEERING GEOLOGY DESIGN	3.0
GEOL410	PLANETARY GEOLOGY	2.0
GPGN438	GEOPHYSICS PROJECT DESIGN	1-3
GPGN/ GEOL470	APPLICATIONS OF SATELLITE REMOTE SENSING	3.0
GPGN475	PLANETARY GEOPHYSICS	3.0
PHGN324	INTRODUCTION TO ASTRONOMY AND ASTROPHYSICS	3.0
PHGN424	ASTROPHYSICS	3.0
PHGN471/481	SENIOR DESIGN PRINCIPLES I	0.5
PHGN472/482	SENIOR DESIGN PRINCIPLES II	0.5

## Underground Construction and Tunneling

### Programs Offered

Minor in Underground Construction and Tunneling (18 credit hours)

### Program Educational Objectives

Underground Construction and Tunneling is a growing discipline involving knowledge in the fields of mining engineering, geological engineering and civil engineering. The Departments/Divisions of Mining Engineering, Geology & Geological Engineering and Engineering (Civil Engineering Specialty) offer an interdisciplinary minor course of study that would allow students from these departments to take a suite of courses requiring a minimum of 18 credit hours. Only three credit hours from the student's degree granting department/division may be used toward the minor. The remainder would be part of a student's free elective courses.

The minor program is delivered and managed by a committee consisting of members from the three departments/divisions. Curricular and advising matters are decided by this committee.

The objectives of the minor are to supplement an engineering background with a formal approach to subsurface engineering that includes site characterization, design and construction of underground infrastructures. Infrastructures could be water, storm water, highway or subway tunnels and subsurface underground facilities beneath major metropolitan cities. The formal approach includes courses in site investigation and geotechnical analysis, mining, structural and foundational design.

### General CSM Minor/ASI requirements can be found at:

<https://nextbulletin.mines.edu/undergraduate/undergraduateinformation/specialprograms/minorasi/>

### Curriculum

Several courses in each department or division were identified and categorized into the following three areas:

1. Site Investigation and Geotechnical Engineering
2. Underground Mining Engineering
3. Civil and Structural Engineering

The Minor Committee faculty members will sign Underground Construction and Tunneling minor forms in routine cases. For exceptions (e.g., course substitutions) the UC&T committee will make decisions.

Students may obtain information on the minor from any of the three participating departments/divisions.

The Underground Construction & Tunneling minor consists of a minimum of 18 credit hours of a logical sequence of courses. Only three of the minimum 18 hours may be taken in the student's degree-granting department.

### Program Requirements

#### Required Courses

MNGN321	INTRODUCTION TO ROCK MECHANICS	3.0
MNGN404	TUNNELING	3.0
MNGN408	UNDERGROUND DESIGN AND CONSTRUCTION	2.0
GEGN466/467	GROUNDWATER ENGINEERING	3.0
Select one of the following:		3-4

GEOL308	INTRODUCTORY APPLIED STRUCTURAL GEOLOGY	
GEOL309	STRUCTURAL GEOLOGY AND TECTONICS	
GEOL311	STRUCTURAL GEOLOGY FOR MINING ENGINEERS	
EGGN342	STRUCTURAL THEORY	3.0
EGGN361	SOIL MECHANICS	3.0
EGGN445	DESIGN OF REINFORCED CONCRETE STRUCTURES	3.0

#### Electives

GEGN468	ENGINEERING GEOLOGY AND GEOTECHNICS	4.0
GEGN469	ENGINEERING GEOLOGY DESIGN	3.0
GEGN470	GROUND-WATER ENGINEERING DESIGN	3.0
GEGN473	GEOLOGICAL ENGINEERING SITE INVESTIGATION	3.0
MNGN314	UNDERGROUND MINE DESIGN	3.0
MNGN333	EXPLOSIVES ENGINEERING I	3.0
MNGN406	DESIGN AND SUPPORT OF UNDERGROUND EXCAVATIONS	3.0
MNGN410	EXCAVATION PROJECT MANAGEMENT	2.0
MNGN418	ADVANCED ROCK MECHANICS	3.0
MNGN424	MINE VENTILATION	3.0
EGGN422	ADVANCED MECHANICS OF MATERIALS	3.0
EGGN441	ADVANCED STRUCTURAL ANALYSIS	3.0
EGGN444	DESIGN OF STEEL STRUCTURES	3.0
EGGN460	NUMERICAL METHODS FOR ENGINEERS	3.0
EGGN464	FOUNDATIONS	3.0

## **Division of Liberal Arts and International Studies (LAIS) Writing Center**

Located in room 309 Stratton Hall (phone: 303-273-3085), the LAIS Writing Center is a teaching facility providing all CSM students with an opportunity to enhance their writing proficiency. The LAIS Writing Center faculty are experienced technical and professional writing instructors. The Center assists writers with all their writing needs, from course assignments to scholarship applications, proposals, letters and resumes. This service is free to CSM students and includes one-to-one tutoring and online resources (at <http://www.mines.edu/academic/lais/wc/>).



## Writing Across the Curriculum (WAC)

To support the institutional goal of developing professional communication skills, required writing and communication-intensive courses are designated in both the core and in the degree-granting programs. According to guidelines approved by the Undergraduate Council, degree-granting programs are to identify four courses, often two junior and two senior-level courses, as writing-intensive. The (generally four) writing-intensive courses within the various degree-granting programs are designated with (WI) in Section 5 of this Bulletin, Undergraduate Information, under Description of Courses.

In addition to disciplinary writing experience, students also obtain writing experience outside their disciplines as courses in LAIS are virtually all writing intensive. The Campus Writing Program, housed in the Division of Liberal Arts and International Studies (LAIS), supports the WAC program.

## **The Guy T. McBride, Jr. Honors Program in Public Affairs**

As of 2011-12, the McBride Honors Program offers a 21 semester-hour program of seminars, courses, and off-campus activities that has the primary goal of providing a select number of students the opportunity to cross the boundaries of their technical expertise into the ethical, cultural, socio-political, and environmental dimensions of human life. Students will develop their skills in communication, critical thinking, and leadership through seminar style classes that explore diverse aspects of the human experience. Themes, approaches, and perspectives from the humanities and the social sciences are integrated with science and engineering perspectives to develop in students habits of thought necessary for a broad understanding of societal and cultural issues that enhance critical thinking, social responsibility, and enlightened leadership. This Program leads to a certificate and a Minor in the McBride Honors Program in Public Affairs.

For more information, see the Interdisciplinary Minors section located in the left-hand navigation bar.

## Bioengineering and Life Sciences (BELS)

Nine CSM departments and divisions have combined resources to offer a Minor Program and an Area of Special Interest (ASI) in Bioengineering and Life Sciences (BELS). The BELS minor and the ASI are flexible, requiring only one common core course (, General Biology I). The rest of the courses can be chosen, in consultation with a BELS program advisor, from a broad list of electives, allowing students to concentrate their learning in areas such as Biomedical Engineering, Biomaterials, Environmental Biotechnology, Biophysics or Pre-Medical studies. Interested students should consult with:

the office of Dr. James F. Ely  
 Director of BELS  
 Alderson Hall 331  
 303-273-3885  
[jely@mines.edu](mailto:jely@mines.edu).

For more information, see the Interdisciplinary Minors section located in the left-hand navigation bar.

## The Energy Minor and ASI (EM)

The discovery, production, and use of energy in modern societies has profound and far-reaching economic, political, and environmental effects. As energy is one of CSM's core statutory missions, several CSM departments have come together to offer Minor and Area of Special Interest programs related to Energy. The 18-credit Energy Minor adds value to any CSM undergraduate degree program by not only addressing the scientific and technical aspects of energy production and use but its broader economic and social impacts as well. Students pursuing the [Energy Minor](#) may choose from three curricular tracks: Fossil Energy, Renewable Energy, or General.

For more information, see the Interdisciplinary Minors section located in the left-hand navigation bar.

## The Humanitarian Engineering Minor

*Certificate Minor, Minor and Area of Special Interest*

The Humanitarian Engineering and Humanitarian Studies Minors (HE & HS) are designed to prepare students to better understand the complexities of and develop a strong appreciation for society, culture, and environment in sustainable humanitarian engineering design projects. Humanitarian engineering projects are intended to provide fundamental needs (food, water, shelter, and clothing), or higher-level needs when these are specifically requested by the local people. The preparatory courses are offered through the Division of Liberal Arts and International Studies (LAIS) with additional technical electives offered by engineering departments across campus. Interested students are encouraged to investigate the many options previously listed and described in more detail below that range from a 12 credit hour area of special interest (ASI) to a 27 credit hour certificate minor in Humanitarian Engineering.

For more information, see the Interdisciplinary Minors section located in the left-hand navigation bar.

## Space and Planetary Science and Engineering (SPSE)

The Space and Planetary Science and Engineering Program offers an Area of Special Interest for students interested in the science and exploration of space. This program brings together courses from five CSM departments and programs covering a diverse array of topics, including planetary science, astronomy, space exploration, and the engineering and design of instrumentation for space exploration. The curriculum can be chosen from a list of approved courses, in consultation with an SPSE program advisor. Interested students should contact Dr Jeff Andrews-Hanna, Director of SPSE ([jcahanna@mines.edu](mailto:jcahanna@mines.edu)).

For more information, see the Interdisciplinary Minors section located in the left-hand navigation bar.

## Underground Construction and Tunneling Minor

[Underground Construction and Tunneling](#) is a growing discipline involving knowledge in the fields of mining engineering, geological engineering and civil engineering. The Departments/Divisions of Mining Engineering, Geology & Geological Engineering and Engineering (Civil Engineering Specialty) offer an interdisciplinary minor course of study that would allow students from these departments to take a suite of courses requiring a minimum of 18 credit hours. Only three credit hours from the student's degree granting department/division may be used toward the minor. The remainder would be part of a student's free elective courses.

For more information, see the Interdisciplinary Minors section located in the left-hand navigation bar.

## Minor Program/Area of Special Interest

Established Minor Programs/Areas of Special Interest (ASI) are offered by all of the undergraduate degree-granting departments as well as the Division of Environmental Science and Engineering, the Division of Liberal Arts and International Studies, and the Military Science Department.

A **Minor Program** of study consists of a minimum of 18 credit hours of a logical sequence of courses. With the exception of four specific programs, only three of these hours may be taken in the student's degree-granting department and no more than three of these hours may be at the 100- or 200- level. A Minor Program may not be completed in the same department as the major. See the specific program details for more information.

An **Area of Special Interest** consists of a minimum of 12 credit hours of a logical sequence of courses. Only three of these hours may be at the 100- or 200-level and no more than three of these hours may be specifically required for the degree program in which the student is graduating. With the approval of the department, an ASI may be completed within the same major department.

As a minimum, CSM requires that any course used to fulfill a minor/ASI requirement be completed with a passing grade. Some programs offering minors/ASIs may, however, impose higher minimum grades for inclusion of the course in the minor/ASI. In these cases, the program specified minimum course grades take precedence. For additional information

on program-specific minimum course grade requirements, refer to the appropriate program section of this Bulletin.

As a minimum, to be awarded a minor/ASI, CSM requires students obtain a cumulative GPA of 2.0 or higher in all minor/ASI courses. All attempts at required minor/ASI courses are used in computing this minor/ASI GPA. Some programs offering minors/ASIs may, however, require a higher minimum cumulative GPA. In these cases, the program specified GPA takes precedence. For additional information on program specific GPA requirements, refer to the appropriate section of this Bulletin.

Students may not request more than half of the required courses for the minor or ASI be completed through transfer credit, including AP, IB and CLEP. Some minor/ASI programs, however, have been established in collaboration with other institutions through formal articulation agreements and these may allow transfer credit exceeding this limit. For additional information on program specific transfer credit limits, refer to the appropriate section of this Bulletin.

A Minor Program/Area of Special Interest declaration (which can be found in the Registrar's Office) should be submitted for approval at the time of application for graduation. If the minor or ASI is added after the application to graduate, it must be submitted to the Registrar's Office by Census Day of the term in which the student is graduating. Once the declaration form is submitted to the Registrar's Office, the student deciding not to complete the minor must officially drop the minor by notifying the Registrar's Office in writing. Should minor requirements not be complete at the time of graduation, the minor program will not be awarded. Minors are not added after the BS degree is posted. Completion of the minor will be recorded on the student's official transcript.

Please see the Department for specific course requirements. For questions concerning changes in the sequence of minor courses after the declaration form is submitted, contact the Registrar's Office for assistance.

## Study Abroad

Students wishing to pursue study abroad opportunities should contact the Office of International Programs (OIP), listed under the Services Section (<https://nextbulletin.mines.edu/undergraduate/undergraduateinformation/specialprograms>) of this Bulletin. Colorado School of Mines encourages students to include an international study/work experience in their undergraduate education. CSM maintains student exchange programs with engineering universities in South America, Europe, Australia, Africa, and Asia. Courses successfully passed abroad can be substituted for their equivalent course at CSM. Overall GPA is not affected by courses taken abroad. In addition, study abroad can be arranged on an individual basis at universities throughout the world.

Financial aid and selected scholarships and grants can be used to finance approved study abroad programs. The OIP has developed a resource center for study abroad information in its office, 1706 Illinois Street, phone 303-384-2121. Students are invited to use the resource materials and meet with staff to discuss overseas study opportunities.

# Policies and Procedures

## Standards, Codes of Conduct

Students can access campus rules and regulations, including the student code of conduct, alcohol policy, public safety and parking policies, the distribution of literature and free speech policy, and a variety of others by visiting the School's policy website (<http://inside.mines.edu/Policies>). We encourage all students to review the website and expect that students know and understand the campus policies, rules and regulations as well as their rights as a student. Questions and comments regarding the above mentioned policies can be directed to the Associate Dean of Students located in the Student Center, Suite 172.

For emphasis, the following policies are included in this section:

- Student Honor Code
- Policy on Academic Integrity/Misconduct
- Policy Prohibiting Sexual Harassment (includes sexual assault and sexual violence)
- Unlawful Discrimination Policy and Complaint Procedure (currently under revision)
- Electronic Communications (Email) Policy

## Student Honor Code

### 1.0 PREAMBLE

The students of Colorado School of Mines have adopted the following Student Honor Code in order to establish a high standard of student behavior at Mines. The Code may only be amended through a student referendum supported by a majority vote of the Mines student body. Mines students shall be involved in the enforcement of the Code through their participation in the Student Conduct Appeals Board.

### 2.0 CODE

Mines students believe it is our responsibility to promote and maintain high ethical standards in order to ensure our safety, welfare, and enjoyment of a successful learning environment. Each of us, under this Code, shall assume responsibility for our behavior in the area of academic integrity. As a Mines student, I am expected to adhere to the highest standards of academic excellence and personal integrity regarding my schoolwork, exams, academic projects, and research endeavors. I will act honestly, responsibly, and above all, with honor and integrity in all aspects of my academic endeavors at Mines. I will not misrepresent the work of others as my own, nor will I give or receive unauthorized assistance in the performance of academic coursework. I will conduct myself in an ethical manner in my use of the library, computing center, and all other school facilities and resources. By practicing these principles, I will strive to uphold the principles of integrity and academic excellence at Mines. I will not participate in or tolerate any form of discrimination or mistreatment of another individual.

## Policy on Academic Integrity/Misconduct

### 1.0 ACADEMIC INTEGRITY

The Colorado School of Mines affirms the principle that all individuals associated with the Mines academic community have a responsibility for establishing, maintaining and fostering an understanding and appreciation for academic integrity. In broad terms, this implies protecting the environment of mutual trust within which scholarly exchange occurs, supporting the ability of the faculty to fairly and effectively evaluate every student's academic achievements, and giving credence to the university's educational mission, its scholarly objectives and the substance of the

degrees it awards. The protection of academic integrity requires there to be clear and consistent standards, as well as confrontation and sanctions when individuals violate those standards. The Colorado School of Mines desires an environment free of any and all forms of academic misconduct and expects students to act with integrity at all times.

### 2.0 POLICY ON ACADEMIC MISCONDUCT

Academic misconduct is the intentional act of fraud, in which an individual seeks to claim credit for the work and efforts of another without authorization, or uses unauthorized materials or fabricated information in any academic exercise. Student Academic Misconduct arises when a student violates the principle of academic integrity. Such behavior erodes mutual trust, distorts the fair evaluation of academic achievements, violates the ethical code of behavior upon which education and scholarship rest, and undermines the credibility of the university. Because of the serious institutional and individual ramifications, student misconduct arising from violations of academic integrity is not tolerated at Mines. If a student is found to have engaged in such misconduct sanctions such as change of a grade, loss of institutional privileges, or academic suspension or dismissal may be imposed. As a guide, some of the more common forms of academic misconduct are noted below. This list is not intended to be all inclusive, but rather to be illustrative of practices the Mines faculty have deemed inappropriate:

1. **Dishonest Conduct** - general conduct unbecoming a scholar. Examples include issuing misleading statements; withholding pertinent information; not fulfilling, in a timely fashion, previously agreed to projects or activities; and verifying as true, things that are known to the student not to be true or verifiable.
2. **Plagiarism** - presenting the work of another as one's own. This is usually accomplished through the failure to acknowledge the borrowing of ideas, data, or the words of others. Examples include submitting as one's own work the work of another student, a ghost writer, or a commercial writing service; quoting, either directly or paraphrased, a source without appropriate acknowledgment; and using figures, charts, graphs or facts without appropriate acknowledgment. Inadvertent or unintentional misuse or appropriation of another's work is nevertheless plagiarism.
3. **Falsification/Fabrication** - inventing or altering information. Examples include inventing or manipulating data or research procedures to report, suggest, or imply that particular results were achieved from procedures when such procedures were not actually undertaken or when such results were not actually supported by the pertinent data; false citation of source materials; reporting false information about practical, laboratory, or clinical experiences; submitting false excuses for absence, tardiness, or missed deadlines; and, altering previously submitted examinations.
4. **Tampering** - interfering with, forging, altering or attempting to alter university records, grades, assignments, or other documents without authorization. Examples include using a computer or a false-written document to change a recorded grade; altering, deleting, or manufacturing any academic record; and, gaining unauthorized access to a university record by any means.
5. **Cheating** - using or attempting to use unauthorized materials or aid with the intent of demonstrating academic performance through fraudulent means. Examples include copying from another student's paper or receiving unauthorized assistance on a homework assignment, quiz, test or examination; using books, notes or other devices such as calculators, PDAs and cell phones, unless explicitly authorized; acquiring without authorization a copy of the examination before the scheduled examination; and copying reports, laboratory work or computer files from other students.

Authorized materials are those generally regarded as being appropriate in an academic setting, unless specific exceptions have been articulated by the instructor.

6. **Impeding** - negatively impacting the ability of other students to successfully complete course or degree requirements. Examples include removing pages from books and removing materials that are placed on reserve in the Library for general use; failing to provide team members necessary materials or assistance; and, knowingly disseminating false information about the nature of a test or examination.
7. **Sharing Work** - giving or attempting to give unauthorized materials or aid to another student. Examples include allowing another student to copy your work; giving unauthorized assistance on a homework assignment, quiz, test or examination; providing, without authorization, copies of examinations before the scheduled examination; posting work on a website for others to see; and sharing reports, laboratory work or computer files with other students.

### 3.0 PROCEDURES FOR ADDRESSING ACADEMIC MISCONDUCT

Faculty members and thesis committees have discretion to address and resolve misconduct matters in a manner that is commensurate with the infraction and consistent with the values of the Institution. This includes imposition of appropriate academic sanctions for students involved in academic misconduct. However, there needs to be a certain amount of consistency when handling such issues, so if a member of the Mines community has grounds for suspecting that a student or students have engaged in academic misconduct, they have an obligation to act on this suspicion in an appropriate fashion. The following procedure will be followed:

- The faculty member or thesis committee informs the student(s) of the allegations and charge of academic misconduct within 10 business days. This involves verbal communication with the student(s). The faculty member/thesis committee must have a meeting with the student(s) regarding the incident. This meeting allows the student the opportunity to give his/her perspective prior to an official decision being made. It also allows the faculty member to have a conversation with the student(s) to educate him/her on appropriate behavior.
- The circumstances of the academic misconduct dictate the process to be followed:
  - In the case of an allegation of academic misconduct associated with **regular coursework**, if after talking with the student(s), the faculty member feels the student is responsible for academic misconduct the faculty member should:
    - Assign a grade of "F" in the course to the student(s) that committed academic misconduct. A faculty member may impose a lesser penalty if the circumstances warrant, however the typical sanction is a grade of "F".
    - Contact the Associate Dean of Students and his/her Department Head/Division Director to officially report the violation in writing within 5 business days of the charge of academic misconduct. The Associate Dean of Students will communicate the final resolution in writing to the student, the faculty member, the Office of Academic Affairs, the Office of Graduate Studies and the student's advisor. The Associate Dean of Students will also keep official records on all students with academic misconduct violations.
  - Prescribed disciplinary action for misconduct associated with regular coursework:
    - 1st Offense: A grade of "F" in the course.

- 2nd Offense: A grade of "F" in the course, one-year academic suspension, and permanent notation of Academic Misconduct on the student's transcript.

- In the case of an allegation of academic misconduct associated with **activities not a part of regular coursework** (e.g, an allegation of cheating on a comprehensive examination), if after talking with the student, faculty member(s) feel the student is responsible for misconduct, the faculty should:
  - Assign an outcome to the activity that constitutes failure. If appropriate, the student's advisor may also assign a grade of "PRU" (unsatisfactory progress) for research credits in which the student is enrolled. Regular institutional procedures resulting from either of these outcomes are then followed. Faculty members may impose a lesser penalty if the circumstances warrant, however, the typical sanction is failure.
  - Contact the Associate Dean of Students, Graduate Dean and the student's Department Head/Division Director to officially report the violation in writing within 5 business days of the charge of misconduct. The Associate Dean of Students will communicate the final resolution in writing to the student, the faculty member, the Office of Graduate Studies, and the student's advisor. The Associate Dean of Students will also keep official records on all students with academic misconduct violations.

- In the case of an allegation of academic misconduct associated with **research activities**, investigation and resolution of the misconduct is governed by the Institution's Research Integrity Policy. The Research Integrity Policy is available as section 10.3 of the Faculty Handbook. If, after talking with the student, the faculty member feels the student is responsible for misconduct of this type, the faculty member should proceed as indicated in the Research Integrity Policy. If appropriate, the student's advisor may also assign a grade of "PRU" for research credits in which the student is enrolled. Regular institutional procedures resulting from this grade assignment are then followed.
- Students who suspect other students of academic misconduct should report the matter to the appropriate faculty member, the appropriate Department Head/Division/Program Director, the Dean of Undergraduate Students, the Dean of Graduate Students, or the Associate Dean of Students. The information is then provided to the faculty member concerned.

### 4.0 APPEAL PROCESS FOR STUDENT ACADEMIC MISCONDUCT

The academic misconduct appeal process is under revision. For the most up-to-date version of this procedure, please see the student section of the policy website ([http://inside.mines.edu/Student\\_policies](http://inside.mines.edu/Student_policies)).

## Policy Prohibiting Sexual Harassment\*

\***Note:** This policy is inclusive of all forms of sexual harassment, including sexual assault and sexual violence.

### 1.0 STATEMENT OF AUTHORITY AND PURPOSE

This policy is promulgated pursuant to the authority conferred by §23-41-104(1), C.R.S., and Title IX of the Education Amendments of 1972 (Title IX), 20 U.S.C. §§ 1681 *et seq.*, and its implementing regulations, 34 C.F.R. Part 106; Title IV of the Civil Rights Act of 1964 (42 U.S.C. § 2000c). Its purpose is to set forth a policy statement from the Board of Trustees concerning sexual harassment at the Colorado School

of Mines ("Mines" or "the School"). This policy shall supersede any Mines' policy that is in conflict herewith.

## 2.0 SEXUAL HARASSMENT POLICY

### 2.1 Policy Statement

The Mines Board of Trustees wishes to foster an environment for the Mines' campus community that is free from all forms of sexual harassment. Accordingly, the School will not tolerate any forms of sexual harassment and will take all necessary measures to deter such misconduct, including but not limited to preventive educational programs, thorough investigation of sexual harassment complaints, and discipline of policy violators with appropriate sanctions. Retaliation in any form against an individual for reporting sexual harassment or cooperating in a sexual harassment investigation is strictly prohibited. Such retaliation shall be dealt with as a separate instance of sexual harassment. Complaints of sexual harassment will be handled in accordance with the administrative procedures that accompany this policy.

### 2.2 Definition of Sexual Harassment

Sexual harassment shall, without regard to the gender of the Complainant or Respondent, consist of unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature when: (1) either explicitly or implicitly, submission to such conduct is made a term or condition of an individual's employment or educational endeavors; (2) submission to or rejection of such conduct by an individual is used as the basis for employment or educational decisions affecting the individual; or (3) such conduct has the purpose or effect of unreasonably interfering with an individual's work or academic performance, or creating an intimidating, hostile, or offensive working or educational environment.

Sexual violence and sexual assault are forms of sexual harassment. Sexual harassment shall also be defined to include retaliation against an individual for reporting sexual harassment or cooperating in a sexual harassment investigation.

### 2.3 Sanctions for Sexual Harassment

Appropriate sanctions may be imposed upon an employee or student who has sexually harassed another. The sanctions may include, but are not limited to one or more of the following: oral reprimand and warning; written reprimand and warning; student probation; suspension or expulsion; monetary fine; attendance at a sexual harassment prevention seminar; suspension without pay; or termination of employment or appointment.

## 3.0 IMPLEMENTATION

The Mines Board of Trustees authorizes and directs the President or President's delegates to develop, administer, and maintain the appropriate administrative policies, procedures, and guidelines to implement this policy.

### Title IX Coordinator:

Maureen Durkin, Director of Policy, Planning & Analysis, Guggenheim Hall, Room 212A, Golden, CO 80401.  
Telephone: 303/384-2236

### Contact for Complaints about Employee or Third-Party Behavior:

Mike Dougherty, Associate Vice President for Human Resources, Guggenheim Hall, Room 110, Golden, CO 80401.  
Telephone: 303/273-3250

### Contact for Complaints about Student Behavior:

Derek Morgan, Associate Dean of Students, Student Center, Room 175, 1200 6th Street, Golden, CO 80401.  
Telephone: 303/273-3288

### Related Administrative Policies, Procedures, Resources:

#### **For Complaints about Employee or Third-Party Behavior:**

- Sexual Harassment Complaint, Investigation and Resolution Procedure for Complaints Involving Employees or Third Parties ([http://inside.mines.edu/UserFiles/File/policies/HUR/HRS\\_Sexual\\_Harassment\\_Complaint\\_Procedure\\_Employee.pdf](http://inside.mines.edu/UserFiles/File/policies/HUR/HRS_Sexual_Harassment_Complaint_Procedure_Employee.pdf))
- Sexual Harassment Complaint Investigation Authorization Form

#### **For Complaints about Student Behavior:**

- Sexual Harassment Complaint, Investigation, Resolution and Adjudication Procedure for Complaints about Student Behavior ([http://inside.mines.edu/UserFiles/File/policies/STU/STU\\_Sexual\\_Harassment\\_Complaint\\_Procedure\\_Students.pdf](http://inside.mines.edu/UserFiles/File/policies/STU/STU_Sexual_Harassment_Complaint_Procedure_Students.pdf))
- Procedures/Resources for Survivors of Sexual Assault or Other Sexual Violence ([http://inside.mines.edu/UserFiles/File/policies/STU/STU\\_Procedures\\_Resources\\_Sexual\\_Assault.pdf](http://inside.mines.edu/UserFiles/File/policies/STU/STU_Procedures_Resources_Sexual_Assault.pdf))
- Anonymous Sexual Violence Reporting Form ([http://inside.mines.edu/UserFiles/File/policies/STU/STU\\_Anonymous\\_Reporting\\_Form\\_Sexual\\_Violence.pdf](http://inside.mines.edu/UserFiles/File/policies/STU/STU_Anonymous_Reporting_Form_Sexual_Violence.pdf))

*This policy was promulgated by the Colorado School of Mines Board of Trustees on March 13, 1992. Amended by the Colorado School of Mines Board of Trustees on March 26, 1998. Amended by the Colorado School of Mines Board of Trustees on June 10, 1999. Amended by the Colorado School of Mines Board of Trustees on June 22, 2000. Amended by the Colorado School of Mines Board of Trustees on June 7, 2003. Amended by the Colorado School of Mines Board of Trustees on December 15, 2011.*

## Unlawful Discrimination Policy and Complaint Procedure

### I. STATEMENT OF AUTHORITY AND PURPOSE

This policy is promulgated by the Board of Trustees pursuant to the authority conferred upon it by §23-41-104(1), C.R.S. (1999) in order to set forth a policy concerning unlawful discrimination at CSM. This policy shall supersede any previously promulgated CSM policy that is in conflict herewith.

### II. UNLAWFUL DISCRIMINATION POLICY

Attendance and employment at CSM are based solely on merit and fairness. Discrimination on the basis of age, gender, race, ethnicity, religion, national origin, disability, sexual orientation, and military veteran status is prohibited. No discrimination in admission, application of academic standards, financial aid, scholastic awards, promotion, compensation, transfers, reductions in force, terminations, re-employment, professional development, or conditions of employment shall be permitted. The remainder of this policy shall contain a complaint procedure outlining a method for reporting alleged violations of this policy and a review mechanism for the impartial determination of the merits of complaints alleging unlawful discrimination.

*As of June 2011, this policy is under revision. For a complete policy statement please see [http://inside.mines.edu/Board\\_Policies](http://inside.mines.edu/Board_Policies). Promulgated by the CSM Board of Trustees on March 13, 1992. Amended by the CSM Board of Trustees on June 10, 1999. Amended by the CSM Board of Trustees on June 22, 2000.*

## Electronic Communications (Email) Policy

### 1.0 BACKGROUND AND PURPOSE

Communication to students at the Colorado School of Mines (Mines) is an important element of the official business of the university. It is vital that Mines have an efficient and workable means of getting important and timely information to students. Examples of communications that require timely distribution include information from Fiscal Services, the Registrar's Office, or other offices on campus that need to deliver official and time-sensitive information to students. (Please note that emergency communications may occur in various forms based on the specific circumstances).

Electronic communication through email and Trailhead Portal announcements provides a rapid, efficient, and effective form of communication. Reliance on electronic communication has become the accepted norm within the Mines community. Additionally, utilizing electronic communications is consistent with encouraging a more environmentally-conscious means of doing business and encouraging continued stewardship of scarce resources. Because of the wide-spread use and acceptance of electronic communication, Mines is adopting the following policy regarding electronic communications with students.

### 2.0 POLICY

It is the policy of the Colorado School of Mines that official university-related communications with students will be sent via Mines' internal email system or via campus or targeted Trailhead announcements. All students will be assigned a Mines email address and are expected to periodically check their Mines assigned email as well as their Trailhead portal page. It is also expected that email sent to students will be read in a timely manner. Communications sent via email to students will be considered to have been received and read by the intended recipients.

### 3.0 PROCEDURES

1. All students will be given an EKey, which is an activation code that offers access to electronic resources at Mines. With their EKey, students must activate their assigned Mines email address.
2. Once their email address is activated, students are expected to check their Mines email inbox on a frequent and consistent basis and have the responsibility to recognize that certain communications from the university may be timecritical. As such, students also are responsible for responding in a timely manner to official communications from the university when a response is requested.
3. The policy does not prevent students from using a personal email address for university-related communications and purposes. If a student chooses to use a personal email address as his or her address of choice for receiving university-related communications, he or she must forward email from the Mines assigned email address to the personal email address. However, if a student chooses to forward communications to a personal email address, she or he must be aware that Mines personnel may not be able to assist in resolving technical difficulties with personal email accounts. Furthermore, forwarding communications to a personal email address does not absolve a student from the responsibilities associated with communication sent to his or her official Mines email address. Please note: If a student changes his or her official Mines email address to a personal address, it will be changed back to the Mines assigned email address. Students have the option to forward their Mines email to a personal address to avoid this

problem. Should a student choose the forwarding option, he or she must ensure that SPAM filters will not block email coming from the mines.edu address.

4. Nothing in these procedures should be construed as prohibiting university-related communications being sent via traditional means. Use of paper-based communication may be necessary under certain circumstances or may be more appropriate to certain circumstances. Examples of such communications could include, but not be limited to disciplinary notices, fiscal services communications, graduation information and so forth.

## Student Complaint Process

Students are consumers of services offered as part of their academic and co-curricular experience at the Colorado School of Mines. If a student needs to make a complaint, specific or general, about their experience at Mines, he or she should contact the Office of the Dean of Students at 303-273-3231. If the issue is related to discrimination or sexual harassment, there are specific procedures that will be followed (these are noted and linked in this section). Regardless, the student should begin with the Dean's Office if interested in making any complaint. All complaints, as well as the interests of all involved parties, will be considered with fairness, impartiality, and promptness while a complaint is being researched and/or investigated by the School.

## Access to Student Records

Students at the Colorado School of Mines are protected by the Family Educational Rights and Privacy Act of 1974, as amended. This Act was designed to protect the privacy of education records, to establish the right of students to inspect and review their education records, and to provide guidelines for the correction of inaccurate or misleading data through informal and formal hearings. Students also have the right to file complaints with The Family Educational Rights and Privacy Act Office (FERPA) concerning alleged failures by the institution to comply with the Act. Copies of local policy can be found in the Registrar's Office. Contact information for FERPA complaints is

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

**Directory Information.** The School maintains lists of information which may be considered directory information as defined by the regulations. This information includes name, current and permanent addresses and phone numbers, date of birth, major field of study, dates of attendance, part or full-time status, degrees awarded, last school attended, participation in officially recognized activities and sports, class, and academic honors. Students who desire that this information not be printed or released must so inform the Registrar before the end of the first two weeks of the fall semester for which the student is registered. Information will be withheld for the entire academic year unless the student changes this request. The student's signature is required to make any changes for the current academic year. The request must be renewed each fall term for the upcoming year. The following student records are maintained by Colorado School of Mines at the various offices listed below:

1. General Records: Registrar and Graduate Dean
2. Transcript of Grades: Registrar
3. Computer Grade Lists: Registrar
4. Encumbrance List: Controller and Registrar
5. Academic Probation/Suspension List: Graduate Dean



6. Advisor File: Academic Advisor
7. Option/Advisor/Enrolled/ Minority/Foreign List: Registrar, Dean of Students, and Graduate Dean
8. Externally Generated SAT/GRE Score Lists: Graduate Dean
9. Financial Aid File: Financial Aid (closed records)
10. Medical History File: School Physician (closed records)

**Student Access to Records.** The graduate student wishing access to his or her educational records will make a written request to the Graduate Dean. This request will include the student's name, date of request and type of record to be reviewed. It will be the responsibility of the Dean to arrange a mutually satisfactory time for review. This time will be as soon as practical but is not to be later than 30 business days from receipt of the request. The record will be reviewed in the presence of the Dean or designated representative. If the record involves a list including other students, steps will be taken to preclude the viewing of the other student name and information.

**Challenge of the Record.** If the student wishes to challenge any part of the record, the Dean will be so notified in writing. The Dean may then

1. remove and destroy the disputed document, or
2. inform the student that it is his decision that the document represents a necessary part of the record; and, if the student wishes to appeal,
3. convene a meeting of the student and the document originator (if reasonably available) in the presence of the Executive Vice President for Academic Affairs as mediator, whose decision will be final.

**Destruction of Records.** Records may be destroyed at any time by the responsible official if not otherwise precluded by law except that no record may be destroyed between the dates of access request and the viewing of the record. If during the viewing of the record any item is in dispute, it may not be destroyed.

**Access to Records by Other Parties.** Colorado School of Mines will not permit access to student records by persons outside the School except as follows:

1. In the case of open record information as specified in the section under Directory Information.
2. To those people specifically designated by the student. Examples would include request for transcript to be sent to graduate school or prospective employer.
3. Information required by a state or federal agency for the purpose of establishing eligibility for financial aid.
4. Accreditation agencies during their on-campus review.
5. In compliance with a judicial order or lawfully issued subpoena after the student has been notified of the intended compliance.
6. Any institutional information for statistical purposes which is not identifiable with a particular student.
7. In compliance with any applicable statute now in effect or later enacted. Each individual record (general, transcript, advisor, and medical) will include a log of those persons not employed by Colorado School of Mines who have requested or obtained access to the student record and the legitimate interest that the person has in making the request.

The School discloses education records without a student's prior written consent under the FERPA exception for disclosure to school officials with legitimate educational interests. A school official is a person employed by the School in an administrative, supervisory, academic or research,

or support staff position (including law enforcement unit personnel and health staff); a person or company with whom the School has contracted as its agent to provide a service instead of using School employees or officials (such as an attorney, auditor, or collection agent); a person serving on the Board of Trustees; or a student serving on an official committee, such as a disciplinary or grievance committee, or assisting another school official in performing his or her tasks.

A school official has a legitimate educational interest if the official needs to review an education record in order to fulfill his or her professional responsibilities for the School.

## Posthumous Degree Awards

The faculty may recognize the accomplishments of students who have died while pursuing their educational goals. If it is reasonable to expect that the student would have completed his or her degree requirements, the faculty may award a Baccalaureate or Graduate Degree that is in all ways identical to the degree the student was pursuing. Alternatively, the faculty may award a Posthumous BS, MS, or Ph.D. to commemorate students who distinguished themselves while at Mines by bringing honor to the School and its traditions.

Consideration for either of these degrees begins with a petition to the Faculty Senate from an academic department or degree granting unit. The petition should identify the degree sought. In the event that the degree-granting unit is seeking a conventional degree award, the petition should include evidence of the reasonable expectations that the student would have completed his or her degree requirements. For a Baccalaureate, such evidence could consist of, but is not limited to:

- The student was a senior in the final semester of coursework,
- The student was enrolled in courses that would have completed the degree requirements at the time of death
- The student would have passed the courses with an acceptable grade, and would likely have fulfilled the requirements of the degree.

For a Graduate Degree:

- For graduate degrees not requiring a research product, the student was enrolled in courses that would have completed the degree requirements at the time of death, would have passed the courses with an acceptable grade, and would likely have fulfilled the requirements of the degree.
- For graduate degrees requiring a research product, the student had completed all course and mastery requirements pursuant to the degree and was near completion of the dissertation or thesis, and the student's committee found the work to be substantial and worthy of the degree.

The requirement that there be a reasonable expectation of degree completion should be interpreted liberally and weight should be given to the judgment of the departmental representative(s) supporting the petition.

In the event that the degree being sought is a Posthumous BS, MS, or Ph.D., the petition should include evidence that the student conducted himself or herself in the best tradition of a Mines' graduate and is therefore deserving of that honor.

## Equal Opportunity, Equal Access, and Affirmative Action

The institution's Statement of Equal Opportunity and Equal Access to Educational Programs, and associated staff contacts, can be found in the Welcome section ([bulletin.mines.edu/undergraduate/sectionwelcome](http://bulletin.mines.edu/undergraduate/sectionwelcome))

of this Bulletin as well as the on the policy website ([bulletin.mines.edu/undergraduate/policiesandprocedures/The%20institution%E2%80%99s%20Statement%20of%20Equal%20Opportunity%20and%20Equal%20Access%20to%20Educational%20Programs,%20and%20associated%20staff%20contacts,%20can%20be%20found%20in%20the%20Welcome%20section%20of%20this%20Bulletin%20as%20well%20as%20the%20following%20website:%20http://inside.mines.edu/Policies.html](http://bulletin.mines.edu/undergraduate/policiesandprocedures/The%20institution%E2%80%99s%20Statement%20of%20Equal%20Opportunity%20and%20Equal%20Access%20to%20Educational%20Programs,%20and%20associated%20staff%20contacts,%20can%20be%20found%20in%20the%20Welcome%20section%20of%20this%20Bulletin%20as%20well%20as%20the%20following%20website:%20http://inside.mines.edu/Policies.html)). Colorado School of Mines has instituted an affirmative action plan, which is available for perusal in numerous CSM offices including the Library, the Dean of Students' Office, and the Office of Human Resources.

## Electronic Communications (E-mail) Policy

### Background and Purpose

Communication to students at the Colorado School of Mines (Mines) is an important element of the official business of the university. It is vital that Mines have an efficient and workable means of getting important and timely information to students. Examples of communications that require timely distribution include information from Fiscal Services, the Registrar's Office, or other offices on campus that need to deliver official and time-sensitive information to students. (Please note that emergency communications may occur in various forms based on the specific circumstances).

Electronic communication through e-mail and Trailhead Portal announcements provides a rapid, efficient, and effective form of communication. Reliance on electronic communication has become the accepted norm within the Mines community. Additionally, utilizing electronic communications is consistent with encouraging a more environmentally-conscious means of doing business and encouraging continued stewardship of scarce resources. Because of the widespread use and acceptance of electronic communication, Mines is adopting the following policy regarding electronic communications with students.

### Policy

It is the policy of the Colorado School of Mines that official university-related communications with students will be sent via Mines' internal e-mail system or via campus or targeted Trailhead announcements. All students will be assigned a Mines e-mail address and are expected to periodically check their Mines assigned e-mail as well as their Trailhead portal page. It is also expected that e-mail sent to students will be read in a timely manner. Communications sent via e-mail to students will be considered to have been received and read by the intended recipients.

### Procedures

1. All students will be given an EKey, which is an activation code that offers access to electronic resources at Mines. With their EKey, students must activate their assigned Mines e-mail address.
2. Once their e-mail address is activated, students are expected to check their Mines e-mail inbox on a frequent and consistent basis and have the responsibility to recognize that certain communications from the university may be time-critical. As such, students also are responsible for responding in a timely manner to official communications from the university when a response is requested.
3. The policy does not prevent students from using a personal e-mail address for university-related communications and purposes. If a student chooses to use a personal e-mail address as his or her address of choice for receiving university-related communications, he or she must forward e-mail from the Mines assigned e-mail

address to the personal e-mail address. However, if a student chooses to forward communications to a personal e-mail address, she or he must be aware that Mines personnel may not be able to assist in resolving technical difficulties with personal e-mail accounts. Furthermore, forwarding communications to a personal e-mail address does not absolve a student from the responsibilities associated with communication sent to his or her official Mines e-mail address. Please note: If a student changes his or her official Mines e-mail address to a personal address, it will be changed back to the Mines assigned e-mail address. Students have the option to forward their Mines e-mail to a personal address to avoid this problem. Should a student choose the forwarding option, he or she must ensure that SPAM filters will not block e-mail coming from the mines.edu address.

4. Nothing in these procedures should be construed as prohibiting university-related communications being sent via traditional means. Use of paper-based communication may be necessary under certain circumstances or may be more appropriate to certain circumstances. Examples of such communications could include, but not be limited to disciplinary notices, fiscal services communications, graduation information and so forth.

### Responsible Parties

Questions about this policy may be directed as follows:

Registrar's Office Phone: 303-273-3200 or  
E-mail: [registrar@mines.edu](mailto:registrar@mines.edu)

Computing, Communications & Information Technologies (CCIT)  
Phone: 303-273-3431 or

Complete a request form at the Mines Help Center (<http://helpdesk.mines.edu/>)

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PETER HAN, 1993-A.B., University of Chicago; M.B.A., University of Colorado; Chief of Staff

ANNE STARK WALKER, 1999-B.S., Northwestern University; J.D., University of Denver; General Counsel

MICHAEL DOUGHERTY, 2003-B.A., Cumberland College; M.B.A., University of Alaska Anchorage; Associate Vice President for Human Resources

ANITA PARISEAU, 2004-B.S., Ithaca College; Director of Alumni Relations/Executive Director CSM Alumni Association

DIANA M. ANGLIN, 2008-B.S., Western Michigan University; Associate Registrar

STEVEN M. ARDERN, 2011-B.S. and M.S., University of Nottingham; Information Security Engineer, Computing, Communications and Information Technology

DAVID G. BEAUSANG, 1993-B.S., Colorado State University; Computing Support Specialist

DEBORAH BEHNFIELD, 2007, B.A., Evergreen State College; B.A. Metropolitan State College of Denver; Recruitment Coordinator

GINA BOICE, 2007-Director of Customer Service and Support

GARY L. BOWERSOCK, JR, 1996-B.S., Colorado Technical University; Director of Facilities Management

HEATHER A. BOYD, 1990-B.S., Montana State University; M.Ed., Colorado State University; Director of Enrollment Management

THOMAS M. BOYD, 1993-B.S., M.S., Virginia Polytechnic Institute and State University; Ph.D., Columbia University; Associate Provost and Dean of Graduate Studies; Associate Professor of Geophysics

RONALD L. BRUMMETT, 1993-B.A., Metropolitan State College; M.A., University of Northern Colorado; M.B.A., University of Colorado Denver; Director of Student Services

DIXIE CIRILLO, 1991-B.S., University of Northern Colorado; Associate Director of Athletics

JEAN MANNING CLARK, 2008-B.A., University of Phoenix; M.A., University of Phoenix; Director of Career Center and Coordinator of Employer Relations

JULIE COAKLEY, 2001-B.S., University of Toledo; M.S., University of Toledo; Senior Vice President for Strategic Enterprises

ERIC CRONKRIGHT, 2010-B.B.A., Western Michigan University, Assistant Director of Financial Aid

TERRANCE DINKEL, 1999-B.S., University of Colorado; M.S., American Technological University; Program Coordinator, Mine Safety and Health Program

STEPHEN DMYTRIW, 1999-B.S., University of Nevada; Program Coordinator, Mine Safety and Health Program

JEFF DUGGAN, 2007-B.S., M.B.A., Regis University; Sports Information Director

LOUISA DULEY, 2000-B.A., Western State College; Assistant Director of Admissions

MAUREEN DURKIN, 2007-B.A., Texas A & M; M.A., Southern Methodist University; M.B.A., Simmons College; Director of Policy, Planning & Analysis

RHONDA L. DVORNAK, 1994-B.S., Colorado School of Mines; Continuing Education Program Coordinator

JOSEPH O. ELLIS III, 2012-A.S., Santa Fe Community College; System Administrator-Linux

KATHLEEN FEIGHNY, 2001-B.A., M.A., University of Oklahoma; Program Manager, Division of Economics and Business

ROBERT FERRITER, 1999-A.S., Pueblo Junior College; B.S., M.S., Colorado School of Mines; Director, Mine Safety and Health Program

RICHARD FISCHER, 1999-B.A., St. John's University; Program Coordinator, Mine Safety and Health Program

REBECCA FLINTOFT, 2007-B.A., Kalamazoo College, M.A., Bowling Green State University; Director of Auxiliary Services and Housing

MELODY A. FRANCISCO, 1988-89, 1991-B.S., Montana State University; Continuing Education Program Coordinator

BRUCE GELLER, 2007-B.S., Dickinson College, M.A., State University of New York at Binghamton, A.M., Harvard University, Ph.D., University of Colorado; Director, Geology Museum

KRISTI GRAHAM GITKIND, 2011-B.A., University of Colorado at Boulder; M.P.A., University of Colorado at Denver; Special Assistant to the President

LISA GOBERIS, 1998-B.S., University of Northern Colorado; Associate Director of Auxiliary Services

KATHLEEN GODEL-GENGENBACH, 1998-B.A., M.A., University of Denver; Ph.D., University of Colorado; Director, Office of International Programs

BRUCE P. GOETZ, 1980-84, 1987- B.A., Norwich University; M.S., M.B.A., Florida Institute of Technology; Director of Admissions

DAHL GRAYCKOWSKI, 2004-B.S, MPA, DeVry University, Associate Registrar

FERNANDO R. GUZMAN, 2012-B.S., Santa Clara University; M.S., California State University; Ph.D. University of Denver; Executive Director of the Multicultural Engineering Program

JEN HAIGHT, 2011 – B.S., Metropolitan State College of Denver; Executive Assistant to the Vice President for Student Life

JENNIFER HANNON, 2008-B.S., University of Kansas; M.S.W., Loyola University; University Counselor

CRAIG S. HARMON, 2001 - Database Administrator, Computing, Communications and Information Technology

LINN HAVELICK, 1988-B.A., M.S., University of Colorado at Denver; CIH; Director, Environmental Health & Safety

AMY HENKELMAN, 2011-B.S., University of Wisconsin-Stout Menomonie, M.A., Michigan University, Mount Pleasant; Assistant Athletic Director-Recreational Sports

ESTHER HENRY, 2006-B.A, B.S., Purdue University, J.D., Indiana University; Associate Counsel

MARIE HORNICKEL, 2007-B.A., University of Wisconsin at Stevens Point, M.S., Minnesota State University at Mankato; Director of Student Activities

GEORGE HUGHES, 2010-B.A., Ohio University; Director of Public Safety

CHRISTINA JENSEN, 1999-B.A., M.P.A., San Diego State University; Associate Director of Financial Aid

TIMOTHY H. KAISER, 2008-B.S., University of Missouri Rolla; M.S. University of California; Ph.D. University of New Mexico; Director of Research and High Performance Computing

JENNIE J. KENNEY, 2005-Executive Assistant to the Provost and Executive Vice President

LISA KINZEL, 2006-B.A., State University of New York at Geneseo; Executive Assistant to the Vice President for Research and Technology Transfer

MELVIN L. KIRK, 1995-B.S., M.A., University of Northern Colorado; Student Development Center Counselor

JOANNE LAMBERT, 2008-B.S., Kent State University; M.A., Colorado Christian University, Assistant Director of Enrollment Management

DAVID LARUE, 1998-B.A., St. Thomas Seminary College; M.A., University of Colorado at Denver; Ph.D., University of Colorado at Boulder; Computer Support Specialist

DEBRA K. LASICH, 1999-B.S., Kearney State College; M.A., University of Nebraska; Executive Director of the Women in Science, Engineering, and Mathematics (WISEM) Program

DAVID M. LEE, 2001-B.S., United States Military Academy, West Point; M.S., Florida Institute of Technology; Director of Enterprise Systems

VIRGINIA A. LEE, 2006-B.A., M.A., Ph.D., University of California at Irvine; Portal, Identity Management and Help Desk Administrator

BRANDON LEIMBACH, 2002-B.A., M.A., St. Mary's College; Associate Director of Athletics

ROBERT MASK, 2007-B.B.A., Sam Houston State University; Director of Campus I.D. Card Services

MICHAEL McGUIRE, 1999-Engineer of Mines, Colorado School of Mines; Program Coordinator, Mine Safety and Health Program

MICHAEL McMILLAN, 2010-B.B.A., Belmont College; Green Center Facilities and Events Manager

LARA MEDLEY, 2003-B.A., University of Colorado at Boulder; M.P.A., University of Colorado at Denver; Registrar

KEVIN L. MOORE, 2005-B.S.E.E, Louisiana State University; M.S.E.E., University of Southern California; Ph.D.E.E., Texas A&M University; Dean of the College of Engineering and Computational Sciences and Professor of Electrical Engineering

ANDREA SALAZAR MORGAN, 1999-B.A., Colorado State University; Senior Assistant Director of Admissions

DEREK MORGAN, 2003- B.S., University of Evansville; M.S., Colorado State University; Associate Dean of Students

DAG NUMMEDAL, 2004-B.A., M.A., University of Oslo; Ph.D., University of Illinois; Executive Director of the Colorado Energy Research Institute

CHARLES O'DELL, 2000- B.A., Metropolitan State College of Denver, M.S., Capella University; Assistant Athletic Director

TRICIA DOUTHIT PAULSON, 1998-B.S., M.S., Colorado School of Mines; Director of Institutional Research

ROGER PIERCE, 2000-B.S., Wisconsin Institute of Technology; Program Coordinator, Mine Safety and Health Program

MICHAEL J. PUSEY, 2004-B.S., Humboldt State University; BI Reporting Administrator

JAMES L. PROUD, 1994-B.S., University of Wisconsin, Whitewater; M.A., California State Polytechnic University; Continuing Education Program Coordinator

ANGIE REYES, 1997-B.A., Chadron State College; Student System Manager.

DEBRA S. ROBERGE, R.N., N.P., 2007-B.S., University of New Hampshire; M.S., Boston College; Director, Student Health Center

FRANK L. ROBERTSON, 2003-A.A., Mesa College; B.S., University of Phoenix; B.S., University of New Mexico; Manager, Computing, Communications and Information Technology Customer Service Center

JILL ROBERTSON, 2009-B.S., M.Ed, Northern Arizona University; Director of Financial Aid

PHILLIP ROMIG III, 1999-B.A., Nebraska Wesleyan University; M.S. and Ph.D., University of Nebraska; Network Engineer and Security Specialist

ARTHUR B. SACKS, 1993-B.A., Brooklyn College; M.A., Ph.D., University of Wisconsin-Madison; Director, Guy T. McBride Jr. Honors Program in Public Affairs for Engineering and Professor of Liberal Arts and International Studies

BRANDON SAMTER, 2008-B.S., Adams State College, Director of International Student and Scholar Services

ERIC SCARBRO, 1991-B.S., University of South Carolina; M.S., Colorado School of Mines; Financial Systems Manager

LORI B. SCHEIDER, 2011-B.A., University of Wyoming, Admissions Counselor

KAY M. SCHNEIDER, 2011-B.S., M.S., Minnesota State, Moorhead; Assessment Director

SARA E. SCHWARZ, 2006-B.S., Colorado State University; M.S., Denver University; Manager, Classroom Technology

LINDA SHERMAN, 2006-B.S., University of Colorado; M.A., University of Phoenix; Assistant Director of the Career Center

JAHY SIMBAL, 2000-B.S., M.B.A., University of Colorado at Boulder; Director of Graduate Recruiting and Admissions

KATIE SIMONS, 2008-B.A., Regis University; Assistant Sports Information Director

SANDRA SIMS, 2004-B.S., Pennsylvania State University, M.S., Florida Institute of Technology, PsyD, Florida Institute of Technology; Counselor

TRAVIS A. SMITH, 2009-B.S., University of Miami, M.S., Eastern Illinois University; Associate Director of Student Activities

THOMAS E. SPICER, 2004-B.S., M.S., Fort Hays State University; Director of Athletics and Head of Physical Education Department

JEFFREY E. STORM, Database Administrator

DIXIE TERMIN, 1979-B.S., Regis University; International Program Coordinator for Special Programs and Continuing Education

COLIN TERRY, 2010, B.A., Gonzaga University; M.A., New York University; Coordinator of Student Academic Services

JACLYNN L. TWEHUES, 2011-B.S., University of Detroit; M.S., Wayne State University; Business Intelligence Manager

SHAM TZEGAI, 2007-B.A., Metropolitan State College; Assistant Director of Financial Aid

WILLIAM VAUGHAN, 2008-B.S., Mariette College, M.S., Ohio University, Ph.D., Ohio State University; Director, Technology Transfer

NATALIE VAN TYNE, 2008-B.S., Rutgers University, M.S., M.B.A., Lehigh University; M.S., Colorado School of Mines; Program Director and Lecturer of EPICS

BRENT WALLER, 2009-B.S., M.B.A., Regis University; Associate Director of Housing for Residence Life

MARSHA WILLIAMS, 1998-B.S., Kansas State University; M.S., University of Colorado; Director of Integrated Marketing Communications

DEREK J. WILSON, 1982-B.S., University of Montana; Chief Information Officer and Director of the Computing, Communications and Information Technology

JEAN YEAGER, 2006-B.A., University of Illinois at Chicago; Executive Assistant to the Sr. Vice President for Finance and Administration

ED ZUCKER, 2001-B.A., M.S., University of Arizona; Computing Services Support Manager

## Emeriti

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NORMAN BLEISTEIN, B.S., Brooklyn College; M.S., Ph.D., New York University; University Emeritus Professor of Mathematical and Computer Sciences

ARDEL J. BOES, B.A., St. Ambrose College; M.S., Ph.D., Purdue University; Emeritus Professor of Mathematical and Computer Sciences

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W. JOHN CIESLEWICZ, B.A., St. Francis College; M.A., M.S., University of Colorado; Emeritus Associate Professor of Slavic Studies and Foreign Languages

L. GRAHAM CLOSS, 1978-A.B., Colgate University; M.S., University of Vermont; Ph.D., Queen's University, Kingston, Ontario; Emeritus Associate Professor of Geology and Geological Engineering, P.E.

JOHN A. CORDES, B.A., J.D., M.A., University of Iowa; Ph.D., Colorado State University; Emeritus Associate Professor of Economics and Business

TIMOTHY A. CROSS, B.A., Oberlin College; M.S., University of Michigan; Ph.D., University of Southern California; Emeritus Associate Professor of Geology and Geological Engineering

STEPHEN R. DANIEL, Min. Eng.- Chem., M.S., Ph.D., Colorado School of Mines; Emeritus Professor of Chemistry and Geochemistry

GERALD L. DEPOORTER, B.S., University of Washington; M.S., Ph.D., University of California at Berkeley; Emeritus Associate Professor of Metallurgical and Materials Engineering

JOHN A. DeSANTO, B.S., M.A., Villanova University; M.S., Ph.D., University of Michigan; Emeritus Professor of Mathematical and Computer Sciences and Physics

DEAN W. DICKERHOOF, B.S., University of Akron; M.S., Ph.D., University of Illinois; Professor Emeritus of Chemistry and Geochemistry

DONALD I. DICKINSON, B.A., Colorado State University; M.A., University of New Mexico; Emeritus Professor of Liberal Arts and International Studies

J. PATRICK DYER, B.P.E., Purdue University; Emeritus Associate Professor of Physical Education and Athletics

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JOHN C. EMERICK, B.S., University of Washington; M.A., Ph.D., University of Colorado; Emeritus Associate Professor of Environmental Science and Engineering

GRAEME FAIRWEATHER, B.S., Ph.D., University of St. Andrews Scotland; Emeritus Professor of Mathematical and Computer Sciences

EDWARD G. FISHER, B.S., M.A., University of Illinois; Emeritus Professor of English

DAVID E. FLETCHER, B.S., M.A., Colorado College; M.S.B.A., Ph.D., University of Denver; Emeritus Professor of Economics and Business

ROBERT H. FROST, B.S., Ph.D., Colorado School of Mines; S.M., M.E., Massachusetts Institute of Technology; Emeritus Associate Professor of Metallurgical and Materials Engineering

S. DALE FOREMAN, B.S., Texas Technological College; M.S., Ph.D., University of Colorado; Emeritus Professor of Civil Engineering, P.E.

JAMES H. GARY B.S., M.S., Virginia Polytechnic Institute; Ph.D., University of Florida; Emeritus Professor of Chemical Engineering



DONALD W. GENTRY, B.S., University of Illinois; M.S., University of Nevada; Ph.D., University of Arizona; Emeritus Professor of Mining Engineering, P.E.

JOHN O. GOLDEN, B.E., M.S., Vanderbilt University; Ph.D., Iowa State University; Emeritus Professor of Chemical Engineering

JOAN P. GOSINK, B.S., Massachusetts Institute of Technology; M.S., Old Dominion University; Ph.D., University of California - Berkeley; Emerita Professor of Engineering

THOMAS L. T. GROSE, B.S., M.S., University of Washington; Ph.D., Stanford University; Emeritus Professor of Geology and Geological Engineering

RAYMOND R. GUTZMAN, A.B., Fort Hays State College; M.S., State University of Iowa; Emeritus Professor of Mathematical and Computer Sciences

FRANK A. HADSELL, B.S., M.S., University of Wyoming; D.Sc., Colorado School of Mines; Emeritus Professor of Geophysics

JOHN P. HAGER, B.S., Montana School of Mines; M.S., Missouri School of Mines; Sc.D., Massachusetts Institute of Technology; University Emeritus Hazen Research Professor of Extractive Metallurgy; Metallurgical and Materials Engineering

FRANK G. HAGIN, B.A., Bethany Nazarene College; M.A., Southern Methodist University; Ph.D., University of Colorado; Emeritus Professor of Mathematical and Computer Sciences

JOHN W. HANCOCK, A.B., Colorado State College; Emeritus Professor of Physical Education and Athletics

ROBERT C. HANSEN, E.M., Colorado School of Mines; M.S.M.E., Bradley University; Ph.D., University of Illinois; Emeritus Professor of Engineering, P.E.

JOHN D. HAUN, A.B., Berea College; M.A., Ph.D., University of Wyoming; Emeritus Professor of Geology, P.E.

T. GRAHAM HEREFORD, B.A., Ph.D. University of Virginia; Emeritus Professor of Liberal Arts and International Studies

JOHN A. HOGAN, B.S., University of Cincinnati; M.A., Lehigh University; Emeritus Professor of Liberal Arts and International Studies

GREGORY S. HOLDEN, B.S., University of Redlands; M.S., Washington State University; Ph.D., University of Wyoming; Emeritus Associate Professor of Geology and Geological Engineering

BRUCE D. HONEYMAN, B.S., M.S., Ph.D., Stanford University; Emeritus Professor of Environmental Science and Engineering

MATTHEW J. HREBAR, III, B.S., The Pennsylvania State University; M.S., University of Arizona; Ph.D., Colorado School of Mines; Emeritus Associate Professor of Mining Engineering

NEIL F. HURLEY, B.S., University of Southern California; M.S., University of Wisconsin at Madison; Ph.D., University of Michigan; Emeritus Charles Boettcher Distinguished Chair in Petroleum Geology and Geology and Geological Engineering

WILLIAM A. HUSTRULID, B.S., M.S., Ph.D., University of Minnesota; Emeritus Professor of Mining Engineering

RICHARD W. HUTCHINSON, B.Sc., University of Western Ontario; M.Sc., Ph.D., University of Wisconsin; Charles Franklin Fogarty Professor in Economic Geology; Emeritus Professor of Geology and Geological Engineering

ABDELWAHID IBRAHIM, B.S., University of Cairo; M.S., University of Kansas; Ph.D., Michigan State University; Emeritus Associate Professor of Geophysics

JAMES G. JOHNSTONE, Geol.E., Colorado School of Mines; M.S., Purdue University; (Professional Engineer); Emeritus Professor of Civil Engineering

ALEXANDER A. KAUFMAN, Ph.D., Institute of Physics of the Earth, Moscow; D.T.Sc., Siberian Branch Academy; Emeritus Professor of Geophysics

MARVIN L. KAY, E.M., Colorado School of Mines; Emeritus Director of Athletics

GEORGE KELLER, B.S., M.S., Ph. D., Pennsylvania State University, Emeritus Professor of Geophysics

THOMAS A. KELLY, B.S., C.E., University of Colorado; Emeritus Professor of Basic Engineering, P.E.

GEORGE H. KENNEDY, B.S., University of Oregon; M.S., Ph.D., Oregon State University; Emeritus Professor of Chemistry and Geochemistry

ARTHUR J. KIDNAY, P.R.E., D.Sc., Colorado School of Mines; M.S., University of Colorado; Emeritus Professor of Chemical Engineering

RONALD W. KLUSMAN, B.S., M.A., Ph.D., Indiana University; Emeritus Professor of Chemistry and Geochemistry

R. EDWARD KNIGHT, B.S., University of Tulsa; M.A., University of Denver; Emeritus Professor of Engineering

KENNETH E. KOLM, B.S., Lehigh University; M.S., Ph.D., University of Wyoming; Emeritus Associate Professor of Environmental Science and Engineering

GEORGE KRAUSS, B.S., Lehigh University; M.S., Sc.D., Massachusetts Institute of Technology; University Emeritus Professor of Metallurgical and Materials Engineering, P.E.

DONALD LANGMUIR, A.B., M.A., Ph.D., Harvard University; Emeritus Professor of Chemistry and Geochemistry and Emeritus Professor of Environmental Science & Engineering

KENNETH L. LARNER, B.S., Colorado School of Mines; Ph.D., Massachusetts Institute of Technology; University Emeritus Professor of Geophysics

WILLIAM B. LAW, B.Sc., University of Nevada; Ph.D., Ohio State University; Emeritus Associate Professor of Physics

KEENAN LEE, B.S., M.S., Louisiana State University; Ph.D., Stanford University; Emeritus Professor of Geology and Geological Engineering

V. ALLEN LONG, A.B., McPherson College; A.M., University of Nebraska; Ph.D., University of Colorado; Emeritus Professor of Physics

GEORGE B. LUCAS, B.S., Tulane University; Ph.D., Iowa State University; Emeritus Professor of Chemistry and Geochemistry

DONALD L. MACALADY, B.S., The Pennsylvania State University; Ph.D., University of Wisconsin-Madison; Emeritus Professor of Chemistry and Geochemistry

DONALD C.B. MARSH, B.S., M.S., University of Arizona; Ph.D., University of Colorado; Emeritus Professor of Mathematical and Computer Sciences

JEAN P. MATHER, B.S.C., M.B.A., University of Denver; M.A., Princeton University; Emeritus Professor of Mineral Economics

FRANK S. MATHEWS, B.A., M.A., University of British Columbia; Ph.D., Oregon State University; Emeritus Professor of Physics

RUTH A. MAURER, B.S., M.S., Colorado State University; Ph.D., Colorado School of Mines; Emerita Associate Professor of Mathematical and Computer Sciences

ROBERT S. McCANDLESS, B.A., Colorado State College; Emeritus Professor of Physical Education and Athletics

MICHAEL B. McGRATH, B.S.M.E., M.S., University of Notre Dame; Ph.D., University of Colorado; Emeritus Professor of Engineering

J. THOMAS MCKINNON, B.S., Cornell University; Ph.D., Massachusetts Institute of Technology; Emeritus Professor of Chemical Engineering

JAMES A. McNEIL, B.S., Lafayette College; M.S., Ph.D., University of Maryland; University Emeritus Professor of Physics

JOHN J. MOORE, 1989-B.S., University of Surrey, England; Ph.D., D. Eng., University of Birmingham, England; Emeritus Professor of Metallurgical and Materials Engineering

DAVID R. MUÑOZ, 1986-B.S.M.E., University of New Mexico; M.S.M.E., Ph.D., Purdue University; Emeritus Associate Professor of Engineering

ERIC P. NELSON, B.S., California State University at Northridge; M.A., Rice University; M.Phil., Ph.D., Columbia University; Emeritus Associate Professor of Geology and Geological Engineering

KARL R. NELSON, Geol.E., M.S., Colorado School of Mines; Ph.D., University of Colorado; Emeritus Associate Professor of Engineering, P.E.

GABRIEL M. NEUNZERT, B.S., M.Sc., Colorado School of Mines; (Professional Land Surveyor); Emeritus Associate Professor of Engineering

KATHLEEN H. OCHS, B.A., University of Oregon; M.A.T., Wesleyan University; M.A., Ph.D., University of Toronto; Emerita Associate Professor of Liberal Arts and International Studies

BARBARA M. OLDS, B.A., Stanford University; M.A., Ph.D., University of Denver; Associate Provost for Educational Innovation; Emerita Professor of Liberal Arts and International Studies

EUL-SOO PANG, B.A. Marshall University; M.A., Ohio University; Ph.D., University of California at Berkeley; Emeritus Professor of Liberal Arts and International Studies

LAURA J. PANG, B.A. University of Colorado; M.A., Ph.D., Vanderbilt University; Emerita Associate Professor of Liberal Arts and International Studies

MICHAEL J. PAVELICH, B.S., University of Notre Dame; Ph.D., State University of New York at Buffalo; Emeritus Professor of Chemistry and Geochemistry

ROBERT W. PEARSON, P.E., Colorado School of Mines; Emeritus Associate Professor of Physical Education and Athletics and Head Soccer Coach

ANTON G. PEGIS, B.A., Western State College; M.A., Ph.D., University of Denver; Emeritus Professor of English

HARRY C. PETERSON, B.S.M.E., Colorado State University; M.S., Ph.D., Cornell University; Emeritus Professor of Engineering

ALFRED PETRICK, JR., A.B., B.S., M.S., Columbia University; M.B.A., University of Denver; Ph.D., University of Colorado; Emeritus Professor of Mineral Economics, P.E.

THOMAS PHILIPPOSE, B.A., M.A., Presidency College- University of Madras; Ph.D., University of Denver; University Emeritus Professor of Liberal Arts and International Studies

EILEEN P. POETER, B.S., Lehigh University; M.S., Ph.D., Washington State University; Emerita Professor of Geology and Geological Engineering, P.E.

STEVEN A. PRUESS, B.S., Iowa State University; M.S., Ph.D., Purdue University; Emeritus Professor of Mathematical and Computer Sciences

DENNIS W. READEY, B.S., University of Notre Dame; Sc.D., Massachusetts Institute of Technology; University Emeritus Herman F. Coors Distinguished Professor of Ceramic Engineering; Professor of Metallurgical and Materials Engineering

SAMUEL B. ROMBERGER, B.S., Ph.D., The Pennsylvania State University; Emeritus Professor of Geology and Geological Engineering

PHILLIP R. ROMIG, JR., B.S., University of Notre Dame; M.S., Ph.D., Colorado School of Mines; Emeritus Professor of Geophysics

ODED RUDAWSKY, B.S., M.S., Ph.D., The Pennsylvania State University; Emeritus Professor of Mineral Economics

ARTHUR B SACKS, B.A., Brooklyn College, M.A., Ph.D., University of Wisconsin-Madison, Emeritus Professor of Liberal Arts and International Studies

ARTHUR Y. SAKAKURA, B.S., M.S., Massachusetts Institute of Technology; Ph.D., University of Colorado; Emeritus Associate Professor of Physics

MIKLOS D. G. SALAMON, Dipl.Eng., Polytechnical University, Hungary; Ph.D., University of Durham, England; Emeritus Professor of Mining Engineering

FRANKLIN D. SCHOWENGERDT, B.S., M.S., Ph.D., University of Missouri at Rolla; Emeritus Professor of Physics

ROBERT L. SIEGRIST, 1997-B.S., M.S., Ph.D. University of Wisconsin-Madison; University Emeritus Professor of Environmental Science and Engineering, P.E.

CATHERINE A. SKOKAN, 1982-B.S., M.S., Ph.D., Colorado School of Mines; Emerita Associate Professor of Engineering

MAYNARD SLAUGHTER, B.S., Ohio University; M.A., University of Missouri; Ph.D., University of Pittsburgh; Emeritus Professor of Chemistry and Geochemistry

JOSEPH D. SNEED, B.A., Rice University; M.S., University of Illinois; Ph.D., Stanford University; Emeritus Professor of Liberal Arts and International Studies

CHARLES W. STARKS, Met.E., M.Met.E., Colorado School of Mines; Emeritus Associate Professor of Chemistry, P.E.

FRANKLIN J. STERMOLE, B.S., M.S., Ph.D., Iowa State University; Emeritus Professor of Chemical Engineering/Mineral Economics; P.E.

ROBERT J. TAYLOR, BAE School of the Art Institute; M.A., University of Denver; Emeritus Associate Professor of Engineering

JOHN E. TILTON, B.A., Princeton University; M.A., Ph.D., Yale University; University Emeritus Professor of Economics and Business

A. KEITH TURNER, B.Sc., Queen's University, Kingston, Ontario; M.A., Columbia University; Ph.D., Purdue University; Emeritus Professor of Geology and Geological Engineering, P.E.

ROBERT G. UNDERWOOD, B.S., University of North Carolina; Ph.D., University of Virginia; Emeritus Associate Professor of Mathematical and Computer Sciences

CRAIG W. VAN KIRK, 1978-B.S., M.S., University of Southern California; Ph.D., Colorado School of Mines; Professor of Petroleum Engineering

FUN-DEN WANG, B.S., Taiwan Provincial Cheng-Kung University; M.S., Ph.D., University of Illinois at Urbana; Emeritus Professor of Mining Engineering

JOHN E. WARME, B.A., Augustana College; Ph.D., University of California at Los Angeles; Emeritus Professor of Geology and Geological Engineering

ROBERT J. WEIMER, B.A., M.A., University of Wyoming; Ph.D., Stanford University; Emeritus Professor of Geology and Geological Engineering, P.E.

WALTER W. WHITMAN, B.E., Ph.D., Cornell University; Emeritus Professor of Geophysics

THOMAS R. WILDEMAN, B.S., College of St. Thomas; Ph.D., University of Wisconsin; Emeritus Professor of Chemistry and Geochemistry

KAREN B. WILEY, B.A., Mills College; M.A., Ph.D., University of Colorado; Emerita Associate Professor of Liberal Arts and International Studies

JOHN T. WILLIAMS, B.S., Hamline University; M.S., University of Minnesota; Ph.D., Iowa State College; Emeritus Professor of Chemistry and Geochemistry

DON L. WILLIAMSON, B.S., Lamar University; M.S., Ph.D., University of Washington; Emeritus Professor of Physics

ROBERT D. WITTERS, B.A., University of Colorado; Ph.D., Montana State College; Emeritus Professor of Chemistry and Geochemistry

ROBERT E. D. WOOLSEY, B.S., M.S., Ph.D., University of Texas at Austin; Emeritus Professor of Economics and Business and of Mathematical and Computer Sciences

BAKI YARAR, B.Sc., M.Sc., Middle East Technical University, Ankara; Ph.D., University of London; Emeritus Professor of Mining Engineering

F. RICHARD YEATTS, B.S., The Pennsylvania State University; M.S., Ph.D., University of Arizona; Emeritus Professor of Physics

VICTOR F. YESAVAGE, B.Ch.E., The Cooper Union; M.S.E., Ph.D., University of Michigan; Emeritus Professor of Chemical Engineering

## Professors

CORBY ANDERSON, 2009-B.S., Montana State University; M.S., Montana Tech.; Ph.D., University of Idaho; Harrison Western Professor of Metallurgical and Materials Engineering

MICHAEL L. BATZLE, 2007-B.S., University of California, Riverside; PhD, Massachusetts Institute of Technology, Baker Hughes Professor of Petrophysics and Borehole Geophysics

BERNARD BIALECKI, 1995-M.S., University of Warsaw, Poland; Ph.D., University of Utah; Professor of Applied Mathematics and Statistics

TRACY CAMP, 1998-B.A. Kalamazoo College; M.S. Michigan State University; Ph.D. College of William and Mary; Professor of Applied Mathematics and Statistics

REUBEN T. COLLINS, 1994-B.A., University of Northern Iowa; M.S., Ph.D., California Institute of Technology; Professor of Physics

JOHN T. CUDDINGTON, 2005-B.A., University of Regina; M.A., Simon Fraser University; M.S., Ph.D., University of Wisconsin; William J. Coulter Professor of Mineral Economics and Professor of Economics and Business

JOHN B. CURTIS, 1990-B.A., M.S., Miami University; Ph.D., The Ohio State University; Professor of Geology and Geological Engineering

KADRI DAGDELEN, 1992-B.S., M.S., Ph.D., Colorado School of Mines; Professor of Mining Engineering and Head of Department

CAROL DAHL, 1991-B.A., University of Wisconsin; Ph.D., University of Minnesota; Professor of Economics and Business

ELIZABETH VAN WIE DAVIS, 2009-B.A., Shimer College; M.A., Ph.D., University of Virginia; Professor of Liberal Arts and International Studies and Division Director

GRAHAM A. DAVIS, 1993-B.S., Queen's University at Kingston; M.B.A., University of Cape Town; Ph.D., The Pennsylvania State University; Professor of Economics and Business

THOMAS L. DAVIS, 1980-B.E., University of Saskatchewan; M.Sc., University of Calgary; Ph.D., Colorado School of Mines; Professor of Geophysics

ANTHONY DEAN, 2000-B.S., Springhill College; A.M., Ph.D., Harvard University; William K. Coors Distinguished Chair in Chemical Engineering and Professor of Chemical and Biological Engineering

JOHN R. DORGAN, 1992-B.S., University of Massachusetts Amherst; Ph.D., University of California, Berkeley; Computer Modeling Group Chair and Professor of Chemical and Biological Engineering

JÖRG DREWES, 2001-Ingenieur cand., Dipl. Ing., Ph.D., Technical University of Berlin; Professor of Civil and Environmental Engineering

RODERICK G. EGGERT, 1986-A.B., Dartmouth College; M.S., Ph.D., The Pennsylvania State University; Professor of Economics and Business and Division Director

JAMES F. ELY, 1981-B.S., Butler University; Ph.D., Indiana University; Professor of Chemical and Biological Engineering

THOMAS E. FURTAK, 1986-B.S., University of Nebraska; Ph.D., Iowa State University; Professor of Physics and Head of Department

MAHADEVAN GANESH, 2003- Ph.D., Indian Institute of Technology; Professor of Applied Mathematics and Statistics

RAMONA M. GRAVES, 1981-B.S., Kearney State College; Ph.D., Colorado School of Mines; Professor of Petroleum Engineering and Head of Department

UWE GREIFE, 1999-M.S., University of Munster; Ph.D., University of Bochum; Professor of Physics

D. VAUGHAN GRIFFITHS, 1994-B.Sc., Ph.D., D.Sc., University of Manchester; M.S., University of California Berkeley; Professor of Civil and Environmental Engineering

MARTE GUTIERREZ, 2008-B.S., Saint Mary's University; M.S., University of the Philippines; Ph.D., University of Tokyo; James R. Paden Distinguished Chair and Professor of Civil and Environmental Engineering

DAVE HALE, 2004-B.S., Texas A&M University; M.S., Ph.D., Stanford University; Charles Henry Green Professor of Exploration Geophysics

WENDY J. HARRISON, 1988-B.S., Ph.D., University of Manchester; Associate Provost; Professor of Geology and Geological Engineering

RANDY L. HAUPT, 2012-B.S., USAF Academy, M.S.E.E., Northeastern University; Ph.D., University of Michigan; Professor of Electrical Engineering and Computer Science

WILLY A. M. HEREMAN, 1989-B.S., M.S., Ph.D., State University of Ghent, Belgium; Professor of Applied Mathematics and Statistics and Head of Department

MURRAY W. HITZMAN, 1996-A.B., Dartmouth College; M.S., University of Washington; Ph.D., Stanford University; Charles Franklin Fogarty Distinguished Chair in Economic Geology; Professor of Geology and Geological Engineering

TISSA ILLANGASEKARE, 1998-B.Sc., University of Ceylon, Peradeniya; M. Eng., Asian Institute of Technology; Ph.D., Colorado State University; Professor and AMAX Distinguished Chair in Civil and Environmental Engineering, P.E.

MICHAEL J. KAUFMAN, 2007-B.S., Ph.D., University of Illinois, Urbana, Professor of Metallurgical and Materials Engineering, Head of Department

HOSSEIN KAZEMI, 2004-B.S., University of Texas at Austin; Ph.D., University of Texas at Austin; Chesebro' Distinguished Chair in Petroleum Engineering; Co-Director of Marathon Center of Excellence for Reservoir Studies and Professor of Petroleum Engineering

ROBERT J. KEE, 1996-B.S., University of Idaho; M.S., Stanford University; Ph.D., University of California at Davis; George R. Brown Distinguished Professor of Mechanical Engineering

ROBERT H. KING, 1981-B.S., University of Utah; M.S., Ph.D., The Pennsylvania State University; Professor of Mechanical Engineering

DANIEL M. KNAUSS, 1996-B.S., The Pennsylvania State University; Ph.D., Virginia Polytechnic Institute and State University; Professor of Chemistry and Geochemistry and Head of Department

CAROLYN KOH, 2006-B.S., Ph.D., University of West London, Brunel; Professor of Chemical and Biological Engineering

FRANK V. KOWALSKI, 1980-B.S., University of Puget Sound; Ph.D., Stanford University; Professor of Physics

STEPHEN LIU, 1987-B.S., M.S., Universidade Federal de MG, Brazil; Ph.D., Colorado School of Mines; Professor of Metallurgical and Materials Engineering, CEng, U.K.

NING LU, 1997-B.S., Wuhan University of Technology; M.S., Ph.D., Johns Hopkins University; Professor of Civil and Environmental Engineering

MARK T. LUSK, 1994-B.S., United States Naval Academy; M.S., Colorado State University; Ph.D., California Institute of Technology; Professor of Physics

PATRICK MacCARTHY, 1976-B.Sc., M.Sc., University College, Galway, Ireland; M.S., Northwestern University; Ph.D., University of Cincinnati; Professor of Chemistry and Geochemistry

DAVID W.M. MARR, 1995-B.S., University of California, Berkeley; M.S., Ph.D., Stanford University; Professor of Chemical and Biological Engineering and Head of Department

PAUL A. MARTIN, 1999-B.S., University of Bristol; M.S., Ph.D., University of Manchester; Professor of Applied Mathematics and Statistics, and Associate Department Head

GERARD P. MARTINS, 1969-B.Sc., University of London; Ph.D., State University of New York at Buffalo; Professor of Metallurgical and Materials Engineering

DAVID K. MATLOCK, 1972-B.S., University of Texas at Austin; M.S., Ph.D., Stanford University; Charles F. Fogarty Professor of Metallurgical Engineering sponsored by the ARMCO Foundation; Professor of Metallurgical and Materials Engineering, P.E.

JOHN E. McCRAY, 1998-B.S., West Virginia University; M.S. Clemson University; Ph.D., University of Arizona; Professor of Civil and Environmental Engineering and Division Director

DINESH MEHTA, 2000-B.Tech., Indian Institute of Technology; M.S., University of Minnesota; Ph.D., University of Florida; Professor of Electrical Engineering and Computer Science

RONALD L. MILLER, 1986-B.S., M.S., University of Wyoming; Ph.D., Colorado School of Mines; Professor of Chemical and Biological Engineering

BRAJENDRA MISHRA, 1997-B. Tech. Indian Institute of Technology; M.S., Ph.D., University of Minnesota; Professor of Metallurgical and Materials Engineering

CARL MITCHAM, 1999-B.A., M.A., University of Colorado; Ph.D., Fordham University; Professor of Liberal Arts and International Studies

MICHAEL MOONEY, 2003-B.S., Washington University in St. Louis; M.S., University of California, Irvine; Ph.D., Northwestern University; Professor of Civil and Environmental Engineering

BARBARA MOSKAL, 1999-B.S., Duquesne University; M.S., Ph.D., University of Pittsburgh; Professor of Applied Mathematics and Statistics and Interim Director of the Trefny Institute

GRAHAM G. W. MUSTOE, 1987-B.S., M.Sc., University of Aston; Ph.D., University College Swansea; Professor of Mechanical Engineering

WILLIAM C. NAVIDI, 1996-B.A., New College; M.A., Michigan State University; M.A., Ph.D., University of California at Berkeley; Professor of Applied Mathematics and Statistics

GARY R. OLHOEFT, 1994-B.S.E.E., M.S.E.E., Massachusetts Institute of Technology; Ph.D., University of Toronto; Professor of Geophysics

DAVID L. OLSON, 1972-B.S., Washington State University; Ph.D., Cornell University; John H. Moore Distinguished Professor of Physical Metallurgy; Professor of Metallurgical and Materials Engineering, P.E.

UGUR OZBAY, 1998-B.S., Middle East Technical University of Ankara; M.S., Ph.D., University of the Witwatersrand; Professor of Mining Engineering

ERDAL OZKAN, 1998-B.S., M.Sc., Istanbul Technical University; Ph.D., University of Tulsa; Co-Director of Marathon Center of Excellence for Reservoir Studies and Professor of Petroleum Engineering

TERENCE E. PARKER, 1994-B.S., M.S., Stanford University; Ph.D., University of California Berkeley; Provost and Executive Vice President; Professor of Engineering

IVAR E. REIMANIS, 1994-B.S., Cornell University; M.S., University of California Berkeley; Ph.D., University of California Santa Barbara; Professor of Metallurgical and Materials Engineering

MAJ DAVID ROZELLE, 1995-B.A., Davidson College, Davidson, North Carolina, 2009 - M.M.S. Marine Corps University, Quantico, Virginia, and Professor of Military Science (Army R.O.T.C.)

PAUL M. SANTI, 2001-B.S., Duke University; M.S., Texas A&M University; Ph.D., Colorado School of Mines; Professor of Geology and Geological Engineering

JOHN A. SCALES, 1992-B.S., University of Delaware; Ph.D., University of Colorado; Professor of Physics

PANKAJ K. (PK) SEN, 2000-B.S., Jadavpur University; M.E., Ph.D., Technical University of Nova Scotia. P.E., Professor of Electrical Engineering and Computer Science

E. DENDY SLOAN, JR., 1976-B.S.Ch.E., M.S., Ph.D., Clemson University; Weaver Distinguished Professor in Chemical and Biological Engineering and Professor of Chemical and Biological Engineering

ROEL K. SNIEDER, 2000-Drs., Utrecht University; M.A., Princeton University; Ph.D., Utrecht University; W.M. Keck Foundation Distinguished Chair in Exploration Science and Professor of Geophysics

STEPHEN A. SONNENBERG, 2007-B.S., M.S., Texas A&M University; Ph.D., Colorado School of Mines; Professor of Geology and Geological Engineering and Charles Boettcher Distinguished Chair in Petroleum Geology

JOHN G. SPEER, 1997-B.S., Lehigh University; Ph.D., Oxford University; Professor of Metallurgical and Materials Engineering

JEFF SQUIER, 2002-B.S., M.S., Colorado School of Mines; Ph.D., University of Rochester; Professor of Physics

P. CRAIG TAYLOR, 2005-A.B., Carleton College; Ph.D., Brown University; Professor of Physics

PATRICK TAYLOR, 2003-B.S., Ph.D., Colorado School of Mines; George S. Ansell Distinguished Chair in Metallurgy and Professor of Metallurgical and Materials Engineering

ILYA D. TSVANKIN, 1992-B.S., M.S., Ph.D., Moscow State University; Professor of Geophysics

AZRA TUTUNCU, 2010-B.S., Istanbul Technical University; M.S., Stanford University; M.S., Ph.D., University of Texas at Austin; Harry D. Campbell Chair in Petroleum Engineering, Director of Unconventional Natural Gas Institute (UNGI) and Professor of Petroleum Engineering

CHESTER J. VAN TYNE, 1988-B.A., B.S., M.S., Ph.D., Lehigh University; FIERF Professor and Professor of Metallurgical and Materials Engineering, P.E.

KENT J. VOORHEES, 1978-B.S., M.S., Ph.D., Utah State University; Professor of Chemistry and Geochemistry

MICHAEL R. WALLS, 1992-B.S., Western Kentucky University; M.B.A., Ph.D., The University of Texas at Austin; Professor of Economics and Business

J. DOUGLAS WAY, 1994-B.S., M.S., Ph.D., University of Colorado; Professor of Chemical and Biological Engineering

RICHARD F. WENDLANDT, 1987-B.A., Dartmouth College; Ph.D., The Pennsylvania State University; Professor of Geology and Geological Engineering

DAVID TAI-WEI WU, 1996-A.B., Harvard University; Ph.D., University of California, Berkeley; Professor of Chemistry and Geochemistry/Chemical and Biological Engineering

YU-SHU WU, 2008-B.S., Daqing Petroleum Institute, China; M.S., Southwest Petroleum Institute, China; M.S., Ph.D., University of California at Berkeley; Professor of Petroleum Engineering

TYRONE VINCENT, 1998-B.S. University of Arizona; M.S., Ph.D. University of Michigan; Professor of Electrical Engineering and Computer Science and Interim Department Head

TERENCE K. YOUNG, 1979-1982, 2000-B.A., Stanford University; M.S., Ph.D., Colorado School of Mines; Professor of Geophysics and Head of Department

## Associate Professors

SUMIT AGARWAL, 2005-B.S., Banaras Hindu University, India; M.S., University of New Mexico; Ph.D., University of California, Santa Barbara; Associate Professor of Chemical Engineering

JOEL M. BACH, 2001-B.S., SUNY Buffalo; Ph.D., University of California at Davis; Associate Professor of Mechanical Engineering

EDWARD J. BALISTRERI, 2004-B.A., Arizona State University; M.A., Ph.D., University of Colorado; Associate Professor of Economics and Business

DAVID A. BENSON, 2005-B.S., New Mexico State University; M.S., San Diego State University; Ph.D., University of Nevada, Reno; Associate Professor of Geology and Geological Engineering

JOHN R. BERGER, 1994-B.S., M. S., Ph.D., University of Maryland; Associate Professor of Mechanical Engineering

THOMAS M. BOYD, 1993-B.S., M.S., Virginia Polytechnic Institute and State University; Ph.D., Columbia University; Dean of Graduate Studies; Associate Professor of Geophysics

STEPHEN G. BOYES, 2005-B.S., Ph.D., University of New South Wales; Associate Professor of Chemistry and Geochemistry

LINCOLN D. CARR, 2005-B.A., University of California at Berkeley; M.S., Ph.D., University of Washington; Associate Professor of Physics

TZAHY CATH, 2006-B.S., Tel Aviv University; M.S., Ph.D., University of Nevada; Associate Professor of Environmental Science and Engineering

CRISTIAN CIOBANU, 2004-B.S., University of Bucharest; M.S., Ph.D., Ohio State University; Associate Professor of Mechanical Engineering

RONALD R. H. COHEN, 1985-B.A., Temple University; Ph.D., University of Virginia; Associate Professor of Civil and Environmental Engineering

SCOTT W. COWLEY, 1979-B.S., M.S., Utah State University; Ph.D., Southern Illinois University; Associate Professor of Chemistry and Geochemistry

CHARLES G. DURFEE, III, 1999-B.S., Yale University; Ph.D., University of Maryland; Associate Professor of Physics

MARK EBERHART, 1998 - B.S., M.S. University of Colorado; Ph.D. Massachusetts Institute of Technology; Associate Professor of Chemistry and Geochemistry

ALFRED W. EUSTES III, 1996-B.S., Louisiana Tech University; M.S., University of Colorado at Boulder; Ph.D., Colorado School of Mines; Associate Professor of Petroleum Engineering, P.E.

LINDA A. FIGUEROA, 1990-B.S., University of Southern California; M.S., Ph.D., University of Colorado; Associate Professor of Civil and Environmental Engineering, P.E.

CHRISTIAN FRENZEL, 2010-M.S., Georgia Institute of Technology, Ph.D., Technische Universität München, Germany; Associate Professor of Mining Engineering

TINA L. GIANQUITTO, 2003-B.A., M.A., and Ph.D., Columbia University; Associate Professor of Liberal Arts and International Studies

BRIAN GORMAN, 2008-B.S., M.S., Ph.D., University of Missouri-Rolla; Associate Professor of Metallurgical and Materials Engineering

QI HAN, 2005-B.S., Yanshan University of China; M.S., Huazhong University of Science and Technology China; Ph.D., University of

California, Irvine; Associate Professor of Electrical Engineering and Computer Science

KATHLEEN J. HANCOCK, 2009-B.A., University of California, Santa Barbara; M.S. George Washington University; Ph.D., University of California, San Diego; Associate Professor of Liberal Arts and International Studies

MICHAEL B. HEELEY, 2004-B.S., The Camborne School of Mines; M.S., University of Nevada; M.S., Ph.D., University of Washington; Associate Professor of Economics and Business

JOHN R. HEILBRUNN, 2001-B.A., University of California, Berkeley; M.A., Boston University, University of California, Los Angeles; Ph.D., University of California, Los Angeles; Associate Professor of Liberal Arts and International Studies

ANDREW M. HERRING, 2006-Bs.C., Ph.D., University of Leeds; Associate Professor of Chemical Engineering

JERRY D. HIGGINS, 1986-B.S., Southwest Missouri State University; M.S., Ph.D., University of Missouri at Rolla; Associate Professor of Geology and Geological Engineering

WILLIAM A. HOFF, 1994-B.S., Illinois Institute of Technology; M.S., Ph.D., University of Illinois-Champaign/Urbana; Associate Professor of Electrical Engineering and Computer Science and Assistant Division Director of Electrical Engineering and Computer Science

TERRI S. HOGUE, 2012-B.S., University of Wisconsin; M.S. & Ph.D., University of Arizona; Associate Professor of Civil and Environmental Engineering

JOHN D. HUMPHREY, 1991-B.S., University of Vermont; M.S., Ph.D., Brown University; Associate Professor of Geology and Geological Engineering and Head of Department

KATHRYN JOHNSON, 2005-B.S., Clarkson University; M.S., Ph.D., University of Colorado; Clare Boothe Luce Associate Professor of Electrical Engineering and Computer Science

PANOS KIOUSIS, 1999-Ph.D., Louisiana State University; Associate Professor of Civil and Environmental Engineering

MARK E. KUCHTA, 1999- B.S. M.S., Colorado School of Mines; Ph.D., Lulea University of Technology, Sweden; Associate Professor of Mining Engineering

JON LEYDENS, 2004-B.A., M.A., Ph.D., Colorado State University; Associate Professor of Liberal Arts and International Studies

YAOGUO LI, 1999-B.S., Wuhan College of Geology, China; Ph.D., University of British Columbia; Associate Professor of Geophysics

MATTHEW LIBERATORE, 2005-B.S., University of Chicago; M.S., Ph.D., University of Illinois at Urbana Champaign; Associate Professor of Chemical and Biological Engineering

JUAN C. LUCENA, 2002-B.S., M.S., Rensselaer Polytechnic Institute; Ph.D., Virginia Tech; Associate Professor of Liberal Arts and International Studies

KEVIN W. MANDERNACK, 1996-B.S., University of Wisconsin at Madison; Ph.D., University of California San Diego; Associate Professor of Chemistry and Geochemistry

REED M. MAXWELL, 2009-B.S., University of Miami; M.S., University of California at Los Angeles; Ph.D., University of California at Berkeley; Associate Professor of Geology and Geological Engineering

HUGH B. MILLER, 2005-B.S., M.S., Ph.D., Colorado School of Mines; Associate Professor of Mining Engineering

JENNIFER L. MISKIMINS, 2002-B.S., Montana College of Mineral Science and Technology; M.S., Ph.D., Colorado School of Mines; Associate Professor of Petroleum Engineering

JUNKO MUNAKATA MARR, 1996-B.S., California Institute of Technology; M.S., Ph.D., Stanford University; Associate Professor of Civil and Environmental Engineering

MASAMI NAKAGAWA, 1996-B.E., M.S., University of Minnesota; Ph.D., Cornell University; Associate Professor of Mining Engineering

ALEXANDRA NEWMAN, 2000-B.S., University of Chicago; M.S., Ph.D., University of California, Berkeley; Associate Professor of Economics and Business

RYAN O'HAYRE, 2006-B.S., Colorado School of Mines; M.S., Ph.D., Stanford University; Associate Professor of Metallurgical and Materials Engineering

TIMOTHY R. OHNO, 1992-B.S., University of Alberta; Ph.D., University of Maryland; Associate Professor of Physics

KENNETH OSGOOD, 2011-B.A., University of Notre Dame, M.A., Ph.D., University of Santa Barbara; Associate Professor of Liberal Arts and International Studies, Director of Guy T. McBride Jr. Honors Program in Public Affairs

ANTHONY J. PETRELLA, 2006-B.S., M.S., Purdue University; Ph.D., University of Pittsburgh; Associate Professor of Mechanical Engineering

MANIKA PRASAD, 2007-B.S., Bombay University; M.S., Ph.D., Kiel University; Co-Director of Center for Rock Abuse and Associate Professor of Petroleum Engineering

JAMES F. RANVILLE, 2004-B.S. Lake Superior State University; M.S., Ph.D., Colorado School of Mines; Associate Professor of Chemistry and Geochemistry

ANDRÉ REVIL, 2007-Diploma, University of Savoie; Ingeneer Diploma, PhD, Ecole de Physique du Globe de Strasbourg, Associate Professor of Geophysics

RYAN M. RICHARDS, 2007-B.S. Michigan State University; M.S. Central Michigan University; Ph.D. Kansas State University; Associate Professor of Chemistry and Geochemistry

FRÉDÉRIC SARAZIN, 2003-Ph.D., GANIL-Caen, France; Associate Professor of Physics

PAUL SAVA, 2006-B.S., University of Bucharest; M.S., Ph.D., Stanford University; Associate Professor of Geophysics

MAJ JANET SCHOENBERG, 2012-B.A. General Studies Columbia College; Masters of Education, Education and Human Resources, Colorado State University; Associate Professor of Military Science

ALAN, SELLINGER, 2012-B.S. Eastern Michigan University; M.S., Ph.D., University of Michigan; Associate Professor of Chemistry and Geochemistry

E. CRAIG SIMMONS, 1977-B.S., University of Kansas; M.S., Ph.D., State University of New York at Stony Brook; Associate Professor of Chemistry and Geochemistry

MARCELO G. SIMOES, 2000-B.E., M.S., Ph.D., University of Sao Paulo; Associate Professor of Electrical Engineering and Computer Science

KAMINI SINGHA-2012-B.S., University of Connecticut; Ph.D., Stanford University; Associate Professor of Geology and Geological Engineering

JOHN R. SPEAR, 2005-B.A., University of California, San Diego; M.S. and Ph.D., Colorado School of Mines; Associate Professor of Civil and Environmental Engineering

JOHN P. H. STEELE, 1988-B.S., New Mexico State University; M.S., Ph.D., University of New Mexico; Associate Professor of Mechanical Engineering, P.E.

JAMES D. STRAKER, 2005-B.A., University of Notre Dame; M.A., Ohio State University; Ph.D., Emory University; Associate Professor of Liberal Arts and International Studies

NEAL SULLIVAN, 2004-B.S., University of Massachusetts; M.S., Ph.D., University of Colorado; Associate Professor of Mechanical Engineering and Director of the Colorado Fuel Cell Center

LUIS TENORIO, 1997-B.A., University of California, Santa Cruz; Ph.D., University of California, Berkeley; Associate Professor of Applied Mathematics and Statistics

STEVEN W. THOMPSON, 1989-B.S., Ph.D., The Pennsylvania State University; Associate Professor of Metallurgical and Materials Engineering

BRUCE TRUDGILL, 2003 -B.S., University of Wales; Ph.D., Imperial College; Associate Professor of Geology and Geological Engineering

BETTINA M. VOELKER, 2004-B.S., M.S., Massachusetts Institute of Technology; Ph.D., Swiss Federal Institute of Technology; Associate Professor of Chemistry and Geochemistry

KIM R. WILLIAMS, 1997-B.Sc., McGill University; Ph.D., Michigan State University; Associate Professor of Chemistry and Geochemistry

COLIN WOLDEN, 1997-B.S., University of Minnesota; M.S., Ph.D., Massachusetts Institute of Technology, Associate Professor of Chemical Engineering

DAVID M. WOOD, 1989-B.A., Princeton University; M.S., Ph.D., Cornell University; Associate Professor of Physics

RAY RUICHONG ZHANG, 1997-B.S., M.S., Tongji University; Ph.D., Florida Atlantic University; Associate Professor of Civil and Environmental Engineering

WEI ZHOU, 2008-B.S., China Geology University; M.S., University of Alaska and University of Missouri-Rolla; Ph.D., University of Missouri-Rolla; Associate Professor of Geology and Geological Engineering



## Assistant Professors

CORY AHERNS, 2011-B.S., Kansas State University; M.S., University of Michigan; Ph.D., University of Colorado at Boulder; Assistant Professor of Applied Mathematics and Statistics

JEFFREY ANDREWS-HANNA, 2008-B.A., Cornell University; Ph.D., Washington University; Assistant Professor of Geophysics

JENNIFER L. ASCHOFF, 2008-B.S., Montana State University; M.S., New Mexico State University; Ph.D., University of Texas at Austin; Assistant Professor of Geology and Geological Engineering

REED A. AYERS, 2006-B.S., M.S., Ph.D., University of Colorado; Assistant Professor of Metallurgical and Materials Engineering

GREGORY BOGIN, 2010-B.S., Xavier University of Louisiana, M.S., Ph.D., University of California, Assistant Professor of Mechanical Engineering

JENNIFER C. BRALEY, 2012-B.S., Colorado State University; Ph.D., Washington State University; Assistant Professor of Chemistry and Geochemistry

ROBERT J. BRAUN, 2007-B.S., M.S., Marquette University; Ph.D., University of Wisconsin-Madison; Assistant Professor of Mechanical Engineering

ZIZHONG (JEFFREY) CHEN, 2008-B.S., Beijing Normal University; M.S., Ph.D., University of Tennessee; Assistant Professor of Electrical Engineering and Computer Science

JON M. COLLIS, 2008-B.S., New Mexico Institute of Mining and Technology; M.S. Colorado School of Mines; Ph.D., Rensselaer Polytechnic Institute; Assistant Professor of Applied Mathematics and Statistics

STEVEN DECALUWE, 2012-B.S., Vanderbilt University; Ph.D., University of Maryland; Assistant Professor of Mechanical Engineering

JASON DELBORNE, 2008-A.B., Stanford University; Ph.D., University of California, Berkeley; Assistant Professor of Liberal Arts and International Studies

HARRISON G. FELL, 2011-B.S., Colorado School of Mines; M.S., Ph.D., University of Washington; Assistant Professor of Economics and Business

KIP FINDLEY, 2008-B.S., Colorado School of Mines; Ph.D., Georgia Institute of Technology; Assistant Professor of Metallurgical and Materials Engineering

SYLVIA GAYLORD, 2007-B.A. and M.A., The Johns Hopkins University; Ph.D., Northwestern University; Assistant Professor of Liberal Arts and International Studies

ULRIKE HAGER, 2012-Ph.D., University of Jyväskylä; Assistant Professor of Physics

AMANDA HERING, 2009-B.S., Baylor University; M.S. Montana State University; Ph.D., Texas A & M University; Assistant Professor of Applied Mathematics and Statistics

CHRISTOPHER P. HIGGINS, 2008-A.B. Harvard University; M.S. Stanford University; Ph.D. Stanford University; Assistant Professor of Civil and Environmental Engineering

B. TODD HOFFMAN, 2011-B.S. Montana Tech of the University of Montana; M.S., Ph.D., Stanford University; Assistant Professor of Petroleum Engineering

DERRICK HUDSON, 2010-B.S., United States Air Force Academy; M.A., University of Central Oklahoma; Ph.D., University of Denver; Assistant Professor of Liberal Arts and International Studies

DANIEL KAFFINE, 2007-B.A., B.S., University of St. Thomas; M.A., Ph.D., University of California, Santa Barbara; Assistant Professor of Economics and Business

NIGEL KELLY, 2007-B.S., Ph.D., University of Sydney (Australia); Assistant Professor of Geology and Geological Engineering

JEFFREY KING, 2009-B.S., New Mexico Institute of Technology; M.S., Ph.D., University of New Mexico; Assistant Professor of Metallurgical and Materials Engineering

MELISSA D. KREBS, 2012-B.S., University of Rochester; M.S., University of Rochester; Ph.D., Case Western Reserve University; Assistant Professor of Chemical and Biological Engineering

YVETTE KUIPER, 2011-M.S., Utrecht University, The Netherlands; Ph.D., University of New Brunswick, Canada; Assistant Professor of Geology and Geological Engineering

HONGJUN LIANG, 2008-B.S., University of Science and Technology of Beijing; M.S., Chinese Academy of Science; Ph.D., University of Illinois at Urbana-Champaign; Assistant Professor of Metallurgical and Materials Engineering

MATTHEW LIBERATORE, 2005-B.S., University of Chicago; M.S., Ph.D., University of Illinois at Urbana Champaign; Associate Professor of Chemical Engineering

C. MARK MAUPIN, 2010- B.S., M.S., Boise State University, Ph.D. University of Utah; Assistant Professor of Chemical Engineering

SALMAN MOHAGHEGHI, 2011-B.Sc., M.S., University of Tehran, M.S., Ph.D., Georgia Institute of Technology, Assistant Professor of Electrical Engineering and Computer Science

THOMAS MONECKE, 2008-B.S. TU Bergakademie Freiberg, Germany and University of Edinburgh, UK; M.S., TU Bergakademie Freiberg; Ph.D., TU Bergakademie Freiberg and Centre for Ore Deposit Research at the University of Tasmania, Australia; Assistant Professor of Geology and Geological Engineering

KEITH B. NEEVES, 2008-B.S., University of Colorado; Ph.D., Cornell University; Assistant Professor of Chemical Engineering

EDWIN NISSEN, 2012-B.A., M.A., University of Cambridge; Ph.D., University of Oxford; Assistant Professor of Geophysics

CORINNE PACKARD, 2010-B.S., M.S., Ph.D., Massachusetts Institute of Technology; Assistant Professor of Metallurgical and Materials Engineering

STEPHEN D. PANKAVICH, 2012-B.S., M.S., Ph.D., Carnegie Mellon University; Assistant Professor of Applied Mathematics and Statistics

IRENE POLYCARPOU, 2008-B.S., M.S., Ph.D., Florida International University; Assistant Professor of Electrical Engineering and Computer Science

JASON PORTER, 2010-B.S., Brigham Young University; M.S., University of Texas at Austin; Ph.D., Stanford University, Assistant Professor of Mechanical Engineering

STEFFEN REBENNACK, 2010-Diploma Ruprecht-Karls Universitaet; M.S., Ph.D., University of Florida; Assistant Professor of Economics and Business

JESSICA S. ROLSTON, 2012-B.A., Macalester College; Ph.D., University of Michigan; Hennebach Assistant Professor in Energy Policy of Liberal Arts and International Studies

JENNIFER SCHNEIDER, 2004-B.A., Albertson College of Idaho; M.A., Ph.D., Claremont Graduate University; Assistant Professor of Liberal Arts and International Studies

JONATHAN O. SHARP, 2008-B.A. Princeton University; M.S. University of California at Berkeley; Ph.D. University of California at Berkeley; Assistant Professor of Civil and Environmental Engineering

ANNE SILVERMAN, 2011-B.S., University of Arizona, M.S., Ph.D., University of Texas at Austin, Assistant Professor of Mechanical Engineering

M. KATHLEEN SMITS, 2012-B.S., U.S. Air Force Academy; M.S., University of Texas at Austin; Ph.D., Colorado School of Mines; Assistant Professor of Civil and Environmental Engineering

AMADEU K. SUM, 2008-B.S., M.S., Colorado School of Mines; Ph.D., University of Delaware; Assistant Professor of Chemical Engineering

ANDRZEJ SZYM CZAK, 2007-M.S., University of Gdansk; M.S. and Ph.D., University of Washington; Assistant Professor of Electrical Engineering and Computer Science

ARNOLD B. TAMAYO, 2009-B.S., University of the Philippines, M.S., Georgia Institute of Technology, Ph.D., University of Southern California; Assistant Professor of Chemistry and Geochemistry

ERIC TOBERER, 2011-B.S., Harvey Mudd College; Ph.D., University of California; Assistant Professor of Physics

BRIAN G. TREWYN, 2012-B.S., University of Wisconsin at La Crosse; Ph.D. Iowa State University; Assistant Professor of Chemistry and Geochemistry

CAMERON J. TURNER, 2008-B.S., University of Wyoming; M.S., Ph.D., University of Texas at Austin; Assistant Professor of Mechanical Engineering

MICHAEL B. WAKIN, 2008-B.S., M.S., Ph.D., Rice University; Assistant Professor of Electrical Engineering and Computer Science

HUA WANG, 2012-B.E., Tsinghua University; M.S., Nanyang Technological University; Ph.D., University of Texas at Arlington; Assistant Professor of Electrical Engineering and Computer Science

JUDITH WANG, 2007-B.A., B.S.E., M.S.E., Ph.D., Case Western Reserve University; Assistant Professor of Civil and Environmental Engineering

NING WU, 2010-B.Sc., M.Sc. National University of Singapore, Ph.D. Princeton University, Assistant Professor of Chemical Engineering

ZHIGANG WU, 2009-B.S., Peking University, Ph.D., College of William and Mary; Assistant Professor of Physics

YONGAN YANG, 2010-B.S., Nankai University, Ph.D., Institute of Photographic Chemistry, Chinese Academy of Sciences; Assistant Professor of Chemistry and Geochemistry

XIAOLONG YIN, 2009-B.S., Beijing University, China; M.S., Lehigh University, Ph.D., Cornell; Assistant Professor of Petroleum Engineering

## Teaching Professors

RAVEL F. AMMERMAN, 2004-B.S., Colorado School of Mines; M.S., University of Colorado; Ph.D., Colorado School of Mines; Teaching Professor of Electrical Engineering and Computer Science

MANOHAR ARORA, 2006-B.S., University of Roorkee; M.S., University of Burdwan; Ph.D., University of Mississippi; Teaching Professor of Mining Engineering

JOSEPH P. CROCKER, 2004-B.S., M.S., Oklahoma State University; Ph.D., University of Utah; Teaching Professor of Civil and Environmental Engineering

JOEL DUNCAN, 2006-B.S. University of Alabama; Ph.D., Florida State University; Teaching Professor of EPICS and Geology and Geological Engineering

ALEX T. FLOURNOY, 2006-B.S., Georgia Institute of Technology, M.S., Ph.D. University of Colorado, Boulder; Teaching Professor of Physics

G. GUSTAVE GREIVEL, 1994-B.S., M.S., Colorado School of Mines; Teaching Professor of Applied Mathematics and Statistics

HUGH KING, 1993-B.S., Iowa State University; M.S. New York University; M.D., University of Pennsylvania; Ph.D., University of Colorado; Teaching Professor of Chemical and Biological Engineering/BELS

JAMES V. JESUDASON, 2002-B.A. Wesleyan University; M.A., Ph.D., Harvard University; Teaching Professor of Liberal Arts and International Studies

ROBERT KLIMEK, 1996-B.A., St. Mary's of the Barrens College; M.Div., DeAndreis Theological Institute; M.A. University of Denver; D.A., University of Northern Colorado; Teaching Professor of Liberal Arts and International Studies

ROBERT KNECHT, 1978-B.S., M.S., Ph.D., Colorado School of Mines; Teaching Professor of EPICS

PATRICK B. KOHL, 2007-B.S., Western Washington University; Ph. D. University of Colorado; Teaching Professor of Physics

H. VINCENT KUO, 2006-B.S., M.S., Ph.D., University of Minnesota; Teaching Professor of Physics

TONI LEFTON, 1998-B.A., Florida State University; M.A., Northern Arizona University; Teaching Professor of Liberal Arts and International Studies

RICHARD PASSAMANECK, 2004-B.S., M.S., University of California, Los Angeles; Ph.D., University of Southern California; Teaching Professor of Mechanical Engineering

CYNDI RADER, 1991-B.S., M.S., Wright State University; Ph.D., University of Colorado; Teaching Professor of Electrical Engineering and Computer Science

TODD RUSKELL, 1999-B.A., Lawrence University; M.S., Ph.D., University of Arizona; Teaching Professor of Physics

CHRISTIAN SHOREY, 2005-B.S., University of Texas at Austin; Ph.D., University of Iowa; Teaching Professor of Geology and Geological Engineering

CHARLES A. STONE, IV, 2007-B.S., North Carolina State University, M.S., University of Wisconsin, Madison, Ph.D., University of California, Los Angeles; Teaching Professor of Physics

CANDACE S. SULZBACH, 1983-B.S., Colorado School of Mines; Teaching Professor of Civil and Environmental Engineering

SANDY WOODSON, 1999-B.A., North Carolina State University; M.A., Colorado State University; M.F.A., University of Montana; Teaching Professor of Liberal Arts and International Studies

MATTHEW YOUNG, 2004-B.S., Ph.D., University of Rochester; Teaching Professor of Physics

## Teaching Associate Professor

LINDA A. BATTALORA, 2006-B.S., M.S., Colorado School of Mines; J.D., Loyola University New Orleans College of Law; Teaching Associate Professor of Petroleum Engineering

GERALD R. BOURNE, 2011-B.S., M.S., Ph.D., University of Florida; Teaching Associate Professor of Metallurgical and Materials Engineering

TERRY BRIDGMAN, 2003-B.S., Furman University; M.S., University of North Carolina at Chapel Hill; Teaching Associate Professor of Applied Mathematics and Statistics

DEBRA CARNEY, 2012-B.S., University of Vermont; Ph.D., University of Maryland; Teaching Associate Professor of Applied Mathematics and Statistics

JOHN P. CHANDLER, 2006-B.A., Transylvania University; M.A., East Carolina University; Ph.D., Penn State University; Teaching Associate Professor of Metallurgical and Materials Engineering

STEPHANIE A. CLAUSSEN, 2012-B.E., Massachusetts Institute of Technology; M.A., Ph.D., Stanford University; Teaching Associate Professor of Electrical Engineering and Computer Science

HOLLY EKLUND, 2009-BA, Marquette University; M.S., Colorado School of Mines; Teaching Associate Professor of Applied Mathematics and Statistics

RENEE L. FALCONER, 2012-B.S., Grove City College; Ph.D., University of South Carolina; Teaching Associate Professor of Chemistry and Geochemistry

ALEX T. FLOURNOY, 2006-B.S., Georgia Institute of Technology, M.S., Ph.D. University of Colorado, Boulder; Teaching Associate Professor of Physics

JASON C. GANLEY, 2012-B.S., University of Missouri Rolla; M.S., Ph.D., University of Illinois; Teaching Associate Professor of Chemical and Biological Engineering

TRACY Q. GARDNER, 1996-B.Sc., 1998-M.Sc., Colorado School of Mines; Ph.D., University of Colorado at Boulder, Teaching Associate Professor of Chemical and Biological Engineering

JOY M. GODESIABOIS, 2008-B.S., Colorado State University, M.B.A., Southern Methodist University, Ph.D., University of Colorado; Teaching Associate Professor of Economics and Business

KEITH HELLMAN, 2009-B.S., The University of Chicago; M.S. Colorado School of Mines; Teaching Associate Professor of Electrical Engineering and Computer Science

SCOTT HOUSER, 2007-B.S., Colorado State University; B.S., University of Southern Colorado; M.S., Ph.D., University of Wisconsin-Madison; Teaching Associate Professor of Economics and Business

PATRICK B. KOHL, 2007-B.S., Western Washington University; Ph. D. University of Colorado; Teaching Associate Professor of Physics

H. VINCENT KUO, 2006-B.S., M.S., Ph.D., University of Minnesota; Teaching Associate Professor of Physics

CARRIE J. MCCLELLAND, 2012-B.S., Colorado School of Mines; M.S., Ph.D., University of Colorado; Teaching Associate Professor of Petroleum Engineering

DAN MILLER, 2009-B.A., University of Colorado, Boulder; Ph.D., University of Iowa; Teaching Associate Professor and Assistant Division Director of Liberal Arts and International Studies

MARK MILLER, 1996-B.S., Ph.D., Colorado School of Mines; Teaching Associate Professor of Petroleum Engineering

RACHEL MORRISH, 2010-B.S.c., Colorado School of Mines, Ph.D. University of Arizona; Teaching Associate Professor of Chemical and Biological Engineering

MIKE NICHOLAS, 2012-B.A., B.S., University of Utah; M.S., Ph.D., Duke University; Teaching Associate Professor of Applied Mathematics and Statistics

CYNTHIA NORRGRAN, 2008-B.S., University of Minnesota; M.D., University of Nevada, Reno; Teaching Associate Professor of Chemical and Biological Engineering/BELS

PAUL OGG, 2007-B.A., Albion College; Ph.D., University of Iowa; Teaching Associate Professor of Chemical and Biological Engineering/BELS

ROSE A. PASS, 2006-A.B, M.A. Boston College; Teaching Associate Professor of Liberal Arts and International Studies

JOHN PERSICHETTI, 1997-B.S., University of Colorado; M.S., Colorado School of Mines; Teaching Associate Professor of Chemical and Biological Engineering

JEFFREY SCHOWALTER, 2009-B.S., M.S., Air Force Institute of Technology; Ph.D., University of Wisconsin, Teaching Associate Professor of Electrical Engineering and Computer Science

CHRISTIAN SHOREY, 2005-B.S., University of Texas at Austin; Ph.D., University of Iowa; Teaching Associate Professor of Geology and Geological Engineering

JOHN STERMOLE, 1988-B.S., University of Denver; M.S., Colorado School of Mines; Teaching Associate Professor of Economics and Business

JENNIFER STRONG, 2009-B.S., M.S., Colorado School of Mines; Teaching Associate Professor of Applied Mathematics and Statistics

SCOTT STRONG, 2003-B.S., M.S., Colorado School of Mines; Teaching Associate Professor of Applied Mathematics and Statistics

CANDACE S. SULZBACH, 1983-B.S., Colorado School of Mines; Teaching Associate Professor of Civil and Environmental Engineering

REBECCA SWANSON, 2012-B.A., Dakota Wesleyan University; M.A., Ph.D., Indiana University; Teaching Associate Professor of Applied Mathematics and Statistics

ROMAN TANKELEVICH, 2003-B.S., M.S., Moscow Physics Engineering Institute; Ph.D., Moscow Energy Institute; Teaching Associate Professor of Electrical Engineering and Computer Science

NATALIE VAN TYNE, 2008-B.S., Rutgers University, M.S., M.B.A., Lehigh University; M.S., Colorado School of Mines; Program Director and Teaching Associate Professor of EPICS

ALEXANDRA WAYLLACE, 2008-B.S., M.S., Colorado School of Mines; Ph.D., University of Missouri-Columbia; Teaching Associate Professor of Civil and Environmental Engineering

## Teaching Assistant Professors

YONG J. BAKOS, 2012-B.A., Northwestern University; M.S., Regis University; Teaching Assistant Professor of Electrical Engineering and Computer Science

JONATHAN H. CULLISON, 2010-B.A., University of South Florida; M.A., University of Denver; Teaching Assistant Professor of Liberal Arts and International Studies

ED A. DEMPSEY, 2007-Electronics Technician Diploma, DeVry Technical Institute; Teaching Assistant Professor of Chemistry and Geochemistry

ANN DOZORETZ, 2004-B.S., University of Denver; M.S., Colorado School of Mines; Teaching Assistant Professor of Economics and Business

PAULA A. FARCA, 2010-B.A., M.A., West University of Timisoara, Romania; M.A., Oklahoma State University; Ph.D., Oklahoma State University; Teaching Assistant Professor of Liberal Arts and International Studies

SARAH J. HITT, 2012-Ph.D., University of Denver; M.A., DePaul University; B.A., MacMurray College; Teaching Assistant Professor of Liberal Arts and International Studies

CORTNEY E. HOLLES, 2010-B.A., Wayne State University; M.A., University of Northern Colorado; Teaching Assistant Professor of Liberal Arts and International Studies

ELIZABETH A. HOLLEY, 2012-B.A., Pomona College; M.S. University of Otago; Ph.D. Colorado School of Mines; Teaching Assistant Professor of Geology and Geological Engineering

MARTIN SPANN, 2006-B.S., National University; Teaching Assistant Professor of EPICS

## Library Faculty

PATRICIA E. ANDERSEN, 2002-Associate Diploma of the Library Association of Australia, Sydney, Australia; Assistant Librarian

CHRISTINE BAKER, 2006-B.A., University of Massachusetts, Amherst; M.L.S., Emporia State University; Assistant Librarian

PAMELA M. BLOME, 2002-B.A., University of Nebraska; M.A.L.S., University of Arizona, Tucson; Assistant Librarian

JULIE CARMEN, 2009-B.A., St. Mary of the Plains College; M.L.S., Emporia State University; Research Librarian

LISA DUNN, 1991-B.S., University of Wisconsin-Superior; M.A., Washington University; M.L.S., Indiana University; Librarian

LAURA A. GUY, 2000-B.A., University of Minnesota; M.L.S., University of Wisconsin; Librarian

JOANNE V. LERUD-HECK, 1989-B.S.G.E., M.S., University of North Dakota; M.A., University of Denver; Librarian and Director of Library

LISA S. NICKUM, 1994-B.A., University of New Mexico; M.S.L.S., University of North Carolina; Associate Librarian

CHRISTOPHER J. J. THIRY, 1995-B.A., M.I.L.S., University of Michigan; Associate Librarian

LIA VELLA, 2011-B.A., University of Rochester; Ph.D., University of Buffalo; M.L.I.S., University of Washington; Assistant Librarian

HEATHER WHITEHEAD, 2001-B.S., University of Alberta; M.L.I.S., University of Western Ontario; Associate Librarian

## Coaches/Athletics Faculty

SATYEN BHAKTA, 2011-B.A., Temple University; Instructor and Assistant Football Coach

STEPHANIE BEGLAY, 2007-B.S., Loras College, M.A., Minnesota State University at Mankato; Assistant Athletics Trainer

BOB BENSON, 2008-B.A., University of Vermont, M.Ed, University of Albany; Instructor and Associate Head Football Coach

ARDEL J. BOES, B.A., St. Ambrose College; M.S., Ph.D., Purdue University; Emeritus Professor of Mathematical and Computer Sciences and Co-Head Cross Country Coach

W. SCOTT CAREY, 2011-B.S., Tarleton State University; M.S., Northeastern State University; Instructor and Assistant Football Coach

CLEMENT GRINSTEAD, 2001-B.A., B.S. Coe College; Instructor and Assistant Football Coach

KRISTIE HAWKINS, 2010-B.S., University of Maine; Instructor and Head Softball Coach

JOHN HOWARD, 2005-B.S., M.S., Western Illinois University; Director of Intramural and Club Sports

JOSHUA HUTCHENS, 2007-B.S. Purdue, M.S. James Madison; Instructor and Co-Head Wrestling Coach

GREGORY JENSEN, 2000-B.S., M.S., Colorado State University; Instructor and Assistant Trainer

TYLER KIMBLE, 2007-B.S., Colorado State University; Instructor and Head Golf Coach

FRANK KOHLENSTEIN, 1998-B.S., Florida State University; M.S., Montana State University; Instructor and Head Soccer Coach

PAULA KRUEGER, 2003-B.S, M.S., Northern State University Head Women's Basketball Coach

ADAM LONG, 2010-B.S., M.S., Northwest Missouri State University; Instructor and Assistant Football Coach

JENNIFER MCINTOSH, 1996-B.S., Russell Sage College, M.S., Chapman University; Head Athletic Trainer

GREG MULHOLLAND, 2007-B.S., Millersville University, M.S., University of Colorado at Denver; Instructor and Assistant Men's Soccer Coach

JERRID OATES, 2004-B.S., Nebraska Wesleyan University, M.S., Fort Hayes State University; Instructor and Head Baseball Coach

PRYOR ORSER, 2002- B.S., M.A., Montana State University; Instructor and Head Men's Basketball Coach

HEATHER ROBERTS, 2008- B.S., William Woods University, M.S., Bemidji State University; Instructor and Assistant Volleyball Coach

NATHAN ROTHMAN, 2008-B.A., University of Colorado; Instructor and Head Swimming and Diving Coach

BRAD J. SCHICK, 2007-B.A., University of Northern Colorado; M.S. University of Nebraska at Omaha; Instructor and Assistant Men's Basketball Coach

ARTHUR SIEMERS, 2004-B.S., Illinois State University-Normal, M.S., University of Colorado-Boulder, Instructor and Head Track and Field and Cross Country Coach

BRITTNEY SIMPSON, 2008-B.S., Mesa State College, M.B.A., University of Colorado at Colorado Springs; Instructor and Assistant Women's Basketball Coach

JAMIE L. SKADELAND, 2007-B.S., University of North Dakota, M.A., Minnesota State University at Mankato; Head Volleyball Coach

ROBERT A. STITT, 2000- B.A., Doane College; M.A., University of Northern Colorado; Head Football Coach

NOLAN SWETT, 2010-B.A., Colorado College, Instructor and Assistant Football Coach

ROB THOMPSON, 2004-B.A., Bowling Green State University, M.A., Bowling Green State University; Instructor and Director of the Outdoor Recreation Center

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