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# Colorado School of Mines Bulletin

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## 2016-2017

### Mission, Vision and Values

Colorado statutes define the role of the Colorado School of Mines 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).*

The Board of Trustees of the Colorado School of Mines has elaborated on this statutory role with the following statement of the School's mission, vision and values.

### Mission

***Education and research in engineering and science to solve the world's challenges related to the earth, energy and the environment***

- Colorado School of Mines educates students and creates knowledge to address the needs and aspirations of the world's growing population.
- Mines embraces engineering, the sciences, and associated fields related to the discovery and recovery of the Earth's resources, the conversion of resources to materials and energy, development of advanced processes and products, fundamental knowledge and technologies that support the physical and biological sciences, and the economic, social and environmental systems necessary for a sustainable global society.
- Mines empowers, and holds accountable, its faculty, students, and staff to achieve excellence in its academic programs, its research, and in its application of knowledge for the development of technology.

### Vision

***Mines will be the premier institution, based on the impact of its graduates and research programs, in engineering and science relating to the earth, energy and the environment***

- Colorado School of Mines is a world-renowned institution that continually enhances its leadership in educational and research programs that serve constituencies throughout Colorado, the nation, and the world.
- Mines is widely acclaimed as an educational institution focused on stewardship of the earth, development of materials, overcoming the earth's energy challenges, and fostering environmentally sound and sustainable solutions.

### Values

***A student-centered institution focused on education that promotes collaboration, integrity, perseverance, creativity, life-long learning, and a responsibility for developing a better world***

- The Mines student graduates with a strong sense of integrity, intellectual curiosity, demonstrated ability to get a job done in collaborative environments, passion to achieve goals, and an enhanced sense of responsibility to promote positive change in the world.
- Mines is committed to providing a quality experience for students, faculty, and staff through student programs, excellence in pedagogy and research, and an engaged and supportive campus community.
- Mines actively promotes ethical and responsible behaviors as a part of all aspects of campus life.

*(Colorado School of Mines Board of Trustees, 2013)*

# Undergraduate

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## 2016-2017

To Mines Students:

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

Published by Colorado School of Mines. 1500 Illinois Street, Golden, CO 80401.

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

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

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

*Student Life:* Dan Fox, Vice President of Student Life

*Financial Aid:* Jill Robertson, Director of Financial Aid, [finaid@mines.edu](mailto:finaid@mines.edu)

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

*Academic Affairs:* Tom Boyd, Interim Provost

# Academic Calendar

## Fall Semester 2016

Description	Date(s)	Day(s) of Week
Confirmation Deadline	Aug. 19	Friday
Faculty Conference	Aug. 19	Friday
Classes Start (1)	Aug. 22	Monday
Graduate Student Registration Deadline - Late Fee Applied After this Date	Aug. 26	Friday
Labor Day - Campus Closed	Sep. 5	Monday
Census Day	Sep. 6	Tuesday
Fall Break (not always Columbus Day)	Oct. 17 & 18	Monday & Tuesday
Midterm Grades Due	Oct. 17	Monday
Last Withdrawal - Continuing Students (12 wks)	Nov. 11	Friday
Priority Registration for Spring Term	Nov. 14-18	Monday - Friday
Non-Class Day prior to Thanksgiving Break	Nov. 23	Wednesday
Thanksgiving Break - Campus Closed	Nov. 24-25	Thursday & Friday
Last Withdrawal - New Freshmen & Transfers	Dec. 2	Friday
Classes End	Dec. 8	Thursday
Dead Week - no exams	Dec. 5-9	Monday - Friday
Dead Day - no academic activities	Dec. 9	Friday
Final Exams	Dec. 10, 12-15	Saturday, Monday - Thursday
Semester Ends	Dec. 16	Friday
Commencement	Dec. 16	Friday
Final Grades Due	Dec. 19	Monday
Winter Break	Dec. 19 - Jan 10	

## Spring Semester 2017

Description	Date(s)	Day(s) of Week
Confirmation Deadline	Jan. 9	Monday
Classes Start (1)	Jan. 10	Tuesday
Graduate Student Registration Deadline - Late Fee Applied After this Date	Jan. 13	Friday
Martin Luther King Day - Campus Closed	Jan. 16	Monday
Census Day	Jan. 25	Wednesday
Non-Class Day - President's Day (2 days)	Feb. 20-21	Monday-Tuesday
Midterm Grades Due	Mar. 6	Monday
Spring Break	Mar. 27-31	Saturday - Sunday
Priority Registration Summer/Fall	April 3-7	Monday - Friday

Last Withdrawal - Continuing April 12 & Grad (13 weeks)		Wednesday
E-Days	April 13-16	Thursday - Saturday
Last Withdrawal - New Freshmen & Transfers	April 28	Friday
Classes End	May 4	Thursday
Dead Week - No Exams	May 1-5	Monday - Friday
Dead Day - No Academic Activities	May 5	Friday
Final Exams	May 6, 8-11	Saturday, Monday - Thursday
Semester Ends	May 12	Friday
Commencement	May 12	Friday
Final Grades Due	May 15	Monday

## Summer Sessions 2017

Description	Date(s)	Day(s) of Week
Summer I Starts (6-week session) (1)	May 15	Monday
Summer I Census	May 19	Friday
Memorial Day - No Classes, Campus Closed	May 29	Monday
Summer I Last Withdrawal - All Students	June 9	Friday
Summer I Ends	June 23	Friday
Summer I Grades Due	June 26	Monday
Summer II Starts (6-week session) (1)	June 26	Monday
Summer II Census	June 30	Friday
Independence Day - No Classes, Campus Closed	July 4	Tuesday
Summer II Last Withdrawal - All Students	July 21	Friday
Summer II Ends (2)	Aug. 4	Friday
Summer II Grades Due	Aug. 7	Monday
Summer Grades Available on Transcript	Aug. 23	Wednesday

<sup>1</sup> Petitions for changes in tuition classification due in the Registrar's Office for this term.

<sup>2</sup> PHGN courses end two weeks later on Thursday, August 17th.

# Welcome

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2016-2017

## 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 Applied Mathematics & Statistics, Chemical Engineering, Chemical & Biochemical Engineering, Chemistry, Civil Engineering, Computer Science, Economics, Electrical Engineering, Engineering Physics, Environmental Engineering, Geological Engineering, Geophysical Engineering, Mechanical Engineering, Metallurgical and Materials 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.

Colorado School of Mines is a public research university devoted to engineering and applied science. It has the highest admission standards of any public university in Colorado and among the highest of any public university in the United States.

## 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, Civil Engineering, Electrical Engineering, Engineering, Engineering Physics, Environmental Engineering, Geological Engineering, Geophysical Engineering, Mechanical 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:

Katie Ludwin, Coordinator of Student Disability Services  
Student Wellness Center, 1770 Elm Street  
Golden, Colorado 80401  
(Telephone: 303.273.3377)

The Title IX Coordinator is:

Karin Ranta-Curran, Assistant Director of HR for EEO and Equity  
Guggenheim Hall, Room 110  
Golden, CO 80401  
(Telephone: 303.384.2558)  
(E-Mail: krcurran@mines.edu)

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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## 2016-2017

### Facilities

#### Student Center

The Ben H. Parker Student Center contains the offices for the Vice President of Student Life, Dean of Students, Student Activities and Greek Life, Student Government (USG and GSG), Financial Aid, Bursar and Cashier, International Office, Career Center, Graduate Studies, Registrar, Campus Events, and student organizations. The Student Center also contains The Periodic Table 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 several health and wellness programs for Mines students: the Coulter Student Health Center, the Student Health Benefits Plan, the Counseling Center, the Dental Clinic 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. Check the website for summer and holiday hours.

**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. 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 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 limited hours during the summer. Services are by appointment only and can be made by calling the Dental Clinic - 303-273-3377. Dental care is on a fee-for-service basis. 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.*

**Immunization Requirement:** *The State of Colorado requires that all students enrolled have proof of two MMRs (measles, mumps and rubella). A blood test showing immunity to all three diseases is acceptable. History of disease is not acceptable. Proof of a Meningococcal vaccine given within the past five years is required of all students living in campus housing. Exemptions to these requirements may be honored with proper documentation.*

**Student Health Insurance Plan:** *The SHIP 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 coverage under a personal or employer plan that meets minimum requirements. International students must purchase the SHIP, unless they meet specific requirements. Information about the Mines Student Health Benefits Plan, as well as the criteria for waiving, is available online at <http://studentinsurance.mines.edu> or by calling 303.273.3388. Enrollment confirmation or waiver of the Mines 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 to submit a waiver is Census Day.*

**Counseling Center:** *Located on the second floor of the W. Lloyd Wright Student Wellness Center, phone 303-273-3377. Individual personal, academic, and career counseling is offered on a short-term basis to all enrolled CSM students who have paid the Student Services fee. 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.

Students are encouraged to utilize the CASA Peer Advisors. Students may walk-in and speak with a fellow student on various issues pertaining to course registration, course enrollment, majors, and minors.

The Registrar's Office creates the first-semester schedule for incoming transfer students. CASA advises undecided transfer students during their first year who have successfully completed 30.0 or more semester hours.

**CSM101:** The First-Year Symposium, CSM101, 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 45 professional staff members (including faculty) and 90 Peer Mentor students.

Transfer students who have successfully completed fewer than 30.0 transcribed semester hours at an institution of higher education after high school graduation will automatically be enrolled in the First-Year Advising and Mentoring Program in their first semester at CSM.

**Tutoring Services:** CASA offers weekly tutoring services for all core-curriculum courses. Our services run Sunday through Thursday and are hosted in CASA and the Library. There is more information about tutoring services available via our website at <http://casa.mines.edu>.

**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.

**Core Supplemental Instruction (CSI):** First-Year students are encouraged to attend our CSI 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 and Additional Services:** In addition to the aforementioned services, CASA offers assistance with readmission to the institution, intensive academic support programs, and specialized courses in spatial modeling and visualization.

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;
- Company research 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 Office)

All new students must have a Blaster Card made as soon as possible after they enroll. The Blaster Card office also issues RTD College Passes, which allows students to ride RTD buses and light rail free of charge (or for a reduced fee for airport bus service). Students can replace lost, stolen, or damaged Blaster Cards for a small fee.

The Blaster Card can be used for student meal plans, to check material out of the CSM Library, to access certain electronic doors, and may be required to attend various CSM campus activities.

## 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. A Board of Student Publications acts in an advisory capacity to the publications staffs and makes recommendations on matters of policy.

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.

## Veterans Services

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

## 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

**The Associated Students of Colorado School of Mines (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. Undergraduate Student Government (USG) and Graduate Student Government (GSG) are the governing bodies recognized by CSM through ASCSM as the representative voice of their respective student bodies. The goal of these groups is to improve the quality of education and offer social programming and academic support.

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 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

**Engineering 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 a concert.

**Homecoming** weekend is one of the high points of the year. Events include a football rally and game, campus decorations, election of Homecoming queen and beast, 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.

## Outdoor Recreation Program

The Outdoor Recreation Program is housed at the Student Recreation 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.

## 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 residence hall floor. Officers are elected each fall for that academic year. For more information, go to RHA (<http://inside.mines.edu/RSL-Residence-Hall-Association>).

## Student Organizations

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

**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. 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.

# International Student Services

## 2016/2017

The International Student & Scholar Services Office (ISSS) serves approximately 800 international students from 75 countries who attend Mines.

The ISSS 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 training
- Provide forms required by international students and their dependents to travel outside the US
- Process legal documents required for the admission of all international students (including undergraduate, graduate, special, exchange, and visiting students)
- Organize orientation programs for entering international undergraduate, graduate and exchange students
- Advise various international student groups, such as International Student Council, Indonesian Student Association, Kuwait Student Association and others
- Provide key pre-departure and arrival information for incoming students, their dependents and scholars.

The ISSS also sponsors events and programs to help students adjust to life in the US and at Mines, and provides counseling related to emergencies and unexpected immigration problems.

If you have questions about international student admissions, degree programs, billing, financial aid, or housing, please visit those specific CSM web pages. Please send other questions and comments about international student life at CSM to [bsamter@mines.edu](mailto:bsamter@mines.edu).

For more information see [www.issm.mines.edu](http://www.issm.mines.edu)

## Multicultural Engineering Program

### 2016-2017

#### Multicultural Engineering Program

The Multicultural Engineering Program (MEP) is located at 1400 Maple Street. MEP provides support that contributes to the recruitment, retention and graduation of historically under-represented students. MEP offers academic support, leadership opportunities, and professional development through programming, tutoring, community outreach, and cultural and social activities.

Working through student professional societies-American Indian Science and Engineering Society (AISES), National Society of Black Engineers (NSBE), Out in Science, Technology, Engineering and Mathematics (oSTEM), Society of Asian Scientists and Engineers (SASE), and the Society of Hispanic Professional Engineers (SHPE), the Multicultural Engineering Program is a center for student, faculty and staff support, and a place for students to become a community of scholars with common goals and objectives in a welcoming learning environment.

**American Indian Science and Engineering Society (AISES)** is a non-profit national organization that represents American Indians and Alaskan Natives in engineering, science, and other related technology disciplines. The mission of AISES is to substantially increase the representation of American Indians and Alaskan Natives in engineering, science, and other related technology disciplines. Through the quality and reach of its programs and the longevity and devoted commitment of its "family," AISES is the undisputed leader in STEM opportunity in Indian Country. Members from over 200 tribal nations are represented within AISES, and AISES enjoys the support and partnership of corporate, government, academic, and tribal decision-makers.

**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."

**Out in Science, Engineering, Technology & Mathematics (oSTEM)** is a national society dedicated to educating and fostering leadership for LGBTQA communities in the STEM fields. Originally established at Mines in 1997, and formally Sigma Lambda.

**Society of Asian Scientists and Engineers (SASE)** The Colorado School of Mines student chapter of the Society of Asian Scientists and Engineers is dedicated to the enhancement of Asian Pacific Americans in the engineering and scientific community. We strive to develop leaders who are educated in issues facing both Asian and non-Asian communities and promote the academic and professional success of our members. Our goal is to erase ignorance and maintain equality through empowerment and positive community impact.

**Society of Hispanic Professional Engineers (SHPE)** is a non-profit organization that exists for the advancement of Hispanic engineering 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. The SHPE organization is governed by a National Board of Directors which includes representatives from all regions including two student representatives.

For further information, contact:

Andrea Salazar Morgan, Director, Multicultural Engineering Program  
Colorado School of Mines  
1400 Maple Street  
Golden, CO 80401  
Phone: (303)273-3021  
[asalazar@mines.edu](mailto:asalazar@mines.edu)

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

### 2016/2017

The Office of International Programs (OIP) fosters and facilitates international education, research and outreach at CSM. OIP is administered by the Office of Academic Affairs.

OIP also advises students interested in applying for one or more of the nationally competitive scholarships, such as Rhodes, Marshall, Churchill, Fulbright, or Mitchell and will work with individual students to prepare competitive application packages.

OIP is located in the Ben Parker Student Center, Suite E110. For more specific information about study abroad and other international programs, contact OIP at 303 384-2121 or visit the OIP web page (<http://OIP.mines.edu>).

The office works with the departments and divisions of the School to:

1. Help develop and facilitate study abroad opportunities for CSM students while serving as an informational and advising resource for them;
2. Assist in attracting new international students to CSM;
3. Serve as a resource for faculty and scholars of the CSM community, promoting faculty exchanges, faculty-developed overseas learning opportunities, and the pursuit of collaborative international research activities;
4. Foster international outreach and technology transfer programs;
5. Facilitate arrangements for official international visitors to CSM; and
6. In general, helps promote the internationalization of CSM's curricular programs and activities.

OIP promotes and coordinates the submission of Fulbright, Rhodes, Churchill, Goldwater, Morris K. Udall and Marshall Scholarship programs on campus.

<http://inside.mines.edu/OIP-home>

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

2016-2017

The WISEM office in the Office of Diversity and Inclusion is located at 1710 Illinois Street. 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 and services for the CSM community regarding gender and equity issues, and produces the Chevron Lecture Series.

For further information, contact:

Stephanie Berry  
Director of the Women in Science, Engineering and Mathematics  
Program  
Colorado School of Mines  
1710 Illinois Street  
Golden, CO 80401-1869  
Phone (303) 273-3146  
E-Mail [stberry@mines.edu](mailto:stberry@mines.edu)

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

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## 2016-2017

Tuition and fees are established by the Board of Trustees of 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 2016-2017 academic year will be available prior to the start of the 2016-2017 academic year and can be found at: <https://inside.mines.edu/UserFiles/File/finance/budget/FY15/FY15%20Tuition%20Schedule.pdf>.

## Fees

The official fees, approved charges, and fee descriptions for the 2016-2017 academic year will be available prior to the start of the 2016-2017 academic year.

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

## Housing & Dining Rates

Room and board charges are established by the Board of Trustees 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 2016-2017 Academic Year. For more information, go to Student Housing ([http://inside.mines.edu/Student\\_Housing](http://inside.mines.edu/Student_Housing)) or Mines Dining (<http://inside.mines.edu/CampusDining>).

## 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  
1200 16th Street 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.

## Late Fee for Application to Graduate after Stated Deadlines - \$250 Beginning Fall 2016

### Undergraduates:

The deadline to apply to graduate and participate in commencement is the first day of class of the term in which the student intends to graduate/participate.

Any request to be added to the graduation list and/or commencement ceremony after the first day of class (and before November 10<sup>th</sup> for fall or April 10<sup>th</sup> for spring and summer) may be made in writing and will be considered by the Registrar's Office. If the request is denied, the student will be required to apply for the next available graduation/ ceremony. If the request is approved and all other conditions are met (i.e. degree requirements can be met, required forms are turned in, and outstanding hours limitations are not exceeded), a mandatory \$250 fee will be applied to the student's account. This fee cannot be waived and cannot be refunded if the student does not meet the graduation check-out deadlines.

For late requests that are approved, tickets to the commencement ceremony for family and friends of the graduate are not guaranteed, as they may have already been distributed or assigned. Additionally, the student's name may not appear in the commencement program due to publishing deadlines.

No undergraduate student will be added to a graduation or commencement when the request is made after November 10<sup>th</sup> for the fall commencement (which includes December graduation), or April 10<sup>th</sup> for the spring and summer commencement ceremony (which includes May and August graduations).

## 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/>

# Financial Aid and Scholarships

## 2016/2017

### 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 \$42.8 million in total assistance in 2014-2015, including over \$25.2 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 freshmen students are made on the basis of their high school GPA and SAT or ACT composite test scores. New transfer students who are seeking their first degree may be eligible for a merit award if they belong to Phi Theta Kappa. 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 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. 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 in the Student Center, 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.

## Residence Halls

### Residence Halls (Yearly Rate)

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

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

Room Type	Rate
Double/Triple Room	\$5,362
Single Room	\$6,668
Temporary Triple	\$4,288

#### Weaver Towers/ Maple / Elm Halls

Room Type	Rate
Double Room	\$6,554
Single Room	\$7,570
Temporary Triple	\$5,244

#### Campus-Owned Fraternity & Sorority Houses

Fraternity/Sorority House	Rate
Alpha Phi Sorority	\$5,730
Fiji Fraternity	\$5,730
Pi Phi Sorority	\$5,730
Sigma Kappa Sorority	\$5,730
All CSM-owned Fraternity and Sorority Houses - Summer	\$90 / week

### Meal Plans

() indicates commuter meal plans available:

Meal Plan	Rate
Marble (Gold): Unlimited meals in Slate Cafe + \$100 Munch Money per semester	\$2,618 per semester
Quartz (Blue): 14 meals/week + \$200 Munch Money per semester	\$2,556 per semester
Granite (Bronze): 160 meals/semester + \$250 Munch Money per semester	\$2,401 per semester
Agate (commuter only): 30 meals per plan at Mines Market. Meals roll over from Fall to Spring semester. \$120 in Munch Money per plan. Munch Money ends at the end of each semester and does not carry over to the next semester. You may purchase multiple Agate plans throughout the semester.	\$290 per block purchased

### Summer Session Residence Hall Housing (Weekly Rate)

Room Type	Rate
Double Room	\$90/Week
Single Room	\$140/week

## Apartment Housing (Monthly Rate)

### Family Housing at Mines Park

Rates includes \$2 per month Community Development fee per resident

# of Bedrooms	Rate
1 Bedroom	\$913
2 Bedroom	\$1000

### Single Student Apartments at Mines Park

Rates includes \$2 per month Community Development fee per resident

# of Bedrooms	Rate
1 Bedroom	\$913
2 Bedroom	\$1,200
3 Bedroom	\$1,644

\* Mines Park resident pays gas and electric utilities. CSM provides free wireless and wired internet, basic expanded cable, water, sewer, public electric, unlimited laundry, and Mines Park parking permit.

## Housing Application

Information and application for residence hall space is included in the packet offering admission to the student. Colorado School of Mines has a First Year Residency Requirement (<http://inside.mines.edu/UserFiles/File/studentLife/ResidenceLife/First-year%20residency%20requirement.pdf>). All housing assignments are based on the date of the enrollment deposit with Admissions.

After the first year, upperclass students may apply for the limited number of spots on the upperclass/transfer student floors in the residence halls. Residence Life encourages upperclass students to apply for the residence halls (<http://inside.mines.edu/RSL-Residence-Halls>) along with the Apartments at Mines Park (<http://inside.mines.edu/Apartments-at-Mines-Park>). Additionally, students associated with Greek Housing may apply for housing through Residence Life in partnership with Greek Life(Student Activities). The submission of a room application for all housing areas can be done in Trailhead (<https://trailhead.mines.edu/cp/home/displaylogin>).

Contracts are issued for the full academic year and no cancellation will be accepted after an agreement has been done, 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.

## 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. The Petition for In-State Tuition Classification can be found on the Registrar's Office website (<http://inside.mines.edu/Petitioning-for-In-State-Tuition-Classification>).

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.

# Housing & Dining

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## 2016-2017

### 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 community style 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. Elm Hall is a neighborhood style facility offering space for 205 students in single and double bedrooms with community bathrooms that offer private options on each floor. Located across the street from Maple Hall, Elm Hall offers four social lounges, three study rooms, courtesy phones on each floor, creativity and design workshop, community kitchen and laundry rooms on each floor, central social lounge, and rent-able indoor bike and storage units.

All residence hall spaces are equipped with a bed, desk, chair, dresser and closet for each student, as well as wired and wireless internet connections. Television services are 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 learning community that is a partnership between Residence Life, administrative departments, and faculty across campus. Theme Learning Communities 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 Adventure Leadership Community (Outdoor Recreation), Oredigger Leadership Community, Visual and Performing Arts, Athleticism and Wellness, Nucleus Scholars, First Year Honors Experience, and Engineering Grand Challenges. For more information, please see the Theme Learning Community Webpage (<http://inside.mines.edu/RSL-Theme-Housing>).

For all Housing & Dining rates, please see the Housing Rates (<http://inside.mines.edu/RSL-Room-Board-Rates>) page.

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

Mines Dining operates a main dining hall and four retail dining facilities on campus. Mines Market features all-you-care-to-eat dining, adjacent to

Elm Hall. Additional retail dining facilities, including The Periodic Table (featuring Starbucks, WOW Café, and Habañeros) in the Student Center, Subway in the Student Recreation Center, coffee shop in Brown Hall, and Einstein Bros. Bagels in CTLM take student meal plans, as well as cash or credit card. Residence hall students are required to maintain a resident meal plan. Students not living in a residence hall may purchase any one of several commuter meal plans which best meets their individual needs. Dining options are limited during breaks (Thanksgiving, Fall, Winter and Spring Break). For more information and hours, go to Mines Dining (<http://inside.mines.edu/CampusDining>).

For rates, please see the Residential Meal Plans (<https://minesdining.sodexomyway.com/dining-plans>) page.

### 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. Residents must be full-time students. Additionally, residents are provided with student and professional staff that live within the community for any assistance, advice, support, and community building.

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://inside.mines.edu/Apartments-at-Mines-Park>). Additionally, the Apartment Housing office is located within Community Center 2 for any additional assistance you may need.

For all Housing & Dining rates, please see the Housing Rates (<http://inside.mines.edu/RSL-Room-Board-Rates>) page.

### 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>).

### Off-Campus Housing

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

# Undergraduate Information

## 2016-2017

### 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 seeks to admit a diverse and dynamic student population representative of the state of Colorado, the nation and beyond. CSM 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 our confidence in one's 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 generally is the academic record and rigor in high school or college.

The admission requirements below are minimum requirements for consideration and may change after a catalog has been finalized. Admission is competitive and not guaranteed. 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

Admission is competitive. The minimum requirements for admission consideration 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
<b>Total Semester Hrs</b>	<b>17.0</b>

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 by consulting with one's high school counselor, or by contacting:

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) (<http://www.collegeboard.com>) (SAT) and [www.act.org](http://www.act.org) (<http://www.act.org>) (ACT).

### Transfer Students

Admission is competitive. 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 requirements for admission consideration 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 must have an overall, cumulative college grade point average of 2.75 or better. Students presenting a lower GPA will be given careful consideration and acted on individually.

- An applicant who cannot re-enroll at the institution from which he or she wishes to transfer, or from any previously attended institution because of scholastic record or other reason will be evaluated on a case-by-case basis.
- Completed or "in progress" college courses which meet CSM graduation requirements are eligible for transfer credit if the institution is regionally accredited, and the course is not remedial or vocational, and the grade earned is a "C" or better. For more information see: <http://bulletin.mines.edu/undergraduate/undergraduateinformation/academicregulations/>

## Former Students

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

- Any student who has attended another college or university since last enrolling at CSM must re-apply for admission through the Admissions Office.
- 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.
- 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. Admission is competitive. 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 \$50 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:

- 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

- An IELTS (International English Language Testing System) Score of 6.5, with no band below a 6.0.
- Pearson Test of English/PTE Academic: Minimum overall score of 53 with no communicative skills score below 50.
- Transferable credit from an accredited US institution of higher education equivalent to 30 credits or more including 6 credits of freshman English composition at a U.S. college or university with a cumulative GPA of 3.0 or higher.

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:

- Credit is granted based upon recommendation by recognized academic publications, primarily provided by the American Association of Collegiate Registrars and Admissions Officers.
- Courses are evaluated by a comparable credit-granting department at Colorado School of Mines.

## Enrollment Requirement - English Language

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.

## Enrollment Requirement - All Admitted Students

All admissions are ultimately contingent upon successful completion and submission of final transcripts reflecting academic achievement similar to assessment at the time of admission. Students are expected to continue to prepare at a similar level of academic rigor, and with similar or better results as the enrollment date approaches. If final transcripts/documents are received that reflect information different from the admission assessment, Colorado School of Mines reserves the right to review the admission offer again, and to take appropriate action. This may include a change in conditions or terms of admission, or a rescission of the admission offer.

## **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 Associate Vice President of Enrollment Management and/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 Associate Vice President of Enrollment Management. A maximum of 12 hours of nondegree credit from Colorado School of Mines may be used toward an undergraduate degree program. A nondegree student who has completed a Bachelor degree or higher, regardless of course level in which one wishes to enroll, must utilize the graduate nondegree process. Courses completed as a non-degree student at the undergraduate level will be included in the overall undergraduate grade point average.

# Academic Regulations

## 2016-2017

### 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

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 or if the institution is international, credit is only considered from institutions that are recognized by the Ministry of Education or other official accrediting or recognition body in the country of origin. Credits must be academic in nature. Military, Vocational, CLEP, DSST, and theological credit is not accepted. No credit is granted for internships, co-ops, practicums, life experience courses, Independent Study, precalculus courses below Calculus I such as trigonometry and geometry, and non-calculus based general/introductory Physics courses.

Only courses completed with grades of "C" or better will be considered for acceptance. Credit that is recorded as "pass" "satisfactory" or "credit" at institutions that do not equate this classification to a C or better grade will not transfer.

Departments may stipulate a higher minimum grade.

### Credit Conversion

Quarter credits are converted to semester credits upon transfer. This is done by multiplying the quarter credits by 0.67 (i.e. 4 quarter credits x 0.67 = 2.6 semester credits).

European Credit Transfer and Accumulation System (ECTS) credits are converted to semester credits by multiplying ECTS credits by 0.5 (i.e. 2 ECTS x 0.5 = 1 semester credit),

Other international credits are converted to the U.S. semester based system according to national standards set by AACRAO International Education Services.

### 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. When an articulation agreement does not exist with another institution, the transfer student may receive credit for a course taken at another institution upon receipt of a certified copy of the student's official transcript from the host institution, subject to review by the appropriate CSM department head or designate to ensure course equivalency. Course materials, such as syllabi, exams, and notes may be requested for evaluation. Credits earned more than 10 years in advance of admission will not transfer.

### 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/major. 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 (<http://inside.mines.edu/Transfer-Credit-Approvals>), 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/major, and the Registrar.

### Prior Learning Credit

Colorado school of Mines makes no promises to prospective students regarding the acceptance of credit awarded by examination, credit for prior learning, or credit for transfer until these credits have been evaluated for applicability to a degree program. If prior learning credits are approved by Mines, up to a maximum of 56.0 semester hours of prior learning credit may be applied to an undergraduate degree based on course applicability for that degree.

### Advanced Placement (AP) and International Baccalaureate (IB)

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 a 5, 4, or 3 depending on the exam. See <http://inside.mines.edu/Advanced-Placement-Credit> for specific information.

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 in a 4, 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 <http://inside.mines.edu/International-Baccalaureate-Credit>.

### Challenge Exams

Qualified students may complete challenge exams to test out of and receive credit for the following foundational Core courses at Mines.



Faculty in each department determine a student's eligibility for sitting for the exams and communicate eligibility requirements to the Registrar for the purposes of communication with the new incoming eligible students.

CBEN110	FUNDAMENTALS OF BIOLOGY I	4.0
CHGN121	PRINCIPLES OF CHEMISTRY I	4.0
CSCI101	INTRODUCTION TO COMPUTER SCIENCE	3.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0
PHGN100	PHYSICS I - MECHANICS	4.5
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	4.5

Incoming students in their first two semesters at CSM may be eligible for challenge exams based on AP scores or other factors as determined by the department offering the exam.

Challenge exams are provided at the department's option and discretion.

Departments are not required to provide exams for all introductory and foundational Core courses.

Students must pass the challenge exam with the equivalent of a "C" grade or better as determined by the department in order to earn credit for the course. Passed exams are recorded as CSM transfer credit with a grade of "T". Challenge exams do not affect the student's grade point average at CSM.

Departments provide information about students who have passed exams to the Registrar's Office prior to Census Day in order to make necessary adjustments to the student's schedule.

Challenge exam credit may not be awarded if it is a repeat of already earned college-level credit.

Students will not be charged tuition but CSM reserves the right to charge an administrative fee to take an exam. No fees are required at this time.

Additional details about these exams can be found on the relevant department's website.

## Military and EPICs

Students with experience in the military who have a DD214 showing a general or honorable discharge will receive a total of two credit hours in PAGN101, PAGN102, and two semesters of PAGN2XX. This will complete the Physical Activity requirements for the undergraduate degree.

Credit will not be granted for College Level General Educational Development (GED) Tests, United States Armed Forces Institute (USAFI) courses, American Council on Education (ACE) recommendations, or courses completed at any United States armed services, with the exception of the military academies and schools with full accreditation by a regional accrediting body. No credit is granted for technical or military programs earned through the Community College of the Air Force or for any course listed on the Joint Service Transcript (JST).

Students who have technical experience outside of the classroom may be eligible to substitute a different technical elective course in place of EPIC251. In order to pursue this course of action, the student must provide information and materials describing the experience and how it applies to the program to the EPICs program director. If approved, the

student will complete the substitution form and turn it in to the Registrar's Office to be placed in the academic file.

## 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 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 signed 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 signature) 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.

## 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 (<http://inside.mines.edu/Independent-Study-Registration>) 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 (<http://oip.mines.edu>) 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 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 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 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 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 Dean of Students within one week of returning to class. Once documentation has been received and approved, the 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 through the Center for Academic Services & Advising (CASA). 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.

# Admissions Procedures

## 2016/2017

### 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 e-mail: [admit@mines.edu](mailto:admit@mines.edu); or via postal mail:

Admissions Office  
Colorado School of Mines  
1812 Illinois 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 early 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. Freshman admission is competitive. Applicants who are admitted are 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 Registrar's 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 articulation agreements with Red Rocks Community College (RRCC), Front Range Community College (FRCC), Community College of Denver (CCD), Community College of Aurora (CCA), and Arapahoe Community College. Students are encouraged to review the articulation information at <http://inside.mines.edu/Transfer-Student-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 semester of attendance at his or her present college. The application will be evaluated upon receipt of the completed application form and application fee, official final high school transcript (or GED), 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, official transcript(s).

### Advanced Placement, International Baccalaureate, and A-Levels

Course work completed for select subjects under the **Advanced Placement** Program in high school may be accepted for college credit provided that the Advanced Placement Program Test grade meets currently evaluated outcomes. Advanced Placement credit is evaluated by Mines faculty every two years and credit will be transferred upon receipt of official test scores. See current Advanced Placement test score requirements for transfer credit at: [http://inside.mines.edu/advanced\\_credit](http://inside.mines.edu/advanced_credit).

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 meets currently evaluated outcomes. International Baccalaureate credit is evaluated by Mines faculty every two years and credit will be transferred upon receipt of official exam scores. In some cases, departmental approval is required before credit is granted. See current International Baccalaureate exam score requirements for transfer credit at: [http://inside.mines.edu/advanced\\_credit](http://inside.mines.edu/advanced_credit).

Course work completed for select subjects within the **UK system (A or AS Exam)**: A-Levels may be accepted for college credit provided the final grade meets currently evaluated outcomes. Generally, Advanced Levels (A-Levels) are reviewed on a course by course basis. However, some exams have been approved for the coming two years starting in the fall of 2016. See current A-Levels exam score requirements for transfer credit at: [http://inside.mines.edu/advanced\\_credit](http://inside.mines.edu/advanced_credit).

### 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. Undergraduate students must register for and maintain 12.0 credit hours, and graduate students must register for and maintain 9.0 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 underpayment 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 undergraduate degree requirement at CSM. Additionally, veterans may request substitution of a technical elective for the institution's core EPICS course requirement in all undergraduate degree programs.

For more information, please visit the Veterans Services (<http://inside.mines.edu/Veterans-Services>) web page.

# 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 ([bulletin.mines.edu/graduate/generalregulations/academicperformance](http://bulletin.mines.edu/graduate/generalregulations/academicperformance)) 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.

# Core Requirements

## Core Curriculum

The Core Curriculum at Mines forms the foundation for advanced study in the major fields. It is designed to give students the fundamental knowledge and skills they will need and put to use in their majors and in careers after graduation. Core courses provide students with fundamental technical, mathematical, and writing skills. In Core courses, students learn basic scientific procedures, principles, concepts, laws, and theories relevant to all applied sciences. In addition, Core courses in the humanities and social sciences help students develop interdisciplinary perspectives on the ethical, social, and cultural contexts within which engineering takes place.

The variety of courses in the Core Curriculum also provide students with opportunities to develop skills in problem solving, critical thinking, teamwork, design, and communication. Students who complete the Core are well prepared to be lifelong learners and leaders who can work effectively in an increasingly globalized world.

The Core Curriculum has three parts, the details of which can be found below. All CSM students complete the courses in the Common Core. Courses required in the Science Requirement and Engineering Requirement vary according to the major field of study. Finally, all students have a number of Free Elective courses. Free Electives are usually taken in the last two years.

Refer to the Degree Requirements section for each major program under Undergraduate Programs and Departments ([bulletin.mines.edu/undergraduate/programs](http://bulletin.mines.edu/undergraduate/programs)) for a listing of Core courses students should take each semester.

## Overview: Core Course Requirements

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

1. **Core Curriculum** - Students in all degree programs are required to complete all course requirements listed in this group.
2. **Humanities and Social Sciences Requirement** - Students in all degree programs are required to complete all course requirements listed in this group.
3. **Science Requirement** - Students in all degree programs are required to complete a minimum of three courses as prescribed by the specific degree program.
4. **Engineering Requirement** - Engineering Requirements are applicable to undergraduate students in engineering disciplines as specified by the degree program. See Department and Division program descriptions in this Bulletin for specific courses required.

### 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
<b>In Design</b>		
EPIC151	DESIGN (EPICS) I	3.0
<b>In Physical Activity (four separate semesters including the following)</b>		
PAGN Elective	PHYSICAL ACTIVITY COURSE	0.5
PAGN Elective	PHYSICAL ACTIVITY COURSE	0.5
PAGN Elective	PHYSICAL ACTIVITY COURSE	0.5
PAGN Elective	PHYSICAL ACTIVITY COURSE	0.5
<b>In Freshman Orientation &amp; Success</b>		
CSM101	FRESHMAN SUCCESS SEMINAR	0.5
<b>Free Electives **</b>		
Minimum of 9.0 Semester Hours		9.0
<b>Total Semester Hrs</b>		<b>38.0</b>

\* A minimum of 2.0 credit hours. See the Physical Education and Athletics (<http://bulletin.mines.edu/undergraduate/programs/additionalprograms/physicaleducationandathletics>) section for specifics.

\*\* A minimum of 9.0 hours of Free Elective are included with each degree-granting program.

1. The choice must not be in conflict with any Graduation Requirements (p. 44).
2. Free electives to satisfy degree requirements may not exceed three semester hours (3.0) in activity courses such as band, choir, studio art, physical activity, and varsity athletics courses combined.
3. Transfer credits used for free electives must comply with the transfer credit guidelines.

### 2) Humanities and Social Science Requirement

H&SS Requirements are applicable to all undergraduate students:

LAIS100	NATURE AND HUMAN VALUES	4.0
LAIS200	HUMAN SYSTEMS	3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0
MID-LEVEL ELECTIVE	Two courses from the approved list of requirements *	6.0
400-LEVEL ELECTIVE	One course at the 400-level from the approved list of requirements *	3.0
<b>Total Semester Hrs</b>		<b>19.0</b>

\* See the approved list in the Liberal Arts and International Studies (p. 107) section of this Bulletin.

### 3) Distributed Science Requirement

The Science Requirement is a minimum of three courses and is applicable to all undergraduate students as follows:

#### APPLIED MATH & STATISTICS

CSCI101	INTRODUCTION TO COMPUTER SCIENCE
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS

**CHEMISTRY - See degree specialty listings to determine if CBEN110 or GEGN101 are required**

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
CBEN110	FUNDAMENTALS OF BIOLOGY I
or GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS

**CHEMICAL ENGINEERING**

CBEN110	FUNDAMENTALS OF BIOLOGY I
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)

**CHEMICAL & BIOCHEMICAL ENGINEERING**

CBEN110	FUNDAMENTALS OF BIOLOGY I
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)

**CIVIL ENGINEERING****FOUR COURSES REQUIRED**

CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
or CBEN110	FUNDAMENTALS OF BIOLOGY I

**COMPUTER SCIENCE**

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
CSCI101	INTRODUCTION TO COMPUTER SCIENCE
CBEN110	FUNDAMENTALS OF BIOLOGY I
or GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
or CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)

**ECONOMICS****CHOOSE THREE FROM BELOW**

CBEN110	FUNDAMENTALS OF BIOLOGY I
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
CSCI101	INTRODUCTION TO COMPUTER SCIENCE

**ELECTRICAL ENGINEERING**

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
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**CHOOSE TWO FROM BELOW**

CBEN110	FUNDAMENTALS OF BIOLOGY I
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY
CSCI101	INTRODUCTION TO COMPUTER SCIENCE

**ENVIRONMENTAL ENGINEERING****FOUR COURSES REQUIRED**

CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
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GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
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**GEOLOGICAL ENGINEERING**

GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS

CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY

**GEOPHYSICAL ENGINEERING**

GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS

CBEN110	FUNDAMENTALS OF BIOLOGY I
or CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY
or CSCI101	INTRODUCTION TO COMPUTER SCIENCE
or MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS

**MECHANICAL ENGINEERING**

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
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CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY

CBEN110	FUNDAMENTALS OF BIOLOGY I
or GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS

**METALLURGICAL & MATERIALS ENGINEERING**

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
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CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY

CBEN110	FUNDAMENTALS OF BIOLOGY I
or GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS

**MINING ENGINEERING**

GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS

CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
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**PETROLEUM ENGINEERING**

GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS
PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS

CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
or CHGN125	MOLECULAR ENGINEERING & MATERIALS CHEMISTRY

**ENGINEERING PHYSICS**

PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS
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CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)
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or CHGN125 MOLECULAR ENGINEERING & MATERIALS  
CHEMISTRY

CBEN110 FUNDAMENTALS OF BIOLOGY I  
or GEGN101 EARTH AND ENVIRONMENTAL SYSTEMS  
or CSCI101 INTRODUCTION TO COMPUTER SCIENCE

#### 4) Engineering Requirement (see degree program listing)

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

### The Freshman Year

Freshmen in all programs normally take similar subjects. A sample first year schedule is listed below:

#### Freshman

Fall		lec	lab	sem.hrs
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
EBGN201	PRINCIPLES OF ECONOMICS <sup>*</sup>			3.0
LAIS100	NATURE AND HUMAN VALUES <sup>*</sup>			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
PAGN	PHYSICAL ACTIVITY ELECTIVE			0.5
Elective				
				<b>16.0</b>
Spring		lec	lab	sem.hrs
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
EPIC151	DESIGN (EPICS) I <sup>**</sup>			3.0
PHGN100	PHYSICS I - MECHANICS			4.5
DIST SCI	Distributed Science Requirement <sup>*</sup>			4.0
PAGN	PHYSICAL ACTIVITY ELECTIVE			0.5
Elective				
				<b>16.0</b>

**Total Semester Hrs: 32.0**

\* For scheduling purposes, registration in combinations of GEGN101, CBEN110, LAIS100, EBGN201, MATH201, CSCI101, 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.

\*\* Completion of EPIC155 in lieu of EPIC151 is by permission only and does not alter the total hours required for completion of the degree.

# General Information

## 2016-2017

### 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 early 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

### Course Numbering & Subject Codes

#### Numbering of Courses

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

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
500-599	Master's Level	
600-699	Doctoral Level	
Over 700	Graduate Research or Thesis Level	

#### Subject Codes:

Course Code	Course Title
CBEN	Chemical & Biological Engineering
CEEN	Civil & Environmental Engineering
CHGC	Geochemistry
CHGN	Chemistry
CSCI	Computer Science
CSM	General Studies; Skills Courses
EBGN	Economics & Business
EENG	Electrical Engineering & Computer Sciences
EGGN	Engineering - General
ENGY	Energy
EPIC	EPICs
ESGN	Environmental Science & 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
MEGN	Mechanical Engineering
MNGN	Mining Engineering
MSGN	Military Science
MLGN	Materials Science
MTGN	Metallurgical & Materials Engineering
NUGN	Nuclear Engineering
PAGN	Physical Education & 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 that students select one of the undergraduate degree programs early in the sophomore year.

### Curriculum Changes

In accordance with the statement on Curriculum Changes, 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, reference the online degree evaluation, and carefully consult any Bulletin Addenda that may be published.

### 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 (<http://inside.mines.edu/500-Level-Course->

Enrollment). 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 ([bulletin.mines.edu/graduate/generalregulations/graduategradingsystem](http://bulletin.mines.edu/graduate/generalregulations/graduategradingsystem)) 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 (<http://inside.mines.edu/Course-Substitutions>).

## 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 (<http://inside.mines.edu/Bulletin-Change>).

## 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 (<http://inside.mines.edu/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 12.0 credit hours per semester for the fall and spring semesters. Full-time enrollment for Summer Session I and Summer Session II combined is 12.0 credit hours.

# Good Standing, Honor Roll & Dean's List, Graduation Awards, Probation & Suspension

## 2016/2017

### 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.

### Honor Roll & Dean's List

To be placed on the academic honor roll, a student must complete at least 14.0 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 at no cost. Additional metal diplomas and parchment diplomas can be ordered online at the Registrar's Office (<http://inside.mines.edu/Diplomas>) webpage 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.

## Academic Probation & 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. The student may not register for more than 15.0 credit hours;
2. The student may be required to withdraw from intercollegiate athletics;
3. The student 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 the 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 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 and receive written permission to remove the hold before being allowed to register.

In the case of three or more Fs in the same course, the student must meet with the faculty Readmissions Committee and receive permission to remove the hold before being allowed to register.

Transfer credit from another school will not be accepted for a twice-failed course.

# Grading System, Grade-Point Average (GPA), and Grade Appeals

## 2016/2017

## 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 his 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	
D-	Poor (lowest passing)
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 Withdrawal
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 END OF THE FOURTH WEEK OF THE FIRST MAJOR TERM OF ATTENDANCE FOLLOWING THAT IN WHICH IT WAS RECEIVED. A grade of INC will be converted to an F grade by the Registrar in the fifth

week if it has not been updated by the instructor prior to this date. This conversion only occurs during the Spring and Fall terms (not summer). 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 and 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. The form is available in the Registrar's Office (<http://inside.mines.edu/Auditing-a-Course>).

### 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.

### GPA 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 GPA 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 GPA hours is divided into the cumulative quality points received. Grades of W, WI, INC, PRG, PRU, or NC are not counted in quality hours.

### Midterm Grading

Midterm grading is conducted using Satisfactory (S) and Unsatisfactory (U) grades. Certain foundational courses are required to be graded between the 6th and 8th weeks of the term to provide students an early warning with time to recover. If the midterm grade is blank in these specific courses, the grade for the student is Satisfactory (S) by default,

or C- or better. Faculty will enter Unsatisfactory (U) grades for those students currently earning grades of D+ or lower.

Courses include: All Core Curriculum and Distributed Science Elective courses with the exception of H&SS Mid-Level Cluster and 400-Level. Additionally, the following courses will also be included: CEEN241 (Statics), CEEN311 (Mechanics of Materials), MEGN361 (Thermodynamics 1), CSCI261 (Programming Concepts), CHGN209 (Chemical Thermodynamics), and CBEN210 (Intro to Thermodynamics) as they are key pre-requisite courses for many students.

## 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. A minimum of three 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 (<http://inside.mines.edu/Degree-Audit-Information>) or contact your major department.

## 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.

## **Class Rank**

Colorado School of Mines does not calculate class rank. The Registrar's Office will provide a letter stating this fact upon request if necessary for the submission of scholarship applications.

## Minor Programs / Areas of Special Interest (ASI)

Established Minor Programs/Areas of Special Interest (ASI) are offered by undergraduate degree-granting departments and the Military Science Department. Additionally CSM offers interdisciplinary minors ([bulletin.mines.edu/undergraduate/interdisciplinaryminors](http://bulletin.mines.edu/undergraduate/interdisciplinaryminors)) and ASIs.

A Minor Program/Area of Special Interest declaration (which can be found in the Registrar's Office (<http://inside.mines.edu/Minor-or-ASI-Declaration>)) 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 the first 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/ASI must officially drop the minor/ASI by notifying the Registrar's Office in writing. Should minor/ASI requirements not be complete at the time of graduation, the minor/ASI program will not be awarded. Minors/ASIs are not added after the BS degree is posted. Completion of the minor/ASI will be recorded on the student's official transcript. Students who return after completing a degree may not take courses solely to complete a minor with the expectation of having the minor added to the transcript. Minors/ASIs are not added after the BS degree is posted.

Please see the Department for specific course requirements. For questions concerning changes in the sequence of minor/ASI courses after the declaration form is submitted, contact the Registrar's Office for assistance.

No more than half of the hours used for the minor or ASI may be transferred from other colleges or universities including AP, IB, or other high school or non-Mines credit. 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 programs section ([bulletin.mines.edu/undergraduate/programs](http://bulletin.mines.edu/undergraduate/programs)) of this Bulletin.

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 programs section ([bulletin.mines.edu/undergraduate/programs](http://bulletin.mines.edu/undergraduate/programs)) 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 completed at CSM. 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 programs section ([bulletin.mines.edu/undergraduate/programs](http://bulletin.mines.edu/undergraduate/programs)) of this Bulletin.

Each department or minor-oversight authority (in the case of interdisciplinary minors) defines a list of requirements that constitute a minor. The lists of requirements clearly delineate any specific courses needed for the minor, may include a set of courses from which the rest of the credits must be completed, and will clearly outline any other

specific restrictions and/or requirements for obtaining the minor. Once recommended by Undergraduate Council and approved by Faculty Senate, the minor requirements will appear in the appropriate department or interdisciplinary sections of this bulletin so that courses may be planned in advance in order for a student to receive a given minor/s.

The objective of a minor is to provide a depth of understanding and expertise to an area outside of, or complementary to, a student's degree. A minor is a thematically-related set of academic activities leading to a transcript designation in addition to but separate from that granted by the student's degree.

### Minors

**All minors are created and awarded based on the following minimum requirements and limitations:**

#### MINIMUM CREDIT HOURS - 18.0

#### MINIMUM HOURS OUTSIDE OF DEGREE REQUIREMENTS - 9.0

At least 9.0 of the hours required for the minor must not be used for any part of the degree other than Free Electives.

#### MINIMUM GPA - 2.0

A 2.0 grade point average, including all CSM graded courses used for the minor, must be met in order to receive the minor designation on the transcript. Transfer credit hours do not factor into the minor grade point average.

#### LEVEL - At least 9.0 credits must be at the 300-level or above.

### CONTENT

There must be sufficient distinction between a degree and a minor obtained by the same student. In general, students may earn minors offered by the same department as their degree program, but the minor may not have the same name as the degree. For example, an Electrical Engineering degree-seeking student may earn a minor in Computer Science. However, degree granting programs, with recommendation by Undergraduate Council and approval by Faculty Senate, may 1) specify minors that are excluded for their students due to insufficient distinction, and/or 2) add restrictions or additional requirements to the minimal requirements for their students to obtain a specific minor. Any approved exclusions and/or additional restrictions will appear in this Bulletin under both the associated degree and minor sections.

### Areas of Special Interest (ASIs)

**All ASIs are created and awarded based on the following minimum requirements and limitations:**

#### MINIMUM CREDIT HOURS - 12.0

#### MINIMUM HOURS OUTSIDE OF DEGREE REQUIREMENTS - 9.0

At least 9.0 of the hours required for the ASI must not be used for any part of the degree other than Free Electives.

**MIMIMUM GPA - 2.0**

A 2.0 grade point average, including all CSM graded courses used for the ASI, must be met in order to receive the ASI designation on the transcript. Transfer credit hours do not factor into the ASI grade point average.

**LEVEL - At least 9.0 credits must be at the 300-level or above.**

# 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 (Civil Engineering)
- Bachelor of Science (Computer Science)
- Bachelor of Science (Economics)
- Bachelor of Science (Electrical Engineering)
- Bachelor of Science (Engineering Physics)
- Bachelor of Science (Environmental Engineering)
- Bachelor of Science (Geological Engineering)
- Bachelor of Science (Geophysical Engineering)
- Bachelor of Science (Mechanical Engineering)
- Bachelor of Science (Metallurgical & Materials Engineering)
- Bachelor of Science (Mining Engineering)
- Bachelor of Science (Petroleum Engineering)

## Degree Retirement Notification and Requirement Definition

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

- Bachelor of Science (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.

Admission into the following degree program is suspended after the Fall 2013 semester:

- Bachelor of Science (Engineering) with specialty/specialties

Both continuing students and students admitted into this degree program Fall, 2013 are encouraged to change programs to the newly approved programs replacing this older program (Civil Engineering, Electrical Engineering, Environmental Engineering, or Mechanical Engineering). Program requirements for students admitted Fall, 2013 wishing to remain in the older program are as defined in the 2013-2014 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 (<http://inside.mines.edu/Application-to-Graduate>) upon completion of 90 hours (upon obtaining Senior class standing). Applications are completed online through the student's Trailhead account.

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 the School. Checkout cards, available at Graduation Salute and 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 two Bachelor of Science degrees must complete the first degree plus a minimum of thirty hours specific to the second degree program. The thirty (or more) hours required for the second degree may not include free electives and may not be double counted with any credit used to complete the first degree. The degree plan for the second degree must be approved by the advisor, the department head, and the Registrar's Office representing Academic Affairs.

When two degrees are completed concurrently, the first degree is the one with fewer total hours required for graduation. In the case of a returning student, the first degree is the original completed degree. The two degrees may be in different colleges. The degree plan may include courses from multiple departments. Different catalogs may be used, one for each degree program. The student receives two separate diplomas. The transcript lists both degrees.

A student may not earn two degrees in the same content area because the course requirements, content, and titles do not significantly differ.

The following combinations are not allowable:

BS in Engineering, Mechanical Specialty & BS in Mechanical Engineering

BS in Engineering, Electrical Specialty & BS in Electrical Engineering

BS in Engineering, Environmental Specialty & BS in Environmental Engineering

BS in Engineering, Civil Specialty & BS in Civil Engineering

BS in Mathematics & Computer Science & BS in Applied Math and Statistics

BS in Mathematics & Computer Science & BS in Computer Science

BS in Chemical Engineering & BS in Chemical and Biochemical Engineering

## 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, and the department in which the course is taught.

## Late Fee for Application to Graduate after Stated Deadlines - \$250 Beginning Fall 2014

### Undergraduates:

The deadline to apply to graduate and participate in commencement is the first day of class of the term in which the student intends to graduate/participate.

Any request to be added to the graduation list and/or commencement ceremony after the first day of class (and before November 10<sup>th</sup> for fall or April 10<sup>th</sup> for spring and summer) may be made in writing and will be considered by the Registrar's Office. If the request is denied, the student will be required to apply for the next available graduation/ceremony. If the request is approved and all other conditions are met (i.e. degree requirements can be met, required forms are turned in, and outstanding hours limitations are not exceeded), a mandatory \$250 fee will be applied to the student's account. This fee cannot be waived and cannot be refunded if the student does not meet the graduation check-out deadlines.

For late requests that are approved, tickets to the commencement ceremony for family and friends of the graduate are not guaranteed, as they may have already been distributed or assigned. Additionally, the

student's name may not appear in the commencement program due to publishing deadlines.

No undergraduate student will be added to a graduation or commencement when the request is made after November 10<sup>th</sup> for the fall commencement (which includes December graduation), or April 10<sup>th</sup> for the spring and summer commencement ceremony (which includes May and August graduations).

# Applied Mathematics & Statistics

## 2016-17

### Program Description

The Applied Mathematics and Statistics Department (AMS) offers an undergraduate degree in which students are 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.

In a broad sense, these programs stress the development of practical applications and techniques to enhance the overall attractiveness of applied mathematics and statistics majors to a wide range of employers in industry and government. More specifically, AMS utilizes 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 and 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 free elective courses to gain knowledge in another discipline and incorporate either an Area of Special Interest (ASI) or a minor in one of the following:

- Computational and Applied Mathematics
- Statistics
- Mathematical Sciences

This adds to the flexibility of the program and qualifies students for a wide variety of careers.

In addition to offering undergraduate and graduate degree programs, 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.

### 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 Accreditation Board for Engineering and Technology's (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					
Fall		lec	lab	sem.	hrs
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0			4.0
CSCI101	INTRODUCTION TO COMPUTER SCIENCE	3.0			3.0
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0		4.0
LAIS100	NATURE AND HUMAN VALUES	4.0			4.0
CSM101	FRESHMAN SUCCESS SEMINAR	0.5			0.5

PAGN Elective	PHYSICAL ACTIVITY COURSE		0.5		
			<b>16.0</b>		
<b>Spring</b>					
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4.0	
PHGN100	PHYSICS I - MECHANICS	3.0	3.0	4.5	
EPIC151	DESIGN (EPICS) I	3.0		3.0	
EBGN201	PRINCIPLES OF ECONOMICS			3.0	
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5	
				<b>15.0</b>	
<b>Sophomore</b>					
<b>Fall</b>					
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0	
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0	
CSCI261	PROGRAMMING CONCEPTS	3.0		3.0	
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.0	3.0	4.5	
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5	
				<b>15.0</b>	
<b>Spring</b>					
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0		3.0	
MATH332	LINEAR ALGEBRA or 342	3.0		3.0	
CSCIxxx	COMPUTER ELECTIVE <sup>1</sup>	3.0		3.0	
LAIS200	HUMAN SYSTEMS	3.0		3.0	
FREE	FREE ELECTIVE	3.0		3.0	
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5	
				<b>15.5</b>	
<b>Summer</b>					
MATH310	INTRODUCTION TO MATHEMATICAL MODELING	3.0	3.0	4.0	
				<b>4.0</b>	
<b>Junior</b>					
<b>Fall</b>					
MATH300	FOUNDATIONS OF ADVANCED MATHEMATICS	3.0		3.0	
MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING	3.0		3.0	
MATH331	MATHEMATICAL BIOLOGY	3.0		3.0	
MATH334	INTRODUCTION TO PROBABILITY	3.0		3.0	
LAIS/EBGN	H&SS ELECTIVE I	3.0		3.0	
				<b>15.0</b>	
<b>Spring</b>					
MATH301	INTRODUCTION TO ANALYSIS	3.0		3.0	
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0		3.0	

MATH408	COMPUTATIONAL METHODS FOR DIFFERENTIAL EQUATIONS	3.0		3.0	
MATH454	COMPLEX ANALYSIS	3.0		3.0	
LAIS/EBGN	H&SS ELECTIVE II	3.0		3.0	
				<b>15.0</b>	
<b>Senior</b>					
<b>Fall</b>					
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3.0		3.0	
MATH458	ABSTRACT ALGEBRA	3.0		3.0	
MATH	MATHEMATICS-CAM ELECTIVE <sup>2</sup>	3.0		3.0	
MATH	MATHEMATICS-CAM ELECTIVE <sup>2</sup>	3.0		3.0	
FREE	FREE ELECTIVE	3.0		3.0	
FREE	FREE ELECTIVE	3.0		3.0	
				<b>18.0</b>	
<b>Spring</b>					
MATH440	PARALLEL SCIENTIFIC COMPUTING	3.0		3.0	
MATH484	MATHEMATICAL AND COMPUTATIONAL MODELING (CAPSTONE)	3.0		3.0	
MATH	MATHEMATICS-CAM ELECTIVE <sup>2</sup>	3.0		3.0	
LAIS/EBGN	H&SS ELECTIVE III	3.0		3.0	
FREE	FREE ELECTIVE	3.0		3.0	
				<b>15.0</b>	

**Total Semester Hrs: 128.5**

<sup>1</sup> May be satisfied by CSCI262 or any other approved computationally intensive course.

#### CAM Elective List <sup>2</sup>

MATH457	INTEGRAL EQUATIONS	3.0		
MATH503	FUNCTIONAL ANALYSIS	3.0		
MATH506	COMPLEX ANALYSIS II	3.0		
MATH536	ADVANCED STATISTICAL MODELING	3.0		
MATH550	NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS	3.0		
MATH556	MODELING WITH SYMBOLIC SOFTWARE	3.0		
CAM ELECTIVE	Department approval required for courses not on list	3.0		

#### Statistics (STATS) EMPHASIS

##### Freshman

<b>Fall</b>					
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4.0	
CSCI101	INTRODUCTION TO COMPUTER SCIENCE	3.0		3.0	
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0	
LAIS100	NATURE AND HUMAN VALUES	4.0		4.0	
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5	
PAGN Elective	PHYSICAL ACTIVITY COURSE			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		4.0
PHGN100	PHYSICS I - MECHANICS	3.0	3.0	4.5
EPIC151	DESIGN (EPICS) I	3.0		3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>15.0</b>

<b>Sophomore</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
<b>Fall</b>				
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
CSCI261	PROGRAMMING CONCEPTS	3.0		3.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.0	3.0	4.5
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>15.0</b>

<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH332	LINEAR ALGEBRA or 342	3.0		3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0		3.0
CSCIXXX	COMPUTER SCIENCE ELECTIVE <sup>1</sup>	3.0		3.0
LAIS200	HUMAN SYSTEMS	3.0		3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
FREE	FREE ELECTIVE			3.0
				<b>15.5</b>

<b>Summer</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH310	INTRODUCTION TO MATHEMATICAL MODELING	3.0	3.0	4.0
				<b>4.0</b>

<b>Junior</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
<b>Fall</b>				
MATH300	FOUNDATIONS OF ADVANCED MATHEMATICS	3.0		3.0
MATH331	MATHEMATICAL BIOLOGY	3.0		3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0		3.0
MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING	3.0		3.0
LAIS/EBGN	H&SS ELECTIVE I	3.0		3.0
				<b>15.0</b>

<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH301	INTRODUCTION TO ANALYSIS			3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0		3.0
MATH408	COMPUTATIONAL METHODS FOR DIFFERENTIAL EQUATIONS	3.0		3.0
MATH454	COMPLEX ANALYSIS	3.0		3.0

LAIS/EBGN	H&SS ELECTIVE II	3.0	3.0
<b>15.0</b>			

<b>Senior</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
<b>Fall</b>				
MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0		3.0
MATH432	SPATIAL STATISTICS	3.0		3.0
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3.0		3.0
MATH	STAT ELECTIVE <sup>2</sup>	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
LAIS/EBGN	H&SS ELECTIVE III	3.0		3.0
				<b>18.0</b>

<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH482	STATISTICS PRACTICUM (STAT Capstone)	3.0		3.0
MATH	STAT ELECTIVE <sup>2</sup>	3.0		3.0
MATH	STAT ELECTIVE <sup>2</sup>	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
				<b>15.0</b>

**Total Semester Hrs: 128.5**

<sup>1</sup> May be satisfied by CSCI262 or any other approved computationally intensive course.

**STAT Elective List <sup>2</sup>**

CSCI403	DATA BASE MANAGEMENT	3.0
MATH436	ADVANCED STATISTICAL MODELING	3.0
MATH437	MULTIVARIATE ANALYSIS	3.0
MATH438	STOCHASTIC MODELS	3.0
MATH439	SURVIVAL ANALYSIS	3.0
STAT Elective	Department approval required for courses not on this list	3.0

General CSM Minor/ASI requirements can be found here (<http://bulletin.mines.edu/undergraduate/undergraduateinformation/minorasi>). An important policy for all CSM Minor/ASI programs is that 9.0 credit hours must occur outside of a student's degree program. The Department of Applied Mathematics and Statistics also requires that one course must be at the 400-level. The following options are available:

1. Minor/ASI in Computational and Applied Mathematics (CAM)
2. Minor/ASI in Statistics (STAT)
3. Minor in Mathematical Sciences, which can include a combination of CAM and STAT coursework

For each of these options, there is a list of required courses and a list of elective courses which a student can choose from to complete his/her Minor/ASI requirements.



## 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	3.0
or MATH235	DIFFERENTIAL EQUATIONS HONORS	
MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING	3.0
MATH332	LINEAR ALGEBRA	3.0
or MATH342	HONORS LINEAR ALGEBRA	

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	3.0
or MATH235	DIFFERENTIAL EQUATIONS HONORS	
MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING	3.0
MATH332	LINEAR ALGEBRA	3.0
or MATH342	HONORS LINEAR ALGEBRA	

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

### CAM Courses

MATH301	INTRODUCTION TO ANALYSIS	3.0
MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING	3.0
MATH331	MATHEMATICAL BIOLOGY	3.0
MATH348	ADVANCED ENGINEERING MATHEMATICS	3.0
MATH406	ALGORITHMS	3.0
MATH408	COMPUTATIONAL METHODS FOR DIFFERENTIAL EQUATIONS	3.0
MATH440	PARALLEL SCIENTIFIC COMPUTING	3.0
MATH441	COMPUTER GRAPHICS	3.0
MATH454	COMPLEX ANALYSIS	3.0
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3.0
MATH457	INTEGRAL EQUATIONS	3.0
MATH484	MATHEMATICAL AND COMPUTATIONAL MODELING (CAPSTONE)	3.0
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:

MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0
MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0

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

MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
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MATH334	INTRODUCTION TO PROBABILITY	3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0
MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0

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

MATH432	SPATIAL STATISTICS	3.0
MATH436	ADVANCED STATISTICAL MODELING	3.0
MATH438	STOCHASTIC MODELS	3.0
MATH439	SURVIVAL ANALYSIS	3.0
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	3.0
or MATH235	DIFFERENTIAL EQUATIONS HONORS	

9 credit hours of Mathematics courses (3 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	3.0
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.

## Department Head

Willy Hereman, Professor

## Professors

Bernard Bialecki

Mahadevan Ganesh

Paul A. Martin

Barbara M. Moskal

William C. Navidi

## Associate Professor

Luis Tenorio

## Assistant Professors

Paul Constantine

Cecilia Diniz Behn

Amanda Hering

Stephen Pankavich

Aaron Porter

## Teaching Professors

G. Gustave Greivel

Scott Strong

## Teaching Associate Professors

Terry Bridgman

Debra Carney

Holly Eklund

Mike Mikucki

Mike Nicholas

Jennifer Strong

Rebecca Swanson

## Emeriti Professors

William R. Astle

Norman Bleistein

Ardel J. Boes

Austin R. Brown

John A. DeSanto

Graeme Fairweather

Raymond R. Gutzman

Frank G. Hagin

Donald C.B. Marsh

Steven Pruess

## Emeriti Associate Professors

Barbara B. Bath

Ruth Maurer

Robert G. Underwood

## Courses

### **MATH100. INTRODUCTORY TOPICS FOR CALCULUS. 2.0 Semester Hrs.**

(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: none. 2 hours lecture, 2 semester hours.

### **MATH111. CALCULUS FOR SCIENTISTS AND ENGINEERS I. 4.0 Semester Hrs.**

Equivalent with MACS111,  
(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 Semester Hrs.**

Equivalent with MACS112, MATH122,  
(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 Semester Hr.**

(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: none. 1 hour lecture; 1 semester hour.

### **MATH122. CALCULUS FOR SCIENTISTS AND ENGINEERS II HONORS. 4.0 Semester Hrs.**

Equivalent with MATH112,  
(I) Same topics as those covered in MATH112 but with additional material and problems. Prerequisite: none. 4 hours lecture; 4 semester hours.

### **MATH198. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### **MATH199. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

### **MATH201. PROBABILITY AND STATISTICS FOR ENGINEERS. 3.0 Semester Hrs.**

Equivalent with MATH323,  
(I, II, S) This course is an introduction to Probability and Statistics, including fundamentals of experimental design and data collection, the summary and display of data, 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. Prerequisites: MATH112, MATH122 or concurrent enrollment in MATH113. 3 hours lecture; 3 semester hours.

**MATH213. CALCULUS FOR SCIENTISTS AND ENGINEERS III. 4.0 Semester Hrs.**

Equivalent with MACS213, MATH214,

(I, II, S) Multivariable calculus, including partial derivatives, multiple integrals, and vector calculus. Prerequisites: Grade of C or better in MATH112 or MATH122 or Concurrent Enrollment in MATH113. 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 Semester Hr.**

Equivalent with MATH213,

(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: none. 1 hour lecture; 1 semester hour.

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

(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: MATH112 or MATH122. 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 Semester Hrs.**

Equivalent with MACS223,

(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 Semester Hrs.**

(I) Early introduction of vectors, linear algebra, multivariable calculus. Vector fields, line and surface integrals. Prerequisite: none. 4 hours lecture; 4 semester hours.

**MATH225. DIFFERENTIAL EQUATIONS. 3.0 Semester Hrs.**

Equivalent with MACS225, MACS315,

(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 from physics, mechanics, electrical engineering, and environmental sciences. May not also receive credit for MATH222. Prerequisites: Grade of C or better in MATH112 or MATH122 or Concurrent Enrollment in MATH113. 3 hours lecture; 3 semester hours.

**MATH235. DIFFERENTIAL EQUATIONS HONORS. 3.0 Semester Hrs.**

Equivalent with MACS325,

(II) Same topics as those covered in MATH225 but with additional material and problems. Prerequisite: none. 3 hours lecture; 3 semester hours.

**MATH298. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MATH299. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

**MATH300. FOUNDATIONS OF ADVANCED MATHEMATICS. 3.0 Semester Hrs.**

(I) (WI) This course is an introduction to communication in mathematics. This writing intensive course provides a transition from the Calculus sequence to theoretical mathematics curriculum in CSM. Topics include logic and recursion, techniques of mathematical proofs, reading and writing proofs. Prerequisites: MATH112 or MATH122. 3 hours lecture; 3 semester hours.

**MATH301. INTRODUCTION TO ANALYSIS. 3.0 Semester Hrs.**

Equivalent with MATH401,

(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.

**MATH307. INTRODUCTION TO SCIENTIFIC COMPUTING. 3.0 Semester Hrs.**

Equivalent with CSCI407, MATH407,

(I, II) This course is designed to introduce scientific computing to scientists and engineers. Students in this course will be taught various numerical methods and programming techniques to solve basic scientific problems. Emphasis will be made on implementation of various numerical and approximation methods to efficiently simulate several applied mathematical models. Prerequisites: MATH213, MATH223, or MATH224 and MATH225 or MATH235. 3 hours lecture; 3 semester hours.

**MATH310. INTRODUCTION TO MATHEMATICAL MODELING. 4.0 Semester Hrs.**

(S) An introduction to modeling and communication in mathematics. A writing intensive course providing a transition from the core math sequence to the upper division AMS curriculum. Topics include a variety of mathematical and statistical modeling techniques. Students will formulate and solve applied problems and will present results orally and in writing. In addition, students will be introduced to the mathematics software that will be used in upper division courses. Prerequisites: MATH201 and MATH225. 3 hours lecture; 3 hours lab; 4 semester hours.

**MATH331. MATHEMATICAL BIOLOGY. 3.0 Semester Hrs.**

Equivalent with BELS331,BELS433,MACS433,MATH433,  
(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 and MATH213 or MATH223 or MATH224. 3 hours lecture, 3 semester hours.

**MATH332. LINEAR ALGEBRA. 3.0 Semester Hrs.**

Equivalent with MACS332,  
(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 Semester Hrs.**

Equivalent with MACS334,MACS434,  
(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 Semester Hrs.**

Equivalent with MACS435,  
(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 Semester Hrs.**

(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 Semester Hrs.**

Equivalent with MACS342,  
(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 Semester Hrs.**

Equivalent with MACS348,  
(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 and MATH213 or MATH223 or MATH224. 3 hours lecture; 3 semester hours.

**MATH358. DISCRETE MATHEMATICS. 3.0 Semester Hrs.**

Equivalent with CSCI358,MACS358,  
(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 Semester Hrs.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MATH399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

Equivalent with CSCI406,MACS406,  
(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.

**MATH408. COMPUTATIONAL METHODS FOR DIFFERENTIAL EQUATIONS. 3.0 Semester Hrs.**

(II) This course is designed to introduce computational methods to scientists and engineers for developing differential equations based computer models. Students in this course will be taught various numerical methods and programming techniques to simulate systems of nonlinear ordinary differential equations. Emphasis will be on implementation of various numerical and approximation methods to efficiently simulate several systems of nonlinear differential equations. Prerequisite: MATH307. 3 hours lecture, 3 semester hours.

**MATH424. INTRODUCTION TO APPLIED STATISTICS. 3.0 Semester Hrs.**

(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: MATH201 or MATH335. 3 hours lecture; 3 semester hours.

**MATH432. SPATIAL STATISTICS. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(II) Modern methods for constructing and evaluating statistical models. Topics include generalized linear models, generalized additive models, hierarchical Bayes methods, and resampling methods. Time series models, including moving average, autoregressive, and ARIMA models, estimation and forecasting, confidence intervals. Prerequisites: MATH335 and MATH424. 3 hours lecture; 3 semester hours.

**MATH437. MULTIVARIATE ANALYSIS. 3.0 Semester Hrs.**

(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 MATH201. 3 hours lecture; 3 semester hours.

**MATH438. STOCHASTIC MODELS. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**MATH440. PARALLEL SCIENTIFIC COMPUTING. 3.0 Semester Hrs.**

Equivalent with CSCI440,  
(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: MATH307/CSCI407. 3 hours lecture; 3 semester hours.

**MATH441. COMPUTER GRAPHICS. 3.0 Semester Hrs.**

Equivalent with CSCI441,  
(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 Semester Hrs.**

Equivalent with CSCI444,  
(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 Semester Hrs.**

Equivalent with CSCI447,  
(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 Semester Hrs.**

Equivalent with MACS454,  
(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 and MATH213 or MATH223 or MATH224. 3 hours lecture, 3 semester hours.

**MATH455. PARTIAL DIFFERENTIAL EQUATIONS. 3.0 Semester Hrs.**

(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 and MATH213 or MATH223 or MATH224. 3 hours lecture; 3 semester hours.

**MATH457. INTEGRAL EQUATIONS. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**MATH474. INTRODUCTION TO CRYPTOGRAPHY. 3.0 Semester Hrs.**

Equivalent with CSCI474,  
(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 (CAPSTONE). 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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, MATH307, and MATH455. 3 hours lecture; 3 semester hours.

**MATH491. UNDERGRADUATE RESEARCH. 1-3 Semester Hr.**

Equivalent with CSCI491,MACS491,

(I) (WI) Individual investigation under the direction of a department faculty member. Written report required for credit. Prerequisite: none. Variable - 1 to 3 semester hours. Repeatable for credit to a maximum of 12 hours.

**MATH492. UNDERGRADUATE RESEARCH. 1-3 Semester Hr.**

(II) (WI) Individual investigation under the direction of a department faculty member. Written report required for credit. Prerequisite: none. Variable - 1 to 3 semester hours. Repeatable for credit to a maximum of 12 hours.

**MATH498. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MATH499. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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

2016-2017

## Program Description

The Department of Civil & Environmental Engineering (CEE) offers design-oriented and interdisciplinary undergraduate programs in Civil Engineering and Environmental Engineering. The degrees build upon fundamental engineering principles and provide specialization within Civil and Environmental Engineering. Graduates are positioned for a broad range of professional opportunities, and are well-prepared for an engineering career in a world of rapid technological change. The Civil Engineering and Environmental Engineering BS degrees are accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

The Civil Engineering degree offers breadth in several traditional sub-fields of Civil Engineering: Geotechnical Engineering, Structural Engineering, Water Resources, Engineering Surveying, Environmental Engineering, and Construction Engineering. Civil students can elect to further specialize in one or more of these areas by selecting related courses to fulfill their Civil Engineering Technical Electives.

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. Topics covered include water reclamation and reuse, hazardous waste management, contaminated site remediation, environmental science, and regulatory processes.

## Program Educational Objectives

The Civil Engineering and Environmental Engineering programs contribute to the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria. Program Educational Objectives (PEOs) of these programs are as follows:

Within three years of attaining the Bachelor of Science in Civil Engineering, graduates will be situated in growing careers or will be successfully pursuing a graduate degree in Civil Engineering or a related field; advancing in their professional standing, generating new knowledge and/or exercising leadership in the field; and contributing to the needs of society through professional practice, research, and/or service.

Within three years of attaining the Bachelor of Science in Environmental Engineering, graduates will be situated in careers or will be successfully pursuing a graduate degree in Environmental Engineering or a related field; advancing in their professional standing, generating new knowledge and/or exercising leadership in their field; and contributing to the needs of society through professional practice, research, and/or service.

## Curriculum

During the first two years at the Colorado School of Mines (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 and chemical phenomena. The basic sciences of physics and chemistry provide an appropriate foundation in the physical sciences; engineering science then builds upon these basic sciences and focuses on applications.

The core curriculum also includes engineering design course work within the Engineering Practice Introductory Course Sequence (EPICS I and II). These courses emphasize design methodology and stress the creative and synthesis aspects of the engineering profession. The core curriculum also includes complementary courses in the humanities and social sciences which explore the links between the environment, human society, and engineering.

In the final two years, students complete discipline-specific advanced engineering courses. The Civil Engineering students explore soil mechanics, structural theory, design of foundations, design of steel or concrete structures, and Civil Engineering technical electives. The Environmental Engineering students explore water chemistry and water quality, air pollution, the fate and transport of chemicals in the environment (air, water, and soil), water resources, environmental policy, and Environmental Engineering technical electives. The discipline-specific curriculum is complemented by courses in advanced engineering design methodology, economics, and additional studies in liberal arts topics. At the student's discretion, free electives (9 credits) can be used to either satisfy his/her personal interest in a topic or the credits can be used to pursue an "area of special interest" (12 semester hours) or a minor (at least 18 semester hours). All students complete a capstone engineering design course which is focused on an in-depth, realistic, and multi-disciplinary engineering project.

Students interested in a research experience, in addition to their undergraduate curriculum, are encouraged to work on an Independent Study project with one of the Civil & Environmental Engineering faculty. These projects can offer an applied experience that is relevant to future graduate studies and a professional career.

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## Bachelor of Science in Civil Engineering Degree Requirements:

Freshman		lec	lab	sem.hrs
<b>Fall</b>				
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
GEEN101	EARTH AND ENVIRONMENTAL SYSTEMS or CBEN 110			4.0
LAIS100	NATURE AND HUMAN VALUES			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>17.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.5

CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)	4.0
EPIC151	DESIGN (EPICS) I	3.0
PAGN	PHYSICAL ACTIVITY COURSE	0.5
Elective		
		<b>16.0</b>

**Sophomore**

<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III		4.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS		4.5
CEEN241	STATICS		3.0
CEEN310	FLUID MECHANICS FOR CIVIL AND ENVIRONMENTAL ENGINEERING		3.0
CSCI260	FORTRAN PROGRAMMING, 261, or EGGN 205		2.0
PAGN	PHYSICAL ACTIVITY COURSE		0.5
Elective			
			<b>17.0</b>

<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
CEEN210	INTRODUCTION TO CIVIL INFRASTRUCTURE		1.5
EPIC267	EPICS II: CIVIL ENGINEERING, 262, 261, or 251		3.0
CEEN311	MECHANICS OF MATERIALS		3.0
EGGN350	MULTIDISCIPLINARY ENGINEERING LABORATORY II		1.5
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS		3.0
LAIS200	HUMAN SYSTEMS		3.0
PAGN	PHYSICAL ACTIVITY COURSE		0.5
Elective			
			<b>15.5</b>

<b>Summer</b>		<b>lec</b>	<b>lab sem.hrs</b>
CEEN331	ENGINEERING FIELD SESSION, CIVIL		3.0
			<b>3.0</b>

**Junior**

<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>
CEEN350	CIVIL AND CONSTRUCTION ENGINEERING MATERIALS		3.0
CEEN314	STRUCTURAL THEORY		3.0
CEEN312	SOIL MECHANICS		3.0
CEEN312L	SOIL MECHANICS LABORATORY		1.0
MEGN315	DYNAMICS		3.0
MATH225	DIFFERENTIAL EQUATIONS		3.0
			<b>16.0</b>

<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
CE BREADTH	Civil Engineering Breadth Elective *		3.0
CE BREADTH	Civil Engineering Breadth Elective *		3.0

CEEN415	FOUNDATION ENGINEERING	3.0
STR ELECT	Structural Design Elective **	3.0
FREE	Free Elective	3.0
LAIS/EBGN	H&SS Restricted Elective I	3.0
		<b>18.0</b>

**Senior**

<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>
EGGN491	SENIOR DESIGN I		3.0
CE ELECT	Civil Engineering Technical Elective ***		3.0
CE ELECT	Civil Engineering Technical Elective ***		3.0
EBGN201	PRINCIPLES OF ECONOMICS		3.0
LAIS/EBGN	H&SS Restricted Elective II		3.0
FREE	Free Elective		3.0
			<b>18.0</b>

<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
EGGN492	SENIOR DESIGN II		3.0
CE ELECT	Civil Engineering Technical Elective ***		3.0
CE ELECT	Civil Engineering Technical Elective ***		3.0
LAIS/EBGN	H&SS Restricted Elective III		3.0
FREE	Free Elective		3.0
			<b>15.0</b>

**Total Semester Hrs: 135.5**

\* **Civil Engineering Breadth Electives** - Students must take a minimum of two courses from this list. These courses may count as Civil Engineering Technical Electives or Free Electives if not used to meet this requirement.

CEEN301	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I
CEEN360	INTRODUCTION TO CONSTRUCTION ENGINEERING
CEEN381	HYDROLOGIC AND WATER RESOURCES ENGINEERING

\*\* **Structural Design Elective** - Students must take a minimum of one course from this list. These courses may count as Civil Engineering Technical Electives or Free Electives if not used to meet this requirement.

CEEN443	DESIGN OF STEEL STRUCTURES
CEEN445	DESIGN OF REINFORCED CONCRETE STRUCTURES

\*\*\* **Civil Engineering Technical Electives** - Students must take a minimum of four courses from this list. These courses may also count as Free Electives if not used to meet this requirement.

CEEN302	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II
CEEN303	ENVIRONMENTAL ENGINEERING LABORATORY



CEEN405	NUMERICAL METHODS FOR ENGINEERS
CEEN406	FINITE ELEMENT METHODS FOR ENGINEERS
CEEN410	ADVANCED SOIL MECHANICS
CEEN411	SOIL DYNAMICS
CEEN412	UNSATURATED SOIL MECHANICS
CEEN421	HIGHWAY AND TRAFFIC ENGINEERING
CEEN423	SURVEYING FOR ENGINEERS AND INFRASTRUCTURE DESIGN PRACTICES
CEEN430	ADVANCED STRUCTURAL ANALYSIS
CEEN433	MATRIX STRUCTURAL ANALYSIS
CEEN440	TIMBER AND MASONRY DESIGN
CEEN441	INTRODUCTION TO THE SEISMIC DESIGN OF STRUCTURES
CEEN461	FUNDAMENTALS OF ECOLOGY
CEEN470	WATER AND WASTEWATER TREATMENT PROCESSES
CEEN471	WATER AND WASTEWATER TREATMENT SYSTEMS ANALYSIS AND DESIGN
CEEN472	ONSITE WATER RECLAMATION AND REUSE
CEEN474	SOLID WASTE MINIMIZATION AND RECYCLING
CEEN475	SITE REMEDIATION ENGINEERING
CEEN476	POLLUTION PREVENTION: FUNDAMENTALS AND PRACTICE
CEEN477	SUSTAINABLE ENGINEERING DESIGN
CEEN480	CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT
CEEN482	HYDROLOGY AND WATER RESOURCES LABORATORY
CEEN492	ENVIRONMENTAL LAW
GEGN466	GROUNDWATER ENGINEERING
GEGN468	ENGINEERING GEOLOGY AND GEOTECHNICS
GEGN473	GEOLOGICAL ENGINEERING SITE INVESTIGATION
MEGN416	ENGINEERING VIBRATION
MEGN424	COMPUTER AIDED ENGINEERING
MNGN321	INTRODUCTION TO ROCK MECHANICS
MNGN404	TUNNELING
MNGN405	ROCK MECHANICS IN MINING
MNGN406	DESIGN AND SUPPORT OF UNDERGROUND EXCAVATIONS

## Bachelor of Science in Environmental Engineering Degree Requirements:

### Freshman

Fall		lec	lab	sem.hrs
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS			4.0
LAIS100	NATURE AND HUMAN VALUES			4.0

CSM101	FRESHMAN SUCCESS SEMINAR			0.5
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>17.0</b>
<b>Spring</b>				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
EPIC151	DESIGN (EPICS) I			3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</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
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS, CBEN 210, or MEGN 361			3.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS			4.5
CEEN310	FLUID MECHANICS FOR CIVIL AND ENVIRONMENTAL ENGINEERING			3.0
CEEN241	STATICS			3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>18.0</b>
<b>Spring</b>				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH225	DIFFERENTIAL EQUATIONS			3.0
CEEN311	MECHANICS OF MATERIALS			3.0
EPIC251	DESIGN (EPICS) II, 261, or 262			3.0
EBGN201	PRINCIPLES OF ECONOMICS			3.0
LAIS200	HUMAN SYSTEMS			3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>15.5</b>
<b>Junior</b>				
<b>Fall</b>				
		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CEEN301	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I			3.0
BIOSCI ELECT	Bioscience Elective			3.0
CEEN381	HYDROLOGIC AND WATER RESOURCES ENGINEERING			3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS			3.0
CSCI260	FORTTRAN PROGRAMMING, 261, or MATH 307			2.0
LAIS/EBGN	H&SS Restricted Elective I			3.0
				<b>17.0</b>

<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
CEEN302	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II		3.0
CEEN303	ENVIRONMENTAL ENGINEERING LABORATORY		3.0
CEEN482	HYDROLOGY AND WATER RESOURCES LABORATORY		3.0
EVE ELECT	Environmental Engineering Elective**		3.0
LAIS/EBGN	H&SS Restricted Elective II		3.0
FREE	Free Elective		3.0
			<b>18.0</b>

<b>Summer</b>		<b>lec</b>	<b>lab sem.hrs</b>
CEEN330	ENGINEERING FIELD SESSION, ENVIRONMENTAL		3.0
			<b>3.0</b>

<b>Senior</b>		<b>lec</b>	<b>lab sem.hrs</b>
<b>Fall</b>			
EGGN491	SENIOR DESIGN I		3.0
CEEN470	WATER AND WASTEWATER TREATMENT PROCESSES		3.0
CEEN480	CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT		3.0
EVE ELECT	Environmental Engineering Elective**		3.0
FREE	Free Elective		3.0
			<b>15.0</b>

<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
EGGN492	SENIOR DESIGN II		3.0
EVE ELECT	Environmental Engineering Elective**		3.0
EVE 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 Semester Hrs: 134.5**

\* **Bio-science Elective Courses** - Students must take a minimum of one course from this list. If this requirement is met with BIOL110, then CEEN461 and CHGN462 may count as Environmental Engineering Electives or Free Electives. BIOL110 cannot count as an Environmental Engineering Elective.

CBEN110	FUNDAMENTALS OF BIOLOGY I
CEEN461	FUNDAMENTALS OF ECOLOGY
CHGN462	MICROBIOLOGY

\*\* **Environmental Engineering Elective Courses** - Students must take a minimum of four courses from this list. These courses may count as Free Electives if not used to meet this requirement.

CEEN312	SOIL MECHANICS
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CEEN405	NUMERICAL METHODS FOR ENGINEERS
CEEN410	ADVANCED SOIL MECHANICS
CEEN461	FUNDAMENTALS OF ECOLOGY
CEEN471	WATER AND WASTEWATER TREATMENT SYSTEMS ANALYSIS AND DESIGN
CEEN472	ONSITE WATER RECLAMATION AND REUSE
CEEN474	SOLID WASTE MINIMIZATION AND RECYCLING
CEEN475	SITE REMEDIATION ENGINEERING
CEEN476	POLLUTION PREVENTION: FUNDAMENTALS AND PRACTICE
CEEN477	SUSTAINABLE ENGINEERING DESIGN
CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY
CHGN462	MICROBIOLOGY
ENGY320	RENEWABLE ENERGY
GEGN466	GROUNDWATER ENGINEERING
GEGN473	GEOLOGICAL ENGINEERING SITE INVESTIGATION
GEGN475	APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS

## Professor and Department Head

John E. McCray

## Professor and James R. Paden Distinguished Chair

Marte Gutierrez

## Professor and AMAX Distinguished Chair

Tissa Illangasekare

## Professor and Grewcock Distinguished Chair

Michael Mooney

## University Emeritus Professor

Robert L. Siegrist

## Emeritus Associate Professor

Ronald R. H. Cohen

## Emeritus Teaching Professor

Candace Sulzbach

## Professors

D.V. Griffiths

Terri Hogue

Ning Lu

John R. Spear

Timothy Strathmann

## Associate Professors

Tzahi Y. Cath

Linda A. Figueroa

Christopher Higgins

Panos Kiouisis

Junko Munakata Marr

Jonathan O. Sharp

Kamini Singha, (Joint appointment with Geology and Geological Engineering)

## Assistant Professors

Christopher Bellona

Reza Hedayat

Shiling Pei

Kathleen Smits

## Teaching Professor

Joseph Crocker

## Teaching Associate Professors

Andres Guerra

Hongyan Liu

Susan Reynolds

Alexandra Wayllace

## Teaching Assistant Professor

Jeffrey Holley

## Adjunct Faculty

Sidney Innerebner

Paul B. Queneau

Tanya Rauch

Patrick Ryan

## Research Assistant Professors

Mengistu Geza

Lee Landkamer

## Courses

### CEEN198. SPECIAL TOPICS. 1-6 Semester Hr.

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### CEEN199. INDEPENDENT STUDY. 1-6 Semester Hr.

(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.

### CEEN210. INTRODUCTION TO CIVIL INFRASTRUCTURE. 1.5 Semester Hr.

(I) An introduction to civil infrastructure systems, including the analysis, design and management of infrastructure that supports human activity, including transportation (road, rail, aviation), water and wastewater, communications and power. 0.75 hours lecture; 2.25 hours lab; 3 semester hours.

### CEEN241. STATICS. 3.0 Semester Hrs.

Equivalent with DCGN241,  
(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.

### CEEN298. SPECIAL TOPICS. 1-6 Semester Hr.

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### CEEN299. INDEPENDENT STUDY. 1-6 Semester Hr.

(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.

### CEEN301. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I. 3.0 Semester Hrs.

Equivalent with EGGN353,ESGN353,  
(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. 3 hours lecture; 3 semester hours.

### CEEN302. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II. 3.0 Semester Hrs.

Equivalent with EGGN354,ESGN354,  
(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. 3 hours lecture; 3 semester hours.

### CEEN303. ENVIRONMENTAL ENGINEERING LABORATORY. 3.0 Semester Hrs.

Equivalent with ESGN355,  
(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: CEEN301 or CEEN302. 1 hour lecture, 6 hour lab. 3 semester hours.

**CEEN310. FLUID MECHANICS FOR CIVIL AND ENVIRONMENTAL ENGINEERING. 3.0 Semester Hrs.**

(I, II) The study and application of principles of incompressible fluid mechanics. Topics include: hydrostatic forces on submerged surfaces, buoyancy, control volume analysis, conservation of mass, fluid motion, Bernoulli's equation and conservation of energy, momentum, dimensional analysis, internal flow (pipe systems), external flow (drag and lift), flow in open channels, and hydraulic jumps. The course will also introduce concepts about municipal water supply networks and storm water drainage and wastewater collection and treatment systems. May not also receive credit for PEGN251 or MEGN351. Prerequisites: PHGN100. Co-requisites: CEEN241. 3 lecture hours, 3 semester hours.

**CEEN311. MECHANICS OF MATERIALS. 3.0 Semester Hrs.**

Equivalent with EGGN320,

(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. May not also receive credit for MEGN312. Prerequisite: CEEN241. 3 hours lecture; 3 semester hours.

**CEEN312. SOIL MECHANICS. 3.0 Semester Hrs.**

Equivalent with EGGN361,

(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: CEEN311. 3 hours lecture; 3 semester hours.

**CEEN312L. SOIL MECHANICS LABORATORY. 1.0 Semester Hr.**

Equivalent with EGGN363,

(I, II) Introduction to laboratory testing methods in soil mechanics. Classification, permeability, compressibility, shear strength. Co-requisites: CEEN312. 3 hours lab; 1 semester hour.

**CEEN314. STRUCTURAL THEORY. 3.0 Semester Hrs.**

Equivalent with EGGN342,

(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: CEEN311. 3 hours lecture; 3 semester hours.

**CEEN330. ENGINEERING FIELD SESSION, ENVIRONMENTAL. 3.0 Semester Hrs.**

Equivalent with EGGN335,

(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 biological) in the laboratory and field. The student will use these skills to collect field data and analyze a given environmental engineering problem. Prerequisites: CEEN301. Three weeks in summer session; 9 hours lab; 3 semester hours.

**CEEN331. ENGINEERING FIELD SESSION, CIVIL. 3.0 Semester Hrs.**

Equivalent with EGGN234,

(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 or EPIC261 or EPIC262 or EPIC267. Three weeks (6 day weeks) in summer field session; 9 hours lab; 3 semester hours.

**CEEN340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.**

Equivalent with EGGN340,EGGN340C,

(I,II,S) Supervised full-time engineering-related employment in which specific educational objectives are set and achieved. The co-op differs from a typical internship in both the length and scope of responsibilities. Students must meet with the CEE Co-op Advisor prior to enrolling to determine the appropriateness of the engagement, clarify the educational objectives, set expectations, and receive written approval for their specific Co-op program. This prior approval of the CEE Co-op Advisor and completion of paperwork with the Career Center is required prior to beginning the work portion of the program. The co-op occurs during academic fall or spring semester(s) and may overlap with a summer session, with a typical length of six months total. Prerequisite: Second semester sophomore status or above and a cumulative grade-point average of at least 2.00. 3.0 credit hours. This course is repeatable.

**CEEN350. CIVIL AND CONSTRUCTION ENGINEERING MATERIALS. 3.0 Semester Hrs.**

(I) This course deals with the nature and performance of civil engineering materials and evaluation of their physical and mechanical properties. This course focuses on materials used in construction and maintenance of building and infrastructure such as metals (steel and aluminum), aggregates, Portland cement, concrete, shotcrete, asphalt, wood, recycled materials, and composites. The course covers standards describing materials and tests for determining material properties and includes a lab component where students conduct tests, analyze the resulting data, and prepare technical reports. Laboratory tests include evaluation of behavior of civil engineering materials under a wide range of conditions. Prerequisites: CEEN311. 2 hours lecture; 3 hours lab, 3 semester hours.

**CEEN360. INTRODUCTION TO CONSTRUCTION ENGINEERING. 3.0 Semester Hrs.**

(II) Overview of the construction process for civil construction (spanning the building, transportation, and infrastructure sectors), including procurement methods and project delivery methods, codes, regulations, tests, standards, and Risk estimation and management. Construction methods and materials. Construction contracts, including drawings and specifications. Construction administration, including submittals, requests for information, change orders, special instructions, claims, disputes, arbitration, litigation, and project close-out. Project scheduling using the Critical Path Method. Construction project management. Construction safety and OSHA. Quantity takeoffs and construction estimating. Application of engineering analysis and design to construction projects. 3 hours lecture; 3 semester hours.

**CEEN381. HYDROLOGIC AND WATER RESOURCES ENGINEERING. 3.0 Semester Hrs.**

Equivalent with CEEN481,ESGN459,

(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: CEEN301. 3 hour lecture; 3 semester hours.

**CEEN398. SPECIAL TOPICS IN CIVIL AND ENVIRONMENTAL ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**CEEN399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

**CEEN405. NUMERICAL METHODS FOR ENGINEERS. 3.0 Semester Hrs.**

Equivalent with EGGN460,

(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, CEEN311. 3 hours lecture; 3 semester hours.

**CEEN406. FINITE ELEMENT METHODS FOR ENGINEERS. 3.0 Semester Hrs.**

Equivalent with EGGN442,

(II) A course combining finite element theory with practical programming experience in which the multi-disciplinary nature of the finite element method as a numerical technique for solving differential equations is emphasized. Topics covered include simple structural element, solid elasticity, steady state analysis, transient analysis. Students get a copy of all the source code published in the course textbook. Prerequisite: CEEN311. 3 hours lecture; 3 semester hours.

**CEEN410. ADVANCED SOIL MECHANICS. 3.0 Semester Hrs.**

Equivalent with EGGN448,

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: CEEN312. 3 hour lectures; 3 semester hours. Fall even years.

**CEEN411. SOIL DYNAMICS. 3.0 Semester Hrs.**

Equivalent with CEEN512,EGGN431,

(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: CEEN311, CEEN312, and MATH225. 3 hours lecture; 3 semester hours.

**CEEN412. UNSATURATED SOIL MECHANICS. 3.0 Semester Hrs.**

Equivalent with CEEN511,

(II) Systematic introduction of soil mechanics under partially saturated conditions. Topics include principles of seepage under variably saturated conditions, principle of the effective stress, shear strength theory, and hydraulic and mechanical properties. When this course is cross-listed and concurrent with CEEN511, students that enroll in CEEN511 will complete additional and/or more complex assignments. Prerequisites: CEEN312. 3 lecture hours, 3 semester hours.

**CEEN415. FOUNDATION ENGINEERING. 3.0 Semester Hrs.**

Equivalent with EGGN464,

(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: CEEN312. 3 hours lecture; 3 semester hours.

**CEEN421. HIGHWAY AND TRAFFIC ENGINEERING. 3.0 Semester Hrs.**

Equivalent with EGGN435,

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.

**CEEN423. SURVEYING FOR ENGINEERS AND INFRASTRUCTURE DESIGN PRACTICES. 3.0 Semester Hrs.**

Equivalent with EGGN333,EGGN433,

(I) Applications of civil engineering skills using the engineer's level, total station, GPS receiver, and commercial software for field data collection, design, and layout of civil infrastructure including survey control, roadways, intersections, and utilities such as water and sewer. The course includes basic road design, horizontal design, vertical design, centerline layout, slope/cross section staking, earthwork volume calculations, engineering astronomy, and preparation of plan/profile drawings. Some discussion of concepts and mathematics of applying GPS data to engineering projects and the principles of map projections (Mercator, Lambert, UTM, State Plane, etc.) and coordinate systems such as (North American Datum) NAD '27, NAD '83, and other reference networks is included. Prerequisite: CEEN331. 2 hours lecture; 8-9 field work days; 3 semester hours.

**CEEN430. ADVANCED STRUCTURAL ANALYSIS. 3.0 Semester Hrs.**

Equivalent with EGGN441,

(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: CEEN314. 3 hour lectures; 3 semester hours.

**CEEN433. MATRIX STRUCTURAL ANALYSIS. 3.0 Semester Hrs.**

Equivalent with CEEN533,

(II) Focused study on computer oriented methods for solving determinate and indeterminate structures such as trusses and frames. Classical stiffness based analysis method will be introduced with hands-on practice to develop customized matrix analysis program using Matlab. Commercial structural analysis programs will also be introduced during the class and practiced through class projects. When this course is cross-listed and concurrent with CEEN533, students that enroll in CEEN533 will complete additional and/or more complex assignments. Prerequisite: CEEN314. 3 lecture hours, 3 semester hours.

**CEEN440. TIMBER AND MASONRY DESIGN. 3.0 Semester Hrs.**

Equivalent with EGGN447,

(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: CEEN311 or equivalent. 3 hours lecture: 3 semester hours. Spring odd years.

**CEEN441. INTRODUCTION TO THE SEISMIC DESIGN OF STRUCTURES. 3.0 Semester Hrs.**

Equivalent with EGGN494,

(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: CEEN443, or CEEN445, or CEEN440. 3 hours lecture; 3 semester hours.

**CEEN443. DESIGN OF STEEL STRUCTURES. 3.0 Semester Hrs.**

Equivalent with EGGN444,

(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: CEEN314. 3 hours lecture; 3 semester hours.

**CEEN445. DESIGN OF REINFORCED CONCRETE STRUCTURES. 3.0 Semester Hrs.**

Equivalent with EGGN445,

(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: CEEN314. 3 hours lecture; 3 semester hours.

**CEEN461. FUNDAMENTALS OF ECOLOGY. 3.0 Semester Hrs.**

Equivalent with ESGN401,

(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.

**CEEN470. WATER AND WASTEWATER TREATMENT PROCESSES. 3.0 Semester Hrs.**

Equivalent with BELS453,EGGN453,ESGN453,

(I) The goal of this course is to familiarize students with the unit operations and processes involved in water and wastewater treatment. This course will focus on the physical, chemical, and biological processes for water and wastewater treatment and reclamation. Treatment objectives, process theory, and practice are considered in detail. Prerequisite: CEEN301. 3 hours lecture; 3 semester hours.

**CEEN471. WATER AND WASTEWATER TREATMENT SYSTEMS ANALYSIS AND DESIGN. 3.0 Semester Hrs.**

(II) The goal of this course is to familiarize students with the design of domestic and industrial water and wastewater treatment systems. This course will focus on the combination of physical, chemical, and biological processes and technologies to form a water or wastewater treatment system. Source water quality, treatment objectives, water reuse, multi-barrier approaches, and water and energy efficiency are considered in detail. Prerequisites: CEEN470, or CEEN570, or other water or wastewater treatment design courses (for graduate students enrolled in this course). 3 hours lecture; 3 semester hours.

**CEEN472. ONSITE WATER RECLAMATION AND REUSE. 3.0 Semester Hrs.**

Equivalent with ESGN460,

(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: CEEN301. 3 hours lecture; 3 semester hours.

**CEEN473. HYDRAULIC PROBLEMS. 3.0 Semester Hrs.**

Equivalent with EGGN451,

(I,II) 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. Prerequisites: CEEN310. 3 hours lecture; 3 semester hours.

**CEEN474. SOLID WASTE MINIMIZATION AND RECYCLING. 3.0 Semester Hrs.**

Equivalent with ESGN462,

(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 3 hours lecture; 3 semester hours.

**CEEN475. SITE REMEDIATION ENGINEERING. 3.0 Semester Hrs.**

Equivalent with EGGN457,ESGN457,

(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: CEEN302. 3 hours lecture; 3 semester hours.

**CEEN476. POLLUTION PREVENTION: FUNDAMENTALS AND PRACTICE. 3.0 Semester Hrs.**

Equivalent with ESGN463,

(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: CEEN301 or CEEN302. 3 hours lecture; 3 semester hours.

**CEEN477. SUSTAINABLE ENGINEERING DESIGN. 3.0 Semester Hrs.**

Equivalent with EGGN490,

(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; 3 hours lecture, 3 semester hours.

**CEEN480. CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT. 3.0 Semester Hrs.**

Equivalent with ESGN440,

(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: CEEN301. 3 hours lecture; 3 semester hours.

**CEEN481. SEE CEEN381. 3.0 Semester Hrs.**

Equivalent with CEEN381,ESGN459,

**CEEN482. HYDROLOGY AND WATER RESOURCES LABORATORY. 3.0 Semester Hrs.**

(I) This course introduces students to the collection, compilation, synthesis and interpretation of data for quantification of the components of the hydrologic cycle, including precipitation, evaporation, infiltration, and runoff. Students will use hydrologic variables and parameters to evaluate watershed processes and behavior. Students will also survey and apply measurement techniques necessary for watershed studies. Advanced topics include development, construction, and application of analytical models for selected problems in hydrology and water resources. Prerequisites: CEEN481. 2 hour lecture; 3 hour lab; 3 semester hours.

**CEEN492. ENVIRONMENTAL LAW. 3.0 Semester Hrs.**

Equivalent with ESGN490,

(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: CEEN301 or CEEN302. 3 hours lecture; 3 semester hours.

**CEEN497. SPECIAL SUMMER COURSE. 15.0 Semester Hrs.****CEEN498. SPECIAL TOPICS IN CIVIL AND ENVIRONMENTAL ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**CEEN499. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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

2016-2017

## Program Description

The Department of Electrical Engineering and Computer Science develops graduates who 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. 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 multidisciplinary 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 three specific areas: energy and power systems; antennas and wireless communications; 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 be come 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.

Students get early-hands-on-design experience in the first year through the Engineering Practice Introductory Course (EPIC I). 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 Bachelors of Science degree in Electrical Engineering is accredited by ABET.

### 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 BSEE degree:

1. Graduates will be working in their chosen field or will be successfully pursuing a graduate degree.
2. Graduates will be situated in growing careers, generating new knowledge, and exercising leadership in the field of electrical engineering.
3. Graduates will be contributing to the needs of society through professional practice, research, and service.

## Bachelor of Science in Computer Science Degree Requirements:

### Freshman

Fall		lec	lab	sem.hrs
CSCI101	INTRODUCTION TO COMPUTER SCIENCE			3.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
LAIS100	NATURE AND HUMAN VALUES			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				<b>16.0</b>
Spring		lec	lab	sem.hrs
CSCI261	PROGRAMMING CONCEPTS			3.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
EPIC151	DESIGN (EPICS) I			3.0
PHGN100	PHYSICS I - MECHANICS			4.5

PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				<b>15.0</b>

### Sophomore

Fall		lec	lab	sem.hrs
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS			4.5
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS, CBEN 110, CHGN 122, or CHGN 125 (Distributed Science Elective)			4.0
CSCI262	DATA STRUCTURES			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				<b>16.0</b>

### Spring

Spring		lec	lab	sem.hrs
CSCI341	COMPUTER ORGANIZATION			3.0
CSCI358	DISCRETE MATHEMATICS			3.0
EBGN201	PRINCIPLES OF ECONOMICS			3.0
MATH225	DIFFERENTIAL EQUATIONS			3.0
LAIS200	HUMAN SYSTEMS			3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				<b>15.5</b>

### Junior

Fall		lec	lab	sem.hrs
CSCI306	SOFTWARE ENGINEERING			3.0
MATH332	LINEAR ALGEBRA			3.0
CSCI403	DATA BASE MANAGEMENT			3.0
FREE	Free Elective			3.0
FREE	Free Elective			3.0
				<b>15.0</b>
Spring		lec	lab	sem.hrs

CSCI406	ALGORITHMS			3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS			3.0
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

Summer		lec	lab	sem.hrs
CSCI370	ADVANCED SOFTWARE ENGINEERING			6.0
				<b>6.0</b>

### Senior

Fall		lec	lab	sem.hrs
CSCI442	OPERATING SYSTEMS			3.0
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 sem.hrs</b>
CSCI400	PRINCIPLES OF PROGRAMMING LANGUAGES		3.0
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 Semester Hrs: 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 sem.hrs</b>
CHGN121	PRINCIPLES OF CHEMISTRY I		4.0

GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS, CBEN 110, CSCI 101, CHGN 122, or CHGN 125 (Distributed Science 1. May not use both CHGN122 and 125)		4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I		4.0
LAIS100	NATURE AND HUMAN VALUES		4.0
CSM101	FRESHMAN SUCCESS SEMINAR		0.5
PAGN	PHYSICAL ACTIVITY COURSE		0.5
Elective			

**17.0**

<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II		4.0
EPIC151	DESIGN (EPICS) I		3.0
PHGN100	PHYSICS I - MECHANICS		4.5
CSCI101	INTRODUCTION TO COMPUTER SCIENCE, CBEN 110, GEGN 101, CHGN 122, or CHGN 125 (Distributed Science 2. May not use both CHGN122 and CHGN125)		3.0
PAGN	PHYSICAL ACTIVITY COURSE		0.5
Elective			

**15.0**

<b>Sophomore</b>			
<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>
LAIS200	HUMAN SYSTEMS		3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III		4.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS		4.5
CSCI261	PROGRAMMING CONCEPTS		3.0
PAGN	PHYSICAL ACTIVITY COURSE		0.5
Elective			

**15.0**

<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
MATH225	DIFFERENTIAL EQUATIONS		3.0
EBGN201	PRINCIPLES OF ECONOMICS		3.0
EENG284	DIGITAL LOGIC		4.0
EENG282	ELECTRICAL CIRCUITS		4.0
PAGN	PHYSICAL ACTIVITY COURSE		0.5
Elective			

**14.5**

<b>Junior</b>			
<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>
MATH332	LINEAR ALGEBRA		3.0
MEGN361	THERMODYNAMICS I or CEEN 241		3.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS		3.0
EENG310	INFORMATION SYSTEMS SCIENCE I		4.0

EENG383	MICROCOMPUTER ARCHITECTURE AND INTERFACING		4.0	
			<b>17.0</b>	
<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
EENG385	ELECTRONIC DEVICES AND CIRCUITS		4.0	
EENG386	FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS		3.0	
EENG389	FUNDAMENTALS OF ELECTRIC MACHINERY		4.0	
EENG311	INFORMATION SYSTEMS SCIENCE II (Information Systems Science II)		3.0	
			<b>14.0</b>	
<b>Summer</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
EENG334	ENGINEERING FIELD SESSION, ELECTRICAL		3.0	
			<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	
EENG450	SYSTEMS EXPLORATION AND ENGINEERING DESIGN LAB		1.0	
EGGN491	SENIOR DESIGN I		3.0	
ELEC Elective	Electrical Engineering Elective *		3.0	
ELEC Elective	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		3.0	
ELEC Elective	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 Semester Hrs: 129.5**

\* Electrical Engineering students are required to take three Electrical Engineering Electives from the following list:

### Electrical Engineering Electives:

CEEN405	NUMERICAL METHODS FOR ENGINEERS	3.0
CSCI410	ELEMENTS OF COMPUTING SYSTEMS	3.0
CSCI341	COMPUTER ORGANIZATION	3.0
CSCI440	PARALLEL COMPUTING FOR SCIENTISTS AND ENGINEERS	3.0
EENG411	DIGITAL SIGNAL PROCESSING	3.0
EENG413	ANALOG AND DIGITAL COMMUNICATION SYSTEMS	4.0

EENG417	MODERN CONTROL DESIGN	3.0
EENG470	INTRODUCTION TO HIGH POWER ELECTRONICS	3.0
EENG472	PRACTICAL DESIGN OF SMALL RENEWABLE ENERGY SYSTEMS	3.0
EENG480	POWER SYSTEMS ANALYSIS	3.0
EENG481	ANALYSIS AND DESIGN OF ADVANCED ENERGY SYSTEMS	3.0
EENG489	COMPUTATIONAL METHODS IN ENERGY SYSTEMS AND POWER ELECTRONICS	3.0
MATH334	INTRODUCTION TO PROBABILITY	3.0
MATH335	INTRODUCTION TO MATHEMATICAL STATISTICS	3.0
MATH455	PARTIAL DIFFERENTIAL EQUATIONS	3.0
MEGN330	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3.0
MEGN441	INTRODUCTION TO ROBOTICS (Introduction to Mathematical Physics)	3.0
PHGN300	PHYSICS III-MODERN PHYSICS I	3.0
PHGN320	MODERN PHYSICS II: BASICS OF QUANTUM MECHANICS	4.0
PHGN435	INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY	3.0
PHGN440	SOLID STATE PHYSICS	3.0
PHGN441	SOLID STATE PHYSICS APPLICATIONS AND PHENOMENA	3.0
PHGN462	ELECTROMAGNETIC WAVES AND OPTICAL PHYSICS	3.0

\*Additional EENG or CSCI 400 level and graduate level classes taught in the EECS department can be considered as tech electives. Talk to your advisor for further guidance. 300 level or higher courses from other departments can be considered by the Department Head.

## Combined BS/MS in Electrical Engineering

The Department of Electrical Engineering and Computer Science offers a combined

Bachelor of Science/Master of Science program in Electrical Engineering that enables

students to work on a Bachelor of Science and a Master of Science simultaneously. This allows undergraduate students to take courses that will count for their graduate degree requirements, while still finishing their undergraduate degree requirements. This will be especially attractive to students who intend to go on to the graduate program, and have availability in their schedules even while fulfilling the undergraduate requirements. Another advantage is that there is an expedited graduate school application process, as described below.

Students must be admitted into the Combined BS/MS degree program prior to the close of registration of the term in which any course toward the MS degree will be applied. Typically this is the beginning of the student's Senior year, but students may apply as early as the first semester of their Junior year. Admissions must be granted no later than the end of registration in the last semester of the Senior year. In order to apply for the combined program, a pro forma graduate school application is submitted, and as long as the undergraduate portion of the program is successfully completed and the student has a GPA above 3.0, the

student is admitted to the non-thesis Master of Science degree program in Electrical Engineering.

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). There is no limit on the number of graduate level (500-level and above) courses a student may take beyond the undergraduate degree requirements, but a student must complete at least one semester as a registered graduate student after completion of the undergraduate degree before being awarded a graduate degree. Students must declare graduate courses through the Registrar's Office at time of registration. Grades count toward the graduate GPA and must meet the minimum grade requirements (C# or higher) to be counted toward graduation requirements. Courses may not be used to meet undergraduate financial aid requirements. Students will declare course work as regular graduate courses on Admission to Candidacy Form. Students should follow the MS Non-thesis degree requirements based on their track in selecting appropriate graduate degree 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 Baccalaureate and Electrical Engineering Masters Degrees

The Department of Electrical Engineering and Computer Science, in collaboration with the Department of Physics, offers a five-year program in which students have the opportunity to obtain specific engineering skill to complement their physics background. Physics students in this program fill in their technical and free electives over their standard four year Engineering Physics 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 degree. Course schedules for this five-year program can be obtained in the Physics Departmental Offices.

General CSM Minor/ASI requirements can be found here (p. 42).

## Computer Science

For an **Area of Special Interest in Computer Science**, the student should take:

CSCI262	DATA STRUCTURES	3.0
CSCI306	SOFTWARE ENGINEERING	3.0

and either

CSCI358	DISCRETE MATHEMATICS	3.0
CSCI406	ALGORITHMS	3.0

or

CSCI341	COMPUTER ORGANIZATION	3.0
CSCI442	OPERATING SYSTEMS	3.0

For a **Minor in Computer Science**, the student should take:

CSCI262	DATA STRUCTURES	3.0
CSCI306	SOFTWARE ENGINEERING	3.0

and either

CSCI358	DISCRETE MATHEMATICS	3.0
CSCI406	ALGORITHMS	3.0

or

CSCI341	COMPUTER ORGANIZATION	3.0
CSCI442	OPERATING SYSTEMS	3.0

along with two 400-level Computer Science courses, which may not be languages transferred from another university.

## Electrical Engineering

ASI in Electrical Engineering

The following twelve credit sequence is required for an ASI in Electrical Engineering: (See Minor/ASI section of the Bulletin for all rules for ASIs at CSM.)

EENG281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER	3.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG386	FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS	3.0
EENG417	MODERN CONTROL DESIGN	3.0
or EENG421	SEMICONDUCTOR DEVICE PHYSICS AND DESIGN	

Minor in Electrical Engineering

A minimum of eighteen credits are required for a Minor in Electrical Engineering as follows. (See Minor/ASI section of the Bulletin for all rules for minors at CSM.)

Students must complete an eighteen credit hour sequence as described below for a minor in EE. All students seeking a minor in EE will need to take one of two possible versions of Electrical Circuits and EENG 307 (3 credits) after which they can pick an emphasis area to complete the remaining minor requirements. The four emphasis areas are as follows

1. Information Systems and Science (ISS), 18 or 18.5 credits

EENG282	ELECTRICAL CIRCUITS	4.0
or EENG281 & EGGN250	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER and MULTIDISCIPLINARY ENGINEERING LABORATORY	
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG284	DIGITAL LOGIC	4.0
EENG310	INFORMATION SYSTEMS SCIENCE I	4.0
EENG311	INFORMATION SYSTEMS SCIENCE II	3.0

2. Energy Systems and Power (ESPE), 18 credits

EENG282	ELECTRICAL CIRCUITS	4.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG385	ELECTRONIC DEVICES AND CIRCUITS	4.0

EENG386	FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS	3.0
EENG389	FUNDAMENTALS OF ELECTRIC MACHINERY	4.0

### 3. Digital Systems, 18 or 18.5 credits

EENG282 or EENG281 & EGGN250	ELECTRICAL CIRCUITS INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER and MULTIDISCIPLINARY ENGINEERING LABORATORY	4.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG284	DIGITAL LOGIC	4.0
EENG383	MICROCOMPUTER ARCHITECTURE AND INTERFACING	4.0
EENG421	SEMICONDUCTOR DEVICE PHYSICS AND DESIGN	3.0

### 4. General Electrical Engineering, 19 or 19.5 credits

EENG282 or EENG281 & EGGN250	ELECTRICAL CIRCUITS INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER and MULTIDISCIPLINARY ENGINEERING LABORATORY	4.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG284	DIGITAL LOGIC	4.0
EENG310	INFORMATION SYSTEMS SCIENCE I	4.0
EENG385	ELECTRONIC DEVICES AND CIRCUITS	4.0

## Interim Department Head & Professor

Atef Elsherbeni, Dobelman Chair

### Professors

Kevin Moore, College Dean

Tracy Camp

Randy Haupt

Dinesh Mehta

P.K. Sen

Tyrone Vincent

### Associate Professors

Qi Han

William Hoff

Kathryn Johnson

Marcelo Simoes

Michael Wakin, Ben L. Fryrear

### Assistant Professors

Salman Mohagheghi

Payam Nayeri

Gongguo Tang

Hua Wang

Bo Wu

Dejun Yang, Ben L. Fryrear

Chuan Yue

Hao Zhang

## Teaching Professors

Ravel Ammerman

Vibhuti Dave

Cyndi Rader

Jeffrey Schowalter

## Teaching Associate Professors

Stephanie Claussen

Keith Hellman

Christopher Painter-Wakefield

Jeffrey Paone

## Emerita Associate Professor

Catherine Skokan

## Courses

### CSCI101. INTRODUCTION TO COMPUTER SCIENCE. 3.0 Semester Hrs.

(I, II) 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, relational databases, structured queries, and computer simulations. A popular procedural programming language will be learned by students and programming assignments will explore ideas from algorithm development, optimization, and computer simulation. Prerequisite: none. 3 hours lecture; 3 semester hours.

### CSCI198. SPECIAL TOPICS. 1-6 Semester Hr.

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### CSCI199. INDEPENDENT STUDY. 1-6 Semester Hr.

(I, II) Individual research or special problem projects supervised by a faculty member, 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.

**CSCI260. FORTRAN PROGRAMMING. 2.0 Semester Hrs.**

Equivalent with MACS260,

(I) 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 Semester Hrs.**

Equivalent with MACS261,

(I, II) This course introduces fundamental computer programming concepts using a high-level language and a modern development environment. Programming skills include sequential, selection, and repetition control structures, functions, input and output, primitive data types, basic data structures including arrays and pointers, objects, and classes. Software engineering skills include problem solving, program design, and debugging practices. Prerequisite: none. 3 hours lecture; 3 semester hours.

**CSCI262. DATA STRUCTURES. 3.0 Semester Hrs.**

Equivalent with MACS262,

(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 Semester Hr.**

(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: CSCI 261. 1 hour lecture; 1 semester hour.

**CSCI298. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**CSCI299. INDEPENDENT STUDY. 1-6 Semester Hr.**

(I, II) Individual research or special problem projects supervised by a faculty member, 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 Semester Hrs.**

Equivalent with MACS306,

(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 Semester Hrs.**

(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 Semester Hrs.**

Equivalent with MACS341,

(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. Co-requisites: CSCI262. 3 hours lecture; 3 semester hours.

**CSCI358. DISCRETE MATHEMATICS. 3.0 Semester Hrs.**

Equivalent with MACS358, MATH358,

(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 Semester Hrs.**

(S) (WI) This capstone course has three primary goals: (1) to enable students to apply their course work knowledge to a challenging applied problem for a real client, (2) to enhance students' verbal and written communication skills, and (3) to provide an introduction to ethical decision making in computer science. Ethics and communication skills are emphasized in a classroom setting. The client work is done in small teams, either on campus or at the client site. Faculty advisors provide guidance related to the software engineering process, which is similar to Scrum. By the end of the course students must have a finished product with appropriate documentation. Prerequisite: CSCI306. 6-week summer session; 6 semester hours.

**CSCI398. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**CSCI399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(I, II) Individual research or special problem projects supervised by a faculty member, 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 Semester Hrs.**

Equivalent with MACS400,

(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 Semester Hrs.**

Equivalent with MACS403,

(I) 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 Semester Hrs.**

Equivalent with MACS404,

(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 MATH201. 3 hours lecture; 3 semester hours.

**CSCI406. ALGORITHMS. 3.0 Semester Hrs.**

Equivalent with MACS406, MATH406,

(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, MATH/CSCI358. 3 hours lecture; 3 semester hours.

**CSCI410. ELEMENTS OF COMPUTING SYSTEMS. 3.0 Semester Hrs.**

(I, 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: CSCI341 or EENG383. 3 lecture hours, 3 credit hours.

**CSCI422. USER INTERFACES. 3.0 Semester Hrs.**

Equivalent with MACS422,

(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.

**CSCI423. COMPUTER SIMULATION. 3.0 Semester Hrs.**

(I) A first course in computer simulation. A project based course emphasizing the rigorous development of simulation applications. Topics will include random number generation, Monte Carlo simulation, discrete event simulation, and the mathematics behind their proper implementation and analysis. To a lesser extent we may discuss, time-step simulations and parallel simulations. The course uses journaling, programming projects and exams for assessment. Prerequisite: CSCI306, and MATH323 or MATH201, and CSCI274. 3 hours lecture; 3 semester hours.

**CSCI440. PARALLEL COMPUTING FOR SCIENTISTS AND ENGINEERS. 3.0 Semester Hrs.**

Equivalent with MATH440,

(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 Semester Hrs.**

Equivalent with MATH441,

(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 Semester Hrs.**

Equivalent with MACS442,

(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 Semester Hrs.**

Equivalent with MACS443,

(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 networking as implemented in Java will be discussed. The basics of the Java Virtual Machine will be presented. Prerequisite: CSCI306. 3 hours lecture; 3 semester hours.

**CSCI444. ADVANCED COMPUTER GRAPHICS. 3.0 Semester Hrs.**

Equivalent with MATH444,

(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 Semester Hrs.**

Equivalent with MACS445,

(I) 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. Co-requisite: CSCI403. 3 hours lecture; 3 semester hours.

**CSCI446. WEB APPLICATIONS. 3.0 Semester Hrs.**

(II) 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. Co-requisites: CSCI400. 3 hours lecture, 3 semester hours.

**CSCI447. SCIENTIFIC VISUALIZATION. 3.0 Semester Hrs.**

Equivalent with MATH447,

(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.

**CSCI448. MOBILE APPLICATION DEVELOPMENT. 3.0 Semester Hrs.**

(I) This course covers basic and advanced topics in mobile application development. Topics include the mobile application lifecycle, user interface components and layouts, storing persistent data, accessing network resources, using location and sensor APIs including GPS and accelerometer, starting and stopping system services, and threading. This is a project-based course where students will design and develop complete applications. Prerequisite: CSCI306 with a grade of C- or higher. Repeatable: Yes, if taught on a different platform (e.g., Android vs. iPhone) up to 6 hours. 3 hours lecture; 3.0 semester hours.

**CSCI471. COMPUTER NETWORKS I. 3.0 Semester Hrs.**

(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. 3 hours lecture, 3 semester hours.

**CSCI473. HUMAN-CENTERED ROBOTICS. 3.0 Semester Hrs.**

Equivalent with CSCI573,

(I) Human-centered robotics is an interdisciplinary area that bridges research and application of methodology from robotics, machine vision, machine learning, human-computer interaction, human factors, and cognitive science. Students will learn about fundamental research in human-centered robotics, as well as develop computational models for robotic perception, internal representation, robotic learning, human-robot interaction, and robot cognition for decision making. Prerequisites: CSCI262 and MATH201. 3 hours lecture; 3 semester hours.

**CSCI474. INTRODUCTION TO CRYPTOGRAPHY. 3.0 Semester Hrs.**

Equivalent with MATH474,

(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, CSCI358, MATH334 or MATH335 or MATH201. 3 hours lecture; 3 semester hours.

**CSCI475. INFORMATION SECURITY AND PRIVACY. 3.0 Semester Hrs.**

(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: CSCI 262 and CSCI 341 (required); CSCI 274 (recommended). 3 hours lecture; 3 semester hours.

**CSCI498. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**CSCI499. INDEPENDENT STUDY. 1-6 Semester Hr.**

(I, II) Individual research or special problem projects supervised by a faculty member, 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.



**EENG198. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**EENG199. INDEPENDENT STUDY. 1-6 Semester Hr.**

(I, II) Individual research or special problem projects supervised by a faculty member, 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.

**EENG281. INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER. 3.0 Semester Hrs.**

Equivalent with DCGN381,EGGN281,EGGN381,  
(I, II) 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, Thevenin 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. May not also receive credit for EENG282. Prerequisites: PHGN200; 3 hours lecture; 3 semester hours.

**EENG282. ELECTRICAL CIRCUITS. 4.0 Semester Hrs.**

(I,II) This course provides an engineering science analysis of electrical circuits. DC and AC (single-phase and three-phase) networks are presented. Transient analysis of RC and RL circuits is studied as is the analysis of circuits in sinusoidal steady-state using phasor concepts. The following topics are included: DC and AC circuit analysis, current and charge relationships. Ohm's Law, resistors, inductors, capacitors, equivalent resistance and impedance, Kirchhoff's Laws, Thevenin 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 steady-state analysis of single-phase and three-phase ac power circuits. May not also receive credit for EENG281. Prerequisites: PHGN200. 3 hours lecture; 3 hours lab; 4 semester hours.

**EENG284. DIGITAL LOGIC. 4.0 Semester Hrs.**

Equivalent with EGGN284,EGGN384,  
(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. Prerequisites: CSCI261. Co-requisites: EENG282 or EENG281 or PHGN215. 3 hours lecture; 3 hours lab; 4 semester hours.

**EENG298. SPECIAL TOPICS IN ELECTRICAL ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**EENG299. INDEPENDENT STUDY. 1-6 Semester Hr.**

(I, II) Individual research or special problem projects supervised by a faculty member, 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.

**EENG307. INTRODUCTION TO FEEDBACK CONTROL SYSTEMS. 3.0 Semester Hrs.**

Equivalent with EGGN307,EGGN407,  
(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: EENG281 or EENG282 or PHGN215, and MATH225. 3 hours lecture; 3 semester hours.

**EENG310. INFORMATION SYSTEMS SCIENCE I. 4.0 Semester Hrs.**

Equivalent with EENG388,EGGN388,  
(I, II) The interpretation, representation and analysis of time-varying 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. Prerequisites: (EENG281 or EENG282 or PHGN215) and MATH225. 3 hours lecture; 1 hour recitation, 4 semester hours.

**EENG311. INFORMATION SYSTEMS SCIENCE II. 3.0 Semester Hrs.**

(I,II) This course covers signals and noise in electrical systems. Topics covered include information theory, signal to noise ratio, random variables, probability density functions, statistics, noise, matched filters, coding and entropy, power spectral density, and bit error rate. Applications are taken from radar, communications systems, and signal processing. Prerequisite: EENG310. 3 hours lecture; 3 semester hours.

**EENG334. ENGINEERING FIELD SESSION, ELECTRICAL. 3.0 Semester Hrs.**

Equivalent with EGGN334,  
(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: EENG284, EENG385 and EENG389. Three weeks in summer session; 3 semester hours.

**EENG340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.**

Equivalent with EGGN340,EGGN340E,  
(I,II,S) Supervised, full-time engineering related employment for a continuous six-month period in which specific educational objectives are achieved. Students must meet with the Department Head prior to enrolling to clarify the educational objectives for their individual Co-op program. Prerequisites: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 3 semester hours credit will be granted once toward degree requirements. Credit earned in EENG340, Cooperative Education, may be used as free elective credit hours if, in the judgment of the Department Head, the required term paper adequately documents the fact that the work experience entailed high-quality application of engineering principles and practice. Applying the credits as free electives requires the student to submit a Declaration of Intent to Request Approval to Apply Co-op Credit toward Graduation Requirements form obtained from the Career Center to the Department Head.

**EENG382. ENGINEERING CIRCUIT ANALYSIS. 3.0 Semester Hrs.**

Equivalent with EGGN382,

(I, II) This course provides for the continuation of basic circuit analysis techniques developed in EENG281, 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) Frequency response of active and passive filter circuits, (iv) Circuit Analysis using Fourier Series, (v) Circuit Analysis using Fourier Transforms, (vi) Two-port networks. The course features PSPICE, a commercial circuit analysis software package. Prerequisites: EENG281. 3 Semester Hours.

**EENG383. MICROCOMPUTER ARCHITECTURE AND INTERFACING. 4.0 Semester Hrs.**

Equivalent with EGGN383, EGGN482,

(I, II) 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. Prerequisites: (EENG281 or EENG282 or PHGN215) and EENG284. 3 hours lecture; 3 hours lab; 4 semester hours.

**EENG385. ELECTRONIC DEVICES AND CIRCUITS. 4.0 Semester Hrs.**

Equivalent with EGGN385,

(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. Prerequisites: EENG382 or EENG307. 3 hours lecture; 3 hours lab; 4 semester hours.

**EENG386. FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS. 3.0 Semester Hrs.**

Equivalent with EGGN386,

(I, 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: EENG281 or EENG282 or EENG382, and MATH225. 3 hours lecture; 3 semester hours.

**EENG389. FUNDAMENTALS OF ELECTRIC MACHINERY. 4.0 Semester Hrs.**

Equivalent with EGGN389,

(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. Prerequisites: EENG282 or EENG382. Co-requisite: EENG386. 3 hours lecture; 3 hours lab; 4 semester hours.

**EENG398. SPECIAL TOPICS IN ELECTRICAL ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**EENG399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(I, II) Individual research or special problem projects supervised by a faculty member, 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.

**EENG411. DIGITAL SIGNAL PROCESSING. 3.0 Semester Hrs.**

Equivalent with EGGN481,

(II) 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: EENG310. 3 hours lecture; 3 semester hours.

**EENG413. ANALOG AND DIGITAL COMMUNICATION SYSTEMS. 4.0 Semester Hrs.**

Equivalent with EGGN483,

(II) Signal classification; Fourier transform; filtering; sampling; signal representation; modulation; demodulation; applications to broadcast, data transmission, and instrumentation. Prerequisite: EENG310. 3 hours lecture; 3 hours lab; 4 semester hours.

**EENG417. MODERN CONTROL DESIGN. 3.0 Semester Hrs.**

Equivalent with EGGN417,

(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: EENG307. 3 lecture hours, 3 semester hours.

**EENG421. SEMICONDUCTOR DEVICE PHYSICS AND DESIGN. 3.0 Semester Hrs.**

(I) This course will explore the field of semiconductors and the technological breakthroughs which they have enabled. We will begin by investigating the physics of semiconductor materials, including a brief foray into quantum mechanics. Then, we will focus on understanding pn junctions in great detail, as this device will lead us to many others (bipolar transistors, LEDs, solar cells). We will explore these topics through a range of sources (textbooks, scientific literature, patents) and discuss the effects they have had on Western society. As time allows, we will conclude with topics of interest to the students (possibilities include quantum devices, MOSFETs, lasers, and integrated circuit fabrication techniques). Prerequisite: EENG385. 3 hours lecture; 3 semester hours.

**EENG425. INTRODUCTION TO ANTENNAS. 3.0 Semester Hrs.**

(II) This course provides an introduction to antennas and antenna arrays. Theoretical analysis and use of computer programs for antenna analysis and design will be presented. Experimental tests and demonstrations will also be conducted to complement the theoretical analysis. Students are expected to use MATLAB to model antennas and their performance. Prerequisites: EENG386.

**EENG427. WIRELESS COMMUNICATIONS. 3.0 Semester Hrs.**

(I,II,S) This course provides the tools needed to analyze and design a wireless system. Topics include link budgets, satellite communications, cellular communications, handsets, base stations, modulation techniques, RF propagation, coding, and diversity. Students are expected to complete an extensive final project. Prerequisites: EENG386, EENG311, and EENG310. 3 hours lecture; 3 semester hours.

**EENG450. SYSTEMS EXPLORATION AND ENGINEERING DESIGN LAB. 1.0 Semester Hr.**

(I, II) This laboratory is a semester-long design and build activity centered around a challenge problem that varies from year to year. Solving this problem requires the design and prototyping of a complex system and utilizes concepts from multiple electrical engineering courses. Students work in intra-disciplinary teams, with students focusing on either embedded systems or control systems. Prerequisites: EENG383 and EENG307. 3 hours lab; 1 semester hour.

**EENG470. INTRODUCTION TO HIGH POWER ELECTRONICS. 3.0 Semester Hrs.**

Equivalent with EGGN485,

(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: EENG282. 3 hours lecture; 3 semester hours.

**EENG472. PRACTICAL DESIGN OF SMALL RENEWABLE ENERGY SYSTEMS. 3.0 Semester Hrs.**

Equivalent with EGGN486,

(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: EENG382. 3 hours lecture; 3 semester hours.

**EENG480. POWER SYSTEMS ANALYSIS. 3.0 Semester Hrs.**

Equivalent with EGGN484,

(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: EENG389. 3 hours lecture; 3 semester hours.

**EENG481. ANALYSIS AND DESIGN OF ADVANCED ENERGY SYSTEMS. 3.0 Semester Hrs.**

Equivalent with EGGN487,

(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: EENG480. 2 Lecture Hours, 3 Laboratory Hours, 3 Semester Hours.

**EENG489. COMPUTATIONAL METHODS IN ENERGY SYSTEMS AND POWER ELECTRONICS. 3.0 Semester Hrs.**

(II) The course presents a unified approach for understanding and applying computational methods, computer-aided analysis and design of electric power systems. Applications will range from power electronics to power systems, power quality, and renewable energy. Focus will be on how these seemingly diverse applications all fit within the smart-grid paradigm. This course builds on background knowledge of electric circuits, control of dc/dc converters and inverters, energy conversion and power electronics by preparing students in applying the computational methods for multi-domain simulation of energy systems and power electronics engineering problems. Prerequisites: EENG282 or EENG382. 1 hour lecture, 2 lab hours, 3 semester hours.

**EENG497. SPECIAL SUMMER COURSE. 15.0 Semester Hrs.****EENG498. SPECIAL TOPICS IN ELECTRICAL ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**EENG499. INDEPENDENT STUDY. 1-6 Semester Hr.**

(I, II) Individual research or special problem projects supervised by a faculty member, 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.

# Mechanical Engineering

## 2016-2017

### Program Description

The Mechanical Engineering Department offers a design-oriented undergraduate program that emphasizes fundamental engineering principles. Students receive a strong foundation in mechanical engineering disciplines, and a working knowledge of modern engineering tools. Classroom education is augmented with extensive practical laboratory experiences. Successful graduates are well-prepared for a mechanical engineering career in a world of rapid technological change.

### Bachelor of Science in Mechanical Engineering

During the freshman and sophomore years, students complete a set of core courses that include mathematics, basic sciences, and fundamental engineering disciplines. These years also include engineering design coursework within Engineering Practice Introductory Course (EPIC 151) and Introduction to Mechanical Engineering (MEGN 200). This experience teaches design methodology and stresses the creative aspects of the mechanical engineering profession. Additionally in the first two years, courses in humanities and social sciences allow students to explore the linkages between the environment, human society, and engineered systems.

In the junior and senior years, students complete an advanced engineering core that includes fluid mechanics, thermodynamics, heat transfer, numerical methods, control theory, machine design, computer-aided engineering, and manufacturing processes. This engineering core is complemented by courses in economics and electives in humanities and social sciences. Students must also take three advanced technical electives and three additional free electives to explore specific fields of interest. In the senior year, all students must complete a capstone design course focused on a multidisciplinary engineering project.

Students in mechanical engineering spend considerable time in laboratories, including the CECS Garage with a variety of prototyping and testing equipment. Students are also 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-fluid systems; and robotics, automation, and design.

The Bachelor of Science in Mechanical Engineering degree is accredited by ABET.

### 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. Accordingly, the Mechanical Engineering Program at CSM has established the following program educational objectives for the B.S. in Mechanical Engineering degree:

Within three to five years of completing their degree, graduates will be:

- Applying their Mechanical Engineering education as active contributors in the workforce or graduate school;
- Effective at communicating technical information in a diverse and globally integrated society;
- Demonstrating their commitment to continued professional development through training, coursework, and/or professional society involvement;
- Exemplifying ethical and social responsibility in their professional activities.

## Bachelor of Science in Mechanical Engineering Degree Requirements:

### Freshman

Fall		lec	lab	sem.hrs
LAIS100	NATURE AND HUMAN VALUES			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
CBEN110	FUNDAMENTALS OF BIOLOGY I or GEGN 101			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>17.0</b>

Spring		lec	lab	sem.hrs
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1) or 125			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
EPIC151	DESIGN (EPICS) I			3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

### Sophomore

Fall		lec	lab	sem.hrs
LAIS200	HUMAN SYSTEMS			3.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS			4.5
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
CEEN241	STATICS			3.0
MEGN200	INTRODUCTION TO MECHANICAL ENGINEERING			3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>18.0</b>

Spring		lec	lab	sem.hrs
MTGN202	ENGINEERED MATERIALS			3.0

MEGN361	THERMODYNAMICS I		3.0
EENG281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER		3.0
MATH225	DIFFERENTIAL EQUATIONS		3.0
MEGN312	INTRODUCTION TO SOLID MECHANICS		3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE		0.5
			<b>15.5</b>
<b>Summer</b>		<b>lec</b>	<b>lab sem.hrs</b>
MEGN201	MECHANICAL FIELD SESSION		3.0
			<b>3.0</b>
<b>Junior</b>			
<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>
EBGN201	PRINCIPLES OF ECONOMICS		3.0
ECCN250	MULTIDISCIPLINARY ENGINEERING LABORATORY		1.5
MEGN351	FLUID MECHANICS		3.0
MATH307	INTRODUCTION TO SCIENTIFIC COMPUTING		3.0
MEGN315	DYNAMICS		3.0
MEGN424	COMPUTER AIDED ENGINEERING		3.0
			<b>16.5</b>
<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
LAIS/EBGN	H&SS Restricted Elective I		3.0
ECCN350	MULTIDISCIPLINARY ENGINEERING LABORATORY II		1.5
MEGN471	HEAT TRANSFER		3.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS		3.0
MEGN481	MACHINE DESIGN		4.0
MEGN381	MANUFACTURING PROCESSES		3.0
			<b>17.5</b>
<b>Senior</b>			
<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>
LAIS/EBGN	H&SS Restricted Elective II		3.0
FREE	Free Elective		3.0
ECCN450	MULTIDISCIPLINARY ENGINEERING LABORATORY III		1.0
ECCN491	SENIOR DESIGN I		3.0
MECH ELECT	Mechanical Engineering Elective *		3.0
MECH ELECT	Mechanical Engineering Elective *		3.0
			<b>16.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
FREE	Free Elective		3.0
LAIS/EBGN	H&SS Restricted Elective III		3.0
MECH ELECT	Mechanical Engineering Elective *		3.0
FREE	Free Elective		3.0

ECCN492	SENIOR DESIGN II	3.0
		<b>15.0</b>

**Total Semester Hrs: 134.5**

\* Mechanical Engineering students are required to take three Mechanical Engineering elective courses. At least one of these courses must be from the Advanced Engineering Sciences list. The remaining must be from either the Advanced Engineering Sciences list or the Mechanical Engineering Electives list.

**Advanced Engineering Sciences:**

MEGN412	ADVANCED MECHANICS OF MATERIALS	3.0
MEGN416	ENGINEERING VIBRATION	3.0
MEGN451	FLUID MECHANICS II	3.0
MEGN461	THERMODYNAMICS II	3.0

**Mechanical Engineering Electives:**

CEEN405	NUMERICAL METHODS FOR ENGINEERS	3.0
CEEN406	FINITE ELEMENT METHODS FOR ENGINEERS	3.0
EBGN321	ENGINEERING ECONOMICS	3.0
EENG389	FUNDAMENTALS OF ELECTRIC MACHINERY	4.0
EENG417	MODERN CONTROL DESIGN	3.0
ECCN401	PROJECTS FOR PEOPLE	3.0
MEGN330	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3.0
MEGN430	MUSCULOSKELETAL BIOMECHANICS	3.0
MEGN435	MODELING AND SIMULATION OF HUMAN MOVEMENT	3.0
MEGN436	COMPUTATIONAL BIOMECHANICS	3.0
MEGN441	INTRODUCTION TO ROBOTICS	3.0
MEGN466	INTRODUCTION TO INTERNAL COMBUSTION ENGINES	3.0
MEGN485	MANUFACTURING OPTIMIZATION WITH NETWORK MODELS	3.0
MEGN493	ENGINEERING DESIGN OPTIMIZATION	3.0
MEGN498	SPECIAL TOPICS IN MECHANICAL ENGINEERING (SPECIAL TOPICS)	1-6
MEGN5XX	ANY 500-LEVEL MEGN COURSE	
MTGN311	STRUCTURE OF MATERIALS	3.0
MTGN450	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS	3.0
MTGN445	MECHANICAL PROPERTIES OF MATERIALS	3.0
MTGN463	POLYMER ENGINEERING	3.0
MTGN464	FORGING AND FORMING	2.0
MTGN475	METALLURGY OF WELDING	2.0
NUGN520	INTRODUCTION TO NUCLEAR REACTOR THERMAL-HYDRAULICS	3.0
PHGN300	PHYSICS III-MODERN PHYSICS I	3.0
PHGN350	INTERMEDIATE MECHANICS	4.0
PHGN419	PRINCIPLES OF SOLAR ENERGY SYSTEMS	3.0

## 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.

Admission into a graduate degree program as a Combined Undergraduate/Graduate degree student may occur as early as the first semester Junior year and *must be granted no later than the end of registration the last semester Senior year*. Students must meet minimum GPA admission requirements for the graduate degree.

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 detail into 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. 42).

## Mechanical Engineering Areas of Special Interest (ASI) and Minor Programs

### General Requirements

The Mechanical Engineering Department offers minor and ASI programs. Students who elect an ASI or minor, must fulfill all prerequisite requirements for each course in a chosen sequence. Students in the sciences or mathematics must be prepared to meet prerequisite requirements in fundamental engineering and engineering science courses. Students in engineering disciplines are better positioned to meet the prerequisite requirements for courses in the minor and ASI Mechanical Engineering program. (See Minor/ASI section of the Bulletin for all requirements for a minor/ASI at CSM.)

For an Area of Special Interest in Mechanical Engineering, the student must complete a minimum of 12 hours from the following:

MEGN312	INTRODUCTION TO SOLID MECHANICS	3.0
MEGN315	DYNAMICS	3.0
MEGN351	FLUID MECHANICS	3.0
MEGN361	THERMODYNAMICS I	3.0

For a Minor in Mechanical Engineering, the student must complete a minimum of 18 hours from the following:

#### 1. Required Courses (choose three, 9 credit hours)

MEGN312	INTRODUCTION TO SOLID MECHANICS	3.0
MEGN315	DYNAMICS	3.0
MEGN351	FLUID MECHANICS	3.0
MEGN361	THERMODYNAMICS I	3.0

#### 2. Tracks (choose one track):

Robotics, Automation & Design Track (10 credit hours)

MEGN424	COMPUTER AIDED ENGINEERING	3.0
MEGN481	MACHINE DESIGN	4.0
MEGN381	MANUFACTURING PROCESSES	3.0
or MEGN441	INTRODUCTION TO ROBOTICS	
or MEGN416	ENGINEERING VIBRATION	
or MEGN485	MANUFACTURING OPTIMIZATION WITH NETWORK MODELS	

Solid Materials Track (9 credit hours)

MEGN412	ADVANCED MECHANICS OF MATERIALS	3.0
MEGN416	ENGINEERING VIBRATION	3.0
MEGN424	COMPUTER AIDED ENGINEERING	3.0

Thermal-Fluids Track (9 credit hours)

MEGN451	FLUID MECHANICS II	3.0
MEGN461	THERMODYNAMICS II	3.0
MEGN471	HEAT TRANSFER	3.0

## Biomechanical Engineering Minor

### General Requirements

To obtain a Biomechanical Engineering Minor, students must take at least 18.0 credits from the courses listed below. Fundamentals of Biology I (CBEN110), Fundamentals of Biology II (CBEN120), and Introduction to Biomechanical Engineering (MEGN330) are required (11.0 credits). Three more courses may be chosen from the proposed list of electives. The list of electives will be modified as new related courses become available.

#### Required Courses (11.0 credits)

CBEN110	FUNDAMENTALS OF BIOLOGY I	4.0
CBEN120	FUNDAMENTALS OF BIOLOGY II	4.0
MEGN330	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3.0

#### Biomechanical Engineering Elective Courses

MEGN430	MUSCULOSKELETAL BIOMECHANICS	3.0
MEGN435	MODELING AND SIMULATION OF HUMAN MOVEMENT	3.0
or MEGN535	MODELING AND SIMULATION OF HUMAN MOVEMENT	
MEGN436	COMPUTATIONAL BIOMECHANICS	3.0
or MEGN536	COMPUTATIONAL BIOMECHANICS	
MEGN530	BIOMEDICAL INSTRUMENTATION	3.0
MEGN531	PROSTHETIC AND IMPLANT ENGINEERING	3.0
MEGN532	EXPERIMENTAL METHODS IN BIOMECHANICS	3.0
MEGN537	PROBABILISTIC BIOMECHANICS	3.0
MEGN553	INTRODUCTION TO COMPUTATIONAL TECHNIQUES FOR FLUID DYNAMICS AND TRANSPORT PHENOMENA	3.0
MEGN x98, x99	SPECIAL TOPICS	3.0
MTGN472	BIOMATERIALS I	3.0
or MTGN572	BIOMATERIALS	
MTGN570	BIOCOMPATIBILITY OF MATERIALS	3.0

CBEN311	INTRODUCTION TO NEUROSCIENCE	3.0
CBEN306	ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN	3.0
CBEN309	ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN LABORATORY	1.0
CBEN320	CELL BIOLOGY AND PHYSIOLOGY	3.0
CBEN454 or CBEN554	APPLIED BIOINFORMATICS	3.0
MATH331	MATHEMATICAL BIOLOGY	3.0
PHGN433	BIOPHYSICS	3.0

\* As the content of these courses varies, the course must be noted as relevant to the biomechanical engineering minor.

## Professor and Department Head

Gregory S. Jackson

## George R. Brown Distinguished Professor

Robert J. Kee

## Professors

John R. Berger

Cristian V. Ciobanu

Graham G. W. Mustoe

Alexandra Newman

Brian Thomas

## Associate professors

Joel M. Bach

Robert Braun

Mark Deinert

Anthony Petrella

John P. H. Steele

Neal Sullivan

Ruichong "Ray" Zhang

## Assistant professors

Gregory Bogin

Ozkan Celik

Steven DeCaluwe

Jason Porter

Anne Silverman

Aaron Stebner

Paulo Tabares-Velasco

Nils Tilton

Douglas Van Bossuyt

Xiaoli Zhang

## Teaching Associate Professors

Robert Amaro

Jenifer Blacklock

Jered Dean

Ventzi Karaivanov

Leslie M. Light

Derrick Rodriguez

## Emeriti Professors

Robert King

Michael B. McGrath

## Emerita Professor

Joan P. Gosink

## Emeritus Associate Professor

David Munoz

## Research Professor

George Gilmer

## Research Associate Professor

Huayang Zhu

## Research Assistant Professors

Christopher B. Dryer

Branden Kappes

Canan Karakaya

Andrew Osborne

Sandrine Ricote

## Affiliate Professor of Mechanical Engineering

Michael Mooney

## Courses

### MEGN200. INTRODUCTION TO MECHANICAL ENGINEERING. 3.0 Semester Hrs.

(I, II, S) Students will learn the fundamentals behind mechanical engineering, design and drafting. The course will include an introduction to solid modeling using CAD and/or SolidWorks. Students will also gain understanding of how to visualize and present technical data. Understanding of the design process will be expanded from the previous course by understanding how drawing and prototyping are implemented through practice in a common team design project. Teamwork, presentations, and technical writing will be an integral part of this course. Prerequisites: EPIC151 or EPIC155. 3 hours lecture; 3 semester hours.

**MEGN201. MECHANICAL FIELD SESSION. 3.0 Semester Hrs.**

Equivalent with EGGN235,

(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: EENG281, MEGN200, and MEGN312 or CEEN311. Three weeks in summer field session; 3 semester hours.

**MEGN298. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MEGN299. INDEPENDENT STUDY. 1-6 Semester Hr.**

(I, II) Individual research or special problem projects supervised by a faculty member, 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.

**MEGN312. INTRODUCTION TO SOLID MECHANICS. 3.0 Semester Hrs.**

(I, II, S) Introduction to the theory and application of the principles of Solid Mechanics by placing an early focus on free body diagrams, stress and strain transformations, and failure theories. Covered topics include: stress and stress transformation, strain and strain transformation, mechanical properties of materials, axial load, torsion, bending, transverse shear, combined loading, pressure vessels, failure theories, stress concentrations, thermal stress, deflection of beams and shafts, and column buckling. Upon completion of the course, students will be able to apply the principles of Solid Mechanics to the analysis of elastic structures under simple and combined loading, use free body diagrams in the analysis of structures, use failure theories to assess safety of design, and effectively communicate the outcomes of analysis and design problems. May not also receive credit for CEEN311. Prerequisites: CEEN241 (C- or better). Co-requisites: MEGN200. 3 hours lecture; 3 semester hours.

**MEGN315. DYNAMICS. 3.0 Semester Hrs.**

Equivalent with EGGN315,

(I,II,S) Absolute and relative motions. Kinetics, work-energy, impulse-momentum, vibrations. Prerequisites: CEEN241 (C- or better) and MATH225 (C- or better). 3 hours lecture; 3 semester hours.

**MEGN330. INTRODUCTION TO BIOMECHANICAL ENGINEERING. 3.0 Semester Hrs.**

Equivalent with BELS325,BELS420,EGGN325,EGGN420,

(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: MEGN312 or CEEN311 and PHGN200. Co-requisites: MEGN315. 3 hours lecture; 3 semester hours.

**MEGN340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.**

Equivalent with EGGN340,EGGN340M,

(I,II,S) Supervised, full-time engineering related employment for a continuous six-month period in which specific educational objectives are achieved. Students must meet with the Department Head prior to enrolling to clarify the educational objectives for their individual Co-op program. Prerequisites: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 3 semester hours credit will be granted once toward degree requirements. Credit earned in MEGN340, Cooperative Education, may be used as free elective credit hours if, in the judgment of the Department Head, the required term paper adequately documents the fact that the work experience entailed high-quality application of engineering principles and practice. Applying the credits as free electives requires the student to submit a Declaration of Intent to Request Approval to Apply Co-op Credit toward Graduation Requirements form obtained from the Career Center to the Department Head.

**MEGN351. FLUID MECHANICS. 3.0 Semester Hrs.**

Equivalent with EGGN351,

(I, II) Fluid properties, fluid statics, control-volume analysis, Bernoulli equation, differential analysis and Navier-Stokes equations, dimensional analysis, internal flow, external flow, open-channel flow, and turbomachinery. May not also receive credit for CEEN310 or PEGN251. Prerequisite: CEEN241 (C- or better) or MNGN317 (C- or better). 3 hours lecture; 3 semester hours.

**MEGN361. THERMODYNAMICS I. 3.0 Semester Hrs.**

Equivalent with EGGN371,

(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. May not also receive credit for CHGN209, CBEN210, or GEGN330. Prerequisite: MATH213 (C- or better). 3 hours lecture; 3 semester hours.

**MEGN381. MANUFACTURING PROCESSES. 3.0 Semester Hrs.**

Equivalent with EGGN390,MEGN380,

(I,II,S) Introduction to a wide variety of manufacturing processes with emphasis on process selection and laboratory measurements of process conditions with product variables. Consideration of relations among material properties, process settings, tooling features and product attributes. Design and implementation of a process for manufacture of a given component. Manual and Automated manufacturing and their implementation in plant layouts. Understanding how to eliminate waste in manufacturing processes and enhance scheduling and satisfying client needs. Quality, tolerances and standards will be discussed along with their importance in a manufacturing setting. Prerequisite: MEGN312 or CEEN311, and MTGN202 and MEGN201. 3 lecture hours, 3 semester hours.

**MEGN398. SPECIAL TOPICS IN MECHANICAL ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.



**MEGN399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(I, II) Individual research or special problem projects supervised by a faculty member, 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.

**MEGN412. ADVANCED MECHANICS OF MATERIALS. 3.0 Semester Hrs.**

Equivalent with EGGN422,

(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 non-circular 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: CEEN311 (C- or better) or MEGN312 (C- or better). 3 hours lecture; 3 semester hours.

**MEGN416. ENGINEERING VIBRATION. 3.0 Semester Hrs.**

Equivalent with EGGN478,

(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: MEGN315 (C- or better). 3 hours lecture; 3 semester hours.

**MEGN424. COMPUTER AIDED ENGINEERING. 3.0 Semester Hrs.**

Equivalent with EGGN413,

(I, II, S) 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: MEGN312 (C- or better) or CEEN311 (C- or better). 3 hours lecture; 3 semester hours.

**MEGN425. ADVANCED COMPUTER AIDED ENGINEERING. 3.0 Semester Hrs.**

(I,S) This course studies advanced topics in engineering analysis using the finite element method. The analyses are conducted using commercial FEA software. The advanced topics include: nonlinear large deformations and elasto-plastic behavior, steady and transient heat transfer and thermally induced stresses, mechanical vibrations and transient dynamic phenomena, deformations and stresses in mechanical and structural assemblies, and stress intensity phenomena. Note, the accuracy and validity of FEA results is assessed by comparison with results obtained with exact or approximate analytical methods wherever possible. Prerequisites: MEGN424. 3 hours lecture; 3 semester hours.

**MEGN430. MUSCULOSKELETAL BIOMECHANICS. 3.0 Semester Hrs.**

Equivalent with BELS425,EGGN425,

(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: MEGN315, (MEGN312 or CEEN311), MEGN330, or instructor permission. 3 hours lecture; 3 semester hours.

**MEGN435. MODELING AND SIMULATION OF HUMAN MOVEMENT. 3.0 Semester Hrs.**

Equivalent with BELS426,EGGN426,

(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: MEGN315 and MEGN330. 3 hours lecture; 3 semester hours.

**MEGN436. COMPUTATIONAL BIOMECHANICS. 3.0 Semester Hrs.**

Equivalent with BELS428,BELS428,EGGN428,

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: MEGN424, MEGN330. 3 hours lecture, 3 semester hours. Fall odd years.

**MEGN441. INTRODUCTION TO ROBOTICS. 3.0 Semester Hrs.**

Equivalent with EGGN400,

(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. Prerequisites: CSCI261 and EENG281. 2 hours lecture; 1 hour lab; 3 semester hours.

**MEGN451. FLUID MECHANICS II. 3.0 Semester Hrs.**

Equivalent with EGGN473,

(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: MEGN351 (C- or better). 3 hours lecture; 3 semester hours.

**MEGN461. THERMODYNAMICS II. 3.0 Semester Hrs.**

Equivalent with EGGN403,

(I) This course extends the subject matter of Thermodynamics I (MEGN361) to include the study of exergy, ideal gas mixture properties, psychrometrics and humid air processes, chemical reactions, and the 1st, 2nd and 3rd Laws of Thermodynamics as applied to reacting systems. Chemical equilibrium of multi-component systems, and simultaneous chemical reactions of real combustion and reaction processes are studied. Phase equilibrium, ionization, and the thermodynamics of compressible flow (nozzles and shock) are also introduced. Concepts of the above are explored through the analysis of advanced thermodynamic systems, such as cascaded and absorption refrigeration systems, cryogenics, and advanced gas turbine and combined power cycles. Prerequisites: MEGN351 (C- or better), MEGN361 (C- or better). 3 hours lecture; 3 semester hours.

**MEGN466. INTRODUCTION TO INTERNAL COMBUSTION ENGINES. 3.0 Semester Hrs.**

(II) Introduction to Internal Combustion Engines (ICEs); with a specific focus on Compression Ignition (CI) and Spark Ignition (SI) reciprocating engines. This is an applied thermo science course designed to introduce students to the fundamentals of both 4-stroke and 2-stroke reciprocating engines ranging in size from model airplane engines to large cargo ship engines. Course is designed as a one ? semester course for students without prior experience with IC engines, however, the course will also include advanced engine technologies designed to deliver more horsepower, utilize less fuel, and meet stringent emission regulations. Discussion of advancements in alternative fueled engines will be covered as well. This course also includes an engine laboratory designed to provide hands-on experience and provide further insight into the material covered in the lectures. Prerequisites: MEGN351, MEGN361. Co-requisites: MEGN471. 3 hours lecture; 1.0 hour lab; 3 semester hours.

**MEGN469. FUEL CELL SCIENCE AND TECHNOLOGY. 3.0 Semester Hrs.**

Equivalent with CBEN469, CHEN469, EGGN469, MTGN469,

(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: MEGN361 or CBEN357 or MTGN351. 3 hours lecture; 3 semester hours.

**MEGN471. HEAT TRANSFER. 3.0 Semester Hrs.**

Equivalent with EGGN471,

(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: C- or better in MATH225 or MATH235, MEGN351, MEGN361 or PHGN341. 3 hours lecture; 3 semester hours.

**MEGN481. MACHINE DESIGN. 4.0 Semester Hrs.**

Equivalent with EGGN411,

(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: C- or better in MEGN315 or PHGN350, and MEGN424. 3 hours lecture, 3 hours lab; 4 semester hours.

**MEGN482. MECHANICAL DESIGN USING GD&T. 3.0 Semester Hrs.**

Equivalent with EGGN410,

(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: MEGN201. 3 hours lecture, 3 semester hours.

**MEGN485. MANUFACTURING OPTIMIZATION WITH NETWORK MODELS. 3.0 Semester Hrs.**

Equivalent with EGGN456,

(I) We examine network flow models that arise in manufacturing, energy, mining, transportation and logistics: minimum cost flow models in transportation, shortest path problems in assigning inspection effort on a manufacturing line, and maximum flow models to allocate machine-hours to jobs. We also discuss an algorithm or two applicable to each problem class. Computer use for modeling (in a language such as AMPL) and solving (with software such as CPLEX) these optimization problems is introduced. Prerequisites: MATH111. 3 hours lecture; 3 semester hours.

**MEGN493. ENGINEERING DESIGN OPTIMIZATION. 3.0 Semester Hrs.**

Equivalent with EGGN493,

(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), CSC1260 or CSC1261 or other experience with computer programming languages (Suggested). 3 hours lecture; 3 semester hours.

**MEGN497. SPECIAL SUMMER COURSE. 15.0 Semester Hrs.****MEGN498. SPECIAL TOPICS IN MECHANICAL ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MEGN499. INDEPENDENT STUDY. 1-6 Semester Hr.**

(I, II) Individual research or special problem projects supervised by a faculty member, 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

2016-17

## 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

### Freshman

Fall		lec	lab	sem.hrs
DIST SCI	Distributed Science*	4.0		4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4.0
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5
EPIC151	DESIGN (EPICS) I	3.0		3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

Spring		lec	lab	sem.hrs
PHGN100	PHYSICS I - MECHANICS	4.5		4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4.0
CSCI101	INTRODUCTION TO COMPUTER SCIENCE	3.0		3.0
LAIS100	NATURE AND HUMAN VALUES	4.0		4.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

### Sophomore

Fall		lec	lab	sem.hrs
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
LAIS200	HUMAN SYSTEMS			3.0
FREE	Free Elective	3.0		3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>13.5</b>

Spring		lec	lab	sem.hrs
EBGN301	INTERMEDIATE MICROECONOMICS	3.0		3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0		3.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
FREE	Free Elective			3.0
EBGN	EBGN Elective I**	3.0		3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>15.5</b>

### Junior

Fall		lec	lab	sem.hrs
EBGN302	INTERMEDIATE MACROECONOMICS	3.0		3.0
EBGN325	OPERATIONS RESEARCH	3.0		3.0
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 sem.hrs</b>		
EBGN303	ECONOMETRICS	3.0	3.0		
EBGN321	ENGINEERING ECONOMICS	3.0	3.0		
EBGN409	MATHEMATICAL ECONOMICS*** or EBGN Elective III**	3.0	3.0		
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 sem.hrs</b>		
EBGN403	FIELD SESSION	3.0	3.0		
		<b>3.0</b>			
<b>Senior</b>					
<b>Fall</b>					
		<b>lec</b>	<b>lab sem.hrs</b>		
EBGN401	ADVANCED TOPICS IN ECONOMICS	3.0	3.0		
EBGN455	LINEAR PROGRAMMING*** or EBGN Elective III**	3.0	3.0		
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>		<b>lec</b>	<b>lab sem.hrs</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	3.0	3.0		
FREE	Free Electives	3.0	3.0		
		<b>15.0</b>			

**Total Semester Hrs: 124.0**

\* 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 must take CSCI101 and MATH201 and one of the following: CBEN110, GEGN101, PHGN200, CHGN122, or CHGN125.

\*\* At least 2 EBGN elective courses must be at the 400-level or above.

\*\*\* Students must take either EBGN409 or EBGN455.

## Degree Requirements (Energy and Environmental Economics specialization)

### Freshman

<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>		
DIST SCI	Distributed Science*	4.0	4.0		
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0	4.0		
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0	
CSM101	FRESHMAN SUCCESS SEMINAR	0.5	0.5		
EPIC151	DESIGN (EPICS) I	3.0	3.0		

PAGN	PHYSICAL ACTIVITY COURSE			0.5	
Elective				<b>16.0</b>	
<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>		
PHGN100	PHYSICS I - MECHANICS	4.5	4.5		
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0	4.0		
CSCI101	INTRODUCTION TO COMPUTER SCIENCE	3.0	3.0		
LAIS100	NATURE AND HUMAN VALUES	4.0	4.0		
PAGN	PHYSICAL ACTIVITY COURSE			0.5	
Elective				<b>16.0</b>	
<b>Sophomore</b>					
<b>Fall</b>					
		<b>lec</b>	<b>lab sem.hrs</b>		
EBGN201	PRINCIPLES OF ECONOMICS	3.0	3.0		
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0	4.0		
LAIS200	HUMAN SYSTEMS			3.0	
FREE	Free Elective	3.0	3.0		
PAGN	PHYSICAL ACTIVITY COURSE			0.5	
Elective				<b>13.5</b>	
<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>		
EBGN301	INTERMEDIATE MICROECONOMICS	3.0	3.0		
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0	3.0		
MATH225	DIFFERENTIAL EQUATIONS	3.0	3.0		
FREE	Free Elective	3.0	3.0		
EBGN	EBGN Elective I	3.0	3.0		
PAGN	PHYSICAL ACTIVITY COURSE			0.5	
Elective				<b>15.5</b>	
<b>Junior</b>					
<b>Fall</b>					
		<b>lec</b>	<b>lab sem.hrs</b>		
EBGN302	INTERMEDIATE MACROECONOMICS	3.0	3.0		
EBGN325	OPERATIONS RESEARCH	3.0	3.0		
EBGN330	ENERGY ECONOMICS	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 sem.hrs</b>		
EBGN303	ECONOMETRICS	3.0	3.0		
EBGN321	ENGINEERING ECONOMICS	3.0	3.0		
EBGN310	ENVIRONMENTAL AND RESOURCE ECONOMICS			3.0	
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 sem.hrs</b>		
EBGN403	FIELD SESSION	3.0	3.0		
		<b>3.0</b>			

**Senior**

<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>
EBGN401	ADVANCED TOPICS IN ECONOMICS	3.0	3.0
EBGN430	ADVANCED ENERGY ECONOMICS		3.0
EBGN455	LINEAR PROGRAMMING** or EBGN Elective II	3.0	3.0
EBGN	EBGN Elective III	3.0	3.0
FREE	Free Elective	3.0	3.0
		<b>15.0</b>	

<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
EBGN409	MATHEMATICAL ECONOMICS** or EBGN Elective II	3.0	3.0
EBGN470	ENVIRONMENTAL ECONOMICS	3.0	3.0
LAIS/EBGN	H&SS GenEd Restricted Elective III	3.0	3.0
FREE	Free Electives	3.0	3.0
FREE	Free Electives	3.0	3.0
		<b>15.0</b>	

**Total Semester Hrs: 124.0**

\* 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 must take CSCI101 and MATH201 and one of the following: CBEN110, GEGN101, PHGN200, CHGN122, or CHGN125.

\*\* Students must take either EBGN409 or EBGN455.

General CSM Minor/ASI requirements can be found here (p. 42).

## Minor Program in Economics

The minor in Economics requires that students complete 6 economics courses, for a total of 18.0 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." Economics courses taken as part of the Humanities and Social Sciences electives can be counted toward the minor.

## Area of Special Interest in Economics

The area of special interest in Economics 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	3.0
EBGN302	INTERMEDIATE MACROECONOMICS	3.0
EBGN303	ECONOMETRICS	3.0
EBGN310	ENVIRONMENTAL AND RESOURCE ECONOMICS	3.0
EBGN315	BUSINESS STRATEGY	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
EBGN401	ADVANCED TOPICS IN ECONOMICS	3.0
EBGN409	MATHEMATICAL ECONOMICS	3.0
EBGN437	REGIONAL ECONOMICS	3.0
EBGN441	INTERNATIONAL ECONOMICS	3.0
EBGN443	PUBLIC ECONOMICS	3.0
EBGN470	ENVIRONMENTAL ECONOMICS	3.0
EBGN495	ECONOMIC FORECASTING	3.0

## Business Focus

EBGN304	PERSONAL FINANCE	3.0
EBGN305	FINANCIAL ACCOUNTING	3.0
EBGN306	MANAGERIAL ACCOUNTING	3.0
EBGN314	PRINCIPLES OF MANAGEMENT	3.0
EBGN321	ENGINEERING ECONOMICS	3.0
EBGN325	OPERATIONS RESEARCH	3.0
EBGN345	PRINCIPLES OF CORPORATE FINANCE	3.0
EBGN360	INTRODUCTION TO ENTREPRENEURSHIP	3.0
EBGN361	BUSINESS PRINCIPLES FOR ENTREPRENEURS	3.0
EBGN455	LINEAR PROGRAMMING	3.0
EBGN459	SUPPLY CHAIN MANAGEMENT	3.0
EBGN460	BUSINESS PLAN DEVELOPMENT	3.0
EBGN461	STOCHASTIC MODELS IN MANAGEMENT SCIENCE	3.0
EBGN474	INVENTING, PATENTING AND LICENSING	3.0

## Professors

John T. Cuddington , Research Professor

Roderick G. Eggert

Graham A. Davis, William Jesse Coulter Professor

Michael R. Walls, Division Director and Professor

## Associate Professors

Edward J. Balistreri

Jared C. Carbone

Michael B. Heeley

Steffan Rebennack

## Assistant professors

Harrison Fell

Ian Lange

Peter Maniloff

## Teaching Associate Professors

Scott Houser

Becky Lafrancois

Mark Mondry

John Stermole

## Professors Emeriti

Carol A. Dahl

John E. Tilton

Franklin J. Stermole

## Courses

### **EBGN198. SPECIAL TOPICS IN ECONOMICS AND BUSINESS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### **EBGN199. INDEPENDENT STUDY. 0.5-6 Semester Hr.**

(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 Semester Hrs.**

(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 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### **EBGN299. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

Equivalent with EBGN411,  
(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 Semester Hrs.**

Equivalent with EBGN412,  
(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 Semester Hrs.**

Equivalent with EBGN390,  
(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 MATH201. 3 hours lecture; 3 semester hours.

### **EBGN304. PERSONAL FINANCE. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hrs.**

Equivalent with CHEN421,

(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 Semester Hrs.**

(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 Semester Hrs.**

Equivalent with ENGY330,

(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 Semester Hrs.**

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 Semester Hrs.**

(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 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**EBGN360. INTRODUCTION TO ENTREPRENEURSHIP. 3.0 Semester Hrs.**

(II) 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. 3 hours lecture; 3 semester hours.

**EBGN361. BUSINESS PRINCIPLES FOR ENTREPRENEURS. 3.0 Semester Hrs.**

(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 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**EBGN399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

(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 Semester Hrs.**

Equivalent with EBGN402,

(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. 3 semester hours.

**EBGN404. ADVANCED TOPICS IN MICROECONOMICS. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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, ENG302, EBGN303. 3 hours lecture; 3 semester hours.

**EBGN409. MATHEMATICAL ECONOMICS. 3.0 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**EBGN430. ADVANCED ENERGY ECONOMICS. 3.0 Semester Hrs.**

(I) Application of economic models to understand markets for oil, gas, coal, electricity, and renewable energy resources. Models, modeling techniques and applications include market structure, energy efficiency, demand-side management, energy policy and regulation. The emphasis in the course is on the development of appropriate models and their application to current issues in energy markets. Prerequisites: EBGN301, EBGN330. 3 hours lecture; 3 semester hours.

**EBGN437. REGIONAL ECONOMICS. 3.0 Semester Hrs.**

(II) (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 or EBGN302. 3 hours lecture; 3 semester hours.

**EBGN441. INTERNATIONAL ECONOMICS. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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 generalequilibrium 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: EBGN301. 3 hours lecture; 3 semester hours.

**EBGN455. LINEAR PROGRAMMING. 3.0 Semester Hrs.**

(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 EBGN409. 3 hours lecture; 3 semester hours.



**EBGN459. SUPPLY CHAIN MANAGEMENT. 3.0 Semester Hrs.**

(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: None. 3 hours lecture; 3 semester hours.

**EBGN460. BUSINESS PLAN DEVELOPMENT. 3.0 Semester Hrs.**

(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 understand 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 Semester Hrs.**

(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: None. 3 hours lecture; 3 semester hours.

**EBGN470. ENVIRONMENTAL ECONOMICS. 3.0 Semester Hrs.**

(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: EBG301. 3 hours lecture; 3 semester hours.

**EBGN474. INVENTING, PATENTING AND LICENSING. 3.0 Semester Hrs.**

(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: None. 3 hours lecture; 3 semester hours.

**EBGN495. ECONOMIC FORECASTING. 3.0 Semester Hrs.**

(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: EBG301, EBG302, EBG303. 3 hours lecture; 3 semester hours.

**EBGN497. SUMMER PROGRAMS. 6.0 Semester Hrs.****EBGN498. SPECIAL TOPICS IN ECONOMICS AND BUSINESS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**EBGN499. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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

2016-2017

## 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, which students are expected to attain within a few years of graduation:

1. Demonstrate a high level of technical competence
2. Demonstrate prowess in written, oral and graphical communication
3. Experience good teamwork and leadership practices

## 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)

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	
<b>Fall</b>				
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS	3.0	3.0	4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4.0
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0
EPIC151	DESIGN (EPICS) I	3.0		3.0
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

		lec	lab sem.hrs	
<b>Spring</b>				
PHGN100	PHYSICS I - MECHANICS	3.5	3.0	4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1) or 125	3.0	3.0	4.0
LAIS100	NATURE AND HUMAN VALUES			4.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>17.0</b>

**Sophomore**

		lec	lab sem.hrs	
<b>Fall</b>				
GEGN203	ENGINEERING TERRAIN ANALYSIS	2.0		2.0
GEGN204	GEOLOGIC PRINCIPLES AND PROCESSES	2.0		2.0
GEGN205	ADVANCED PHYSICAL GEOLOGY LABORATORY		3.0	1.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
CEEN241	STATICS	3.0		3.0
LAIS200	HUMAN SYSTEMS	3.0		3.0
PAGN	PHYSICAL ACTIVITY COURSE	0.5		0.5
Elective				
				<b>15.5</b>

		lec	lab sem.hrs	
<b>Spring</b>				
EPIC264	EPICS II: GEOLOGY GIS	2.0	3.0	3.0
GEGN206	EARTH MATERIALS	2.0	3.0	3.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
MATH222	INTRODUCTION TO DIFFERENTIAL EQUATIONS FOR GEOLOGISTS & GEOLOGICAL ENGINEERS or 225 <sup>^</sup>	2.0		2.0

CEEN311	MECHANICS OF MATERIALS	3.0		3.0
PAGN	PHYSICAL ACTIVITY COURSE	0.5		0.5
Elective				
				<b>16.0</b>

**Junior**

		lec	lab sem.hrs	
<b>Fall</b>				
GEO309	STRUCTURAL GEOLOGY AND TECTONICS	3.0	3.0	4.0
GEO321	MINERALOGY AND MINERAL CHARACTERIZATION	2.0	3.0	3.0
GEGN330	GEOSCIENTISTS THERMODYNAMICS, CHGN 209, or MEGN 361			3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
CEEN312	SOIL MECHANICS or MNGN 321			3.0
				<b>16.0</b>

		lec	lab sem.hrs	
<b>Spring</b>				
GEGN307	PETROLOGY	2.0	3.0	3.0
GEGN317	GEOLOGIC FIELD METHODS	1.0	8.0	2.0
GEO314	STRATIGRAPHY	3.0	3.0	4.0
GEGN351	GEOLOGICAL FLUID MECHANICS	3.0		3.0
LAIS	H&SS GenEd Restricted Elective I	3.0		3.0
TECH ELECT	Tech Elective II <sup>*</sup>	3.0		3.0
				<b>18.0</b>

		lec	lab sem.hrs	
<b>Summer</b>				
GEGN316	FIELD GEOLOGY		6.0	6.0
				<b>6.0</b>

**Senior**

		lec	lab sem.hrs	
<b>Fall</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	3.0
LAIS	H&SS GenEd Restricted Elective II	3.0		3.0
FREE	Free Elective			3.0
				<b>17.0</b>

		lec	lab sem.hrs	
<b>Spring</b>				
GEGN ELECT	GEGN4xx Design Elective	2.0	3.0	3.0
GEGN ELECT	GEGN4xx Design Elective	2.0	3.0	3.0
LAIS	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 Semester Hrs: 136.5**

\* Technical Electives I & II: Either MNGN321 or CEEN312 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.

^ 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.)

**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.*

**Freshman**

Fall		lec	lab	sem.hrs
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS	3.0	3.0	4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4.0
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0
EPIC151	DESIGN (EPICS) I	3.0		3.0
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				<b>16.0</b>

Spring		lec	lab	sem.hrs
PHGN100	PHYSICS I - MECHANICS	3.5	3.0	4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1) or 125	3.0	3.0	4.0
LAIS100	NATURE AND HUMAN VALUES	4.0		4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				<b>17.0</b>

**Sophomore**

Fall		lec	lab	sem.hrs
GEGN203	ENGINEERING TERRAIN ANALYSIS	2.0		2.0
GEGN204	GEOLOGIC PRINCIPLES AND PROCESSES	2.0		2.0
GEGN205	ADVANCED PHYSICAL GEOLOGY LABORATORY		3.0	1.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
CEEN241	STATICS	3.0		3.0
LAIS200	HUMAN SYSTEMS	3.0		3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				<b>15.5</b>

Spring		lec	lab	sem.hrs
EPIC264	EPICS II: GEOLOGY GIS	3.0		3.0
GEGN206	EARTH MATERIALS	2.0	3.0	3.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
MATH222	INTRODUCTION TO DIFFERENTIAL EQUATIONS FOR GEOLOGISTS & GEOLOGICAL ENGINEERS or 225^	2.0		2.0
CEEN311	MECHANICS OF MATERIALS	3.0		3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5
				<b>16.0</b>

**Junior**

Fall		lec	lab	sem.hrs
GEGN212	PETROGRAPHY FOR GEOLOGICAL ENGINEERS	1.0	3.0	2.0
GEOL309	STRUCTURAL GEOLOGY AND TECTONICS	3.0	3.0	4.0
GEGN330	GEOLOGICAL ENGINEERING THERMODYNAMICS, CHGN 209, or MEGN 361			3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
CEEN312	SOIL MECHANICS			3.0
CEEN312L	SOIL MECHANICS LABORATORY			1.0
				<b>16.0</b>

Spring		lec	lab	sem.hrs
GEGN317	GEOLOGIC FIELD METHODS	1.0	8.0	2.0
GEGN473	GEOLOGICAL ENGINEERING SITE INVESTIGATION	3.0		3.0
GEOL314	STRATIGRAPHY	3.0	3.0	4.0
GEGN351	GEOLOGICAL FLUID MECHANICS	3.0		3.0
LAIS	H&SS GenEd Restricted Elective I	3.0		3.0
MNGN321	INTRODUCTION TO ROCK MECHANICS	2.0	3.0	3.0
				<b>18.0</b>

Summer		lec	lab	sem.hrs
GEGN316	FIELD GEOLOGY		6.0	6.0
				<b>6.0</b>

**Senior**

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
GEGN468	ENGINEERING GEOLOGY AND GEOTECHNICS	3.0	3.0	4.0
GEGN467	GROUNDWATER ENGINEERING	3.0	3.0	4.0
GEGN432	GEOLOGICAL DATA MANAGEMENT	1.0	6.0	3.0
LAIS	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		3.0
GEGN470	GROUND-WATER ENGINEERING DESIGN	3.0		3.0
LAIS	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 Semester Hrs: 136.5**

^ 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.)

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**

CEEN415	FOUNDATION ENGINEERING	3.0
GEGN475	APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS	3.0
EBGN321	ENGINEERING ECONOMICS	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
MNGNnull445/545	ROCK SLOPE ENGINEERING	3.0

**Water Engineering Emphasis**

CEEN301	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I	3.0
CEEN302	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II	3.0
CEEN461	FUNDAMENTALS OF ECOLOGY	3.0
CEEN470	WATER AND WASTEWATER TREATMENT PROCESSES	3.0
CEEN471	WATER AND WASTEWATER TREATMENT SYSTEMS ANALYSIS AND DESIGN	3.0
CEEN475	SITE REMEDIATION ENGINEERING	3.0
CEEN480	CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT	3.0
CSCI260	FORTRAN PROGRAMMING	2.0
CSCI261	PROGRAMMING CONCEPTS	3.0
EBGN321	ENGINEERING ECONOMICS	3.0
CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY	3.0
CEEN492	ENVIRONMENTAL LAW	3.0
GEGN475	APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS	3.0
GEGN481	ADVANCED HYDROGEOLOGY	3.0
GEGN483	MATHEMATICAL MODELING OF GROUNDWATER SYSTEMS	3.0
GEGN499	INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY	1-6
GEOL321	MINERALOGY AND MINERAL CHARACTERIZATION	3.0
LAIS487	ENVIRONMENTAL POLITICS AND POLICY	3.0
LAIS488	WATER POLITICS AND POLICY	3.0
MATH332	LINEAR ALGEBRA	3.0
MEGN451	FLUID MECHANICS II	3.0

General CSM Minor/ASI requirements can be found here (p. 42).

**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 GEGN101 (4 hours) and up to 4 hours at the 200-level.

Students must consult with the Department to have their sequence of courses approved before embarking on a minor program.

**Professor and Department Head**

Paul M. Santi

**Professors**

Wendy J. Harrison

Murray W. Hitzman, Charles F. Fogarty Professor of Economic Geology

Reed M. Maxwell

Stephen A. Sonnenberg, Charles Boettcher Distinguished Chair in Petroleum Geology

Richard F. Wendlandt

Lesli J. Wood, Weimer Distinguished Chair and Professor, Geology

## Associate Professors

David A. Benson

Thomas Monecke

Piret Plink-Bjorklund

Kamini Singha, Joint appointment with Civil and Environmental Engineering

Bruce Trudgill

Wei Zhou

## Assistant Professors

Alexander Gysi

Yvette Kuiper

Alexis Sitchler

Gabriel Walton

## Teaching Professor

Christian V. Shorey

## Research Professors

Dag Nummedal

David Pyles

J. Fredrick Sarg

## Research Associate Professor

Nicholas B. Harris

## Research Assistant Professors

Jennifer L. Aschoff

Jeremy Boak

Maeve Boland

Mary Carr

Karin Hoal

Nigel Kelly

Katharina Pfaff

## Professors Emerita

Eileen Poeter

## Professors Emeriti

John B. Curtis

Thomas L.T. Grose

John D. Haun

Jerry D. Higgins

Neil F. Hurley

Keenan Lee

Samuel B. Romberger

A. Keith Turner

John E. Warne

Robert J. Weimer

## Associate Professors Emeriti

L. Graham Closs

Timothy A. Cross

Gregory S. Holden

## Joint Appointment

Stephen M. Enders

John E. McCray

## Courses

### **GEGN101. EARTH AND ENVIRONMENTAL SYSTEMS. 4.0 Semester Hrs.**

Equivalent with SYGN101,

(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.

### **GEGN198. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### **GEGN199. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

### **GEGN203. ENGINEERING TERRAIN ANALYSIS. 2.0 Semester Hrs.**

(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: GEGN101. Must be taken concurrently with GEGN204 and GEGN205 for GE majors. 2 hours lecture, 2 semester hours.

**GEGN204. GEOLOGIC PRINCIPLES AND PROCESSES. 2.0 Semester Hrs.**

(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: GEGN101. Must be taken concurrently with GEGN203 and GEGN205 for GE majors. 2 hours lecture, 2 semester hours.

**GEGN205. ADVANCED PHYSICAL GEOLOGY LABORATORY. 1.0 Semester Hr.**

(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: GEGN101. Must be taken concurrently with GEGN203 and GEGN204 for GE majors. 3 hours laboratory, 1 semester hour.

**GEGN206. EARTH MATERIALS. 3.0 Semester Hrs.**

(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: GEGN101, GEGN203, GEGN204, GEGN205. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN212. PETROGRAPHY FOR GEOLOGICAL ENGINEERS. 2.0 Semester Hrs.**

(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.

**GEGN298. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**GEGN299. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY. 1-6 Semester Hr.**

(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 Semester Hrs.**

Equivalent with GEOL307,

(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, CHGN209. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN316. FIELD GEOLOGY. 6.0 Semester Hrs.**

(S) Six weeks of field work, stressing geology of the Southern Rocky Mountain Province. Mapping of igneous, metamorphic, and sedimentary terrain using air photos, topographic maps, 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. Prerequisites: GEGN203, GEGN204, GEGN205, GEGN206, GEGN212 or GEGN307, GEOL314, GEOL309, and GEGN317. 6 semester hours (Summer Term).

**GEGN317. GEOLOGIC FIELD METHODS. 2.0 Semester Hrs.**

(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 and topographic maps. Geologic cross sections, maps, and reports. Weekend exercises required. Prerequisites: GEGN203, GEGN204, GEGN205, GEOL309 or GEOL308, GEGN212 or completion or concurrent enrollment in GEGN307, and completion or concurrent enrollment in GEOL314. 1 hour lecture, 8 hours field; 2 semester hours.

**GEGN330. GEOSCIENTISTS THERMODYNAMICS. 3.0 Semester Hrs.**

(I) Introduction to fundamental principles of thermodynamics applied to geosciences and geoengineering. Thermodynamics are used as a tool for evaluating the stability and chemical transformation of minerals and rocks, evolution of vapors and liquids and their reaction paths when subjected to different P-T geological regimes. The course will focus on basic principles of thermodynamics and make use of examples relevant to geoscientists encompassing: i) calculation of thermodynamic properties (volume, heat capacity, enthalpy and entropy) as a function of pressure, temperature and composition, ii) the study of heat transfer and volume change associated to chemical reactions and iii) evaluation of phase stabilities using Gibbs energy minimization and law of mass action. Introduction to pure phase properties, ideal and non-ideal solutions, activities, equilibrium constants, chemical potential, electrolytes, phase rule and Gibbs energy function. Prerequisites: CHGN121, CHGN122 or CHGN125, MATH111, MATH112, GEGN206. May not also receive credit for CHGN209, CBEN210, or MEGN361. 3 hours lecture; 3 semester hours.

**GEGN340. COOPERATIVE EDUCATION. 1-3 Semester Hr.**

(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 Semester Hrs.**

(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: GEGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN351. GEOLOGICAL FLUID MECHANICS. 3.0 Semester Hrs.**

(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: CEEN241. 3 hours lecture; 3 semester hours.

**GEGN398. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**GEGN399. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY. 1-6 Semester Hr.**

(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 Semester Hrs.**

(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: CHGN209, GEGN307, GEGN316. 3 hours lecture, 3 hours lab; 4 semester hours.

**GEGN403. MINERAL EXPLORATION DESIGN. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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. 6 hours lab; 3 semester hours.

**GEGN432. GEOLOGICAL DATA MANAGEMENT. 3.0 Semester Hrs.**

(I, II, S) 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. 2 hour lecture, 3 hours lab; 3 semester hours.

**GEGN438. PETROLEUM GEOLOGY. 4.0 Semester Hrs.**

(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 Semester Hrs.**

Equivalent with PEGN439,

(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 Semester Hrs.**

(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. Prerequisites: Calc III (MATH213 or MATH223 or MATH224) and DiffEQ (MATH225 or MATH235) and GEGN351 or MEGN351. 3 hours lecture, 3 semester hours.

**GEGN467. GROUNDWATER ENGINEERING. 4.0 Semester Hrs.**

(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. Prerequisites: Calc III (MATH213, MATH223 or MATH224) and DiffEQ (MATH225 or MATH235) and GEGN351 or MEGN351. 3 hours lecture, 3 hours lab, 4 semester hours.

**GEGN468. ENGINEERING GEOLOGY AND GEOTECHNICS. 4.0 Semester Hrs.**

(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 CEEN312/CEEN312L. 3 hours lecture, 3 hours lab, 4 semester hours.

**GEGN469. ENGINEERING GEOLOGY DESIGN. 3.0 Semester Hrs.**

(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 EPIC264. 2 hours lecture, 3 hours lab; 3 semester hours.



**GEGN470. GROUND-WATER ENGINEERING DESIGN. 3.0 Semester Hrs.**

(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 and EPIC264. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN473. GEOLOGICAL ENGINEERING SITE INVESTIGATION. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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: GEGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEGN481. ADVANCED HYDROGEOLOGY. 3.0 Semester Hrs.**

Equivalent with GEGN581,

(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. 3 hours lecture; 3 semester hours.

**GEGN483. MATHEMATICAL MODELING OF GROUNDWATER SYSTEMS. 3.0 Semester Hrs.**

(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 Semester Hrs.****GEGN498. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**GEGN499. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY. 1-6 Semester Hr.**

(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 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hr.**

(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: GEGN101 or concurrent enrollment. 1 hour lecture; 1 semester hour.

**GEO198. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**GEO199. INDEPENDENT STUDY IN GEOLOGY. 1-6 Semester Hr.**

(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.

**GEO198. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**GEO199. INDEPENDENT STUDY. 1-6 Semester Hr.****GEO1308. INTRODUCTORY APPLIED STRUCTURAL GEOLOGY. 3.0 Semester Hrs.**

(II) Nature and origin of structural features of Earth's crust emphasizing structural controls on oil and gas entrapment. Structural patterns and associations are discussed in context of plate tectonic theories, using examples from across the globe. In class exercises and field projects in structural geometry, mapping and cross section construction and seismic reflection data interpretation. Course required of all PEGN and GPGN students. Prerequisite: GEGN101. 3 hours lecture; 3 semester hours.

**GEOL309. STRUCTURAL GEOLOGY AND TECTONICS. 4.0 Semester Hrs.**

(I) (WI) Recognition, habitat, and origin of deformational structures related to stresses and strains (rock mechanics and microstructures) and plate tectonics. Structural development of mountain belts, rift, strike-slip and salt systems. Comprehensive field and laboratory projects use descriptive geometry, stereographic projection, structural contours, map and cross section construction, air photo interpretation, and seismic reflection data analysis. Required of Geological Engineers. Prerequisite: GEGN101, GEGN203, GEGN204, GEGN205 and GEGN206 or PPGN200. 3 hours lecture, 3 hours lab; 4 semester hours.

**GEOL310. EARTH MATERIALS AND RESOURCES. 4.0 Semester Hrs.**

(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: GEGN101. 3 hours lecture, 3 hours lab; 4 semester hours.

**GEOL311. STRUCTURAL GEOLOGY FOR MINING ENGINEERS. 2.0 Semester Hrs.**

(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: GEGN101 and GEOL310. 1 hour lecture; 3 hours lab; 2 semester hours.

**GEOL314. STRATIGRAPHY. 4.0 Semester Hrs.**

(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. Prerequisites: GEGN101, GEGN203 or GEGN204, GEGN205. 3 hours lecture, 3 hours lab; 4 semester hours.

**GEOL315. SEDIMENTOLOGY AND STRATIGRAPHY. 3.0 Semester Hrs.**

(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: GEGN101, PEGN308. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEOL321. MINERALOGY AND MINERAL CHARACTERIZATION. 3.0 Semester Hrs.**

(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: GEGN101, CHGN122 or CHGN125, GEGN206. 2 hours lecture, 3 hours lab; 3 semester hours.

**GEOL398. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**GEOL399. INDEPENDENT STUDY IN GEOLOGY. 1-6 Semester Hr.**

(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 Semester Hrs.**

(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: GEGN101. 2 hours lecture; 2 semester hours.

**GEOL443. UNDERGRADUATE FIELD SEMINAR. 1-3 Semester Hr.**

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. Fees assessed for field and living expenses and transportation. 1 to 3 semester hours; may be repeated for credit.

**GEOL444. INVERTEBRATE PALEONTOLOGY. 3.0 Semester Hrs.**

(II) Fossils are the basis for establishing global correlation among Phanerozoic sedimentary rocks, and thus are critical to the reconstruction of the past 550 million years of Earth history. This is a lecture elective course that will aid in rounding out undergraduate Earth science/engineering geological knowledge. Fossil preservation, taphonomy, evolution, mass extinctions, biostratigraphy, graphic correlation, invertebrate phyla and their geologic history and evolution. Prerequisites: GEGN204, GEGN205, GEGN206. 3 hours lecture; 3 semester hours.

**GEOL470. APPLICATIONS OF SATELLITE REMOTE SENSING. 3.0 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**GEOL497. SPECIAL SUMMER COURSE. 15.0 Semester Hrs.****GEOL498. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**GEOL499. INDEPENDENT STUDY IN GEOLOGY. 1-6 Semester Hr.**

(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.

# Geophysics

2016-2017

## 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 nearly 20 active faculty and smaller class sizes, 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. Noninvasive imaging beneath the surface of Earth and other planets by geophysicists is analogous to noninvasive 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 noninvasively 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, nearly 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. 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, electrical, and electromagnetic 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 Hughes.

## 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 such as the U.S. Geological Survey. 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 CSM faculty member, either part-time during the semester, or full-time during the summer. As an alternative to a summer internship, students may wish to participate in a Research Experience for Undergraduates (REU), either at Mines or at another university. REU's are typically sponsored by the National Science Foundation (NSF) and are listed on the NSF website.

## 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, the curriculum includes electives in the humanities and social sciences that give students an understanding of international issues and different cultures. Every student who obtains a Bachelor's Degree in Geophysical Engineering completes the CSM Core Curriculum plus the courses listed below. We recommend students download the current curriculum flowchart from the Departmental webpage, <http://geophysics.mines.edu/GEO-Undergraduate-Program>.

## Degree Requirements (Geophysical Engineering)

### Freshman

Fall		lec	lab	sem.hrs
GEEN101	EARTH AND ENVIRONMENTAL SYSTEMS	3.0	3.0	4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4.0
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0
EPIC151	DESIGN (EPICS) I	3.0		3.0
CSM101	FRESHMAN SUCCESS SEMINAR	0.5		0.5
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

### Spring

		lec	lab	sem.hrs
PHGN100	PHYSICS I - MECHANICS	3.5	3.0	4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4.0
CSCI101	INTRODUCTION TO COMPUTER SCIENCE, MATH 201, CHGN 122, CHGN 125, or CBEN 110	3.0		3.0
LAIS100	NATURE AND HUMAN VALUES	4.0		4.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

### Sophomore

Fall		lec	lab	sem.hrs
GEEN203	ENGINEERING TERRAIN ANALYSIS or 204 <sup>1</sup>	2.0	3.0	2.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
GEEN205	ADVANCED PHYSICAL GEOLOGY LABORATORY			1.0
GPGN200	INTRODUCTION TO GEOPHYSICS			3.0

EBGN201	PRINCIPLES OF ECONOMICS	3.0	3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0	4.0
PAGN Elective	PHYSICAL ACTIVITY COURSE		0.5

**18.0**

<b>Spring</b>			
		<b>lec</b>	<b>lab sem.hrs</b>
LAIS200	HUMAN SYSTEMS		3.0
GPGN221	THEORY OF FIELDS I: STATIC FIELDS	3.0	3.0
CSCI261	PROGRAMMING CONCEPTS <sup>2</sup>	3.0	3.0
MATH225	DIFFERENTIAL EQUATIONS	3.0	3.0
GPGN268	GEOPHYSICAL DATA ANALYSIS		3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE		0.5

**15.5**

<b>Junior</b>			
<b>Fall</b>			
		<b>lec</b>	<b>lab sem.hrs</b>
GPGN304	INTRO TO GRAVITY AND MAGNETIC METHODS	2.0	3.0 3.0
GPGN315	SUPPORTING GEOPHYSICAL FIELD INVESTIGATIONS		1.0
GPGN322	THEORY OF FIELDS II: TIME-VARYING FIELDS	3.0	3.0
MATH348	ADVANCED ENGINEERING MATHEMATICS or PHGN 311	3.0	3.0
ELECT	Electives <sup>3</sup>	6.0	6.0

**16.0**

<b>Spring</b>			
		<b>lec</b>	<b>lab sem.hrs</b>
GPGN305	INTRODUCTION TO SEISMIC EXPLORATION	2.0	3.0 3.0
GPGN308	INTRODUCTION TO ELECTRICAL AND ELECTROMAGNETIC METHODS	2.0	3.0 3.0
GPGN320	ELEMENTS OF CONTINUUM MECHANICS AND WAVE PROPAGATION	3.0	3.0
GEOL308	INTRODUCTORY APPLIED STRUCTURAL GEOLOGY or 309 <sup>4</sup>	2.0	3.0 3.0
ELECT	Electives <sup>3</sup>	6.0	6.0

**18.0**

<b>Summer</b>			
		<b>lec</b>	<b>lab sem.hrs</b>
GPGN486	GEOPHYSICS FIELD CAMP		4.0 4.0

**4.0**

<b>Senior</b>			
<b>Fall</b>			
		<b>lec</b>	<b>lab sem.hrs</b>
GPGN404	DIGITAL SIGNAL ANALYSIS	3.0	3.0
GP ELECT	GPGN Advanced Elective <sup>5</sup>	3.0	3.0 4.0
GP ELECT	GPGN Advanced Elective <sup>5</sup>	3.0	3.0 4.0
GPGN438	GEOPHYSICS PROJECT DESIGN or 439 (in Spring Semester) <sup>6</sup>		3.0
ELECT	Electives <sup>3</sup>	3.0	3.0

**17.0**

<b>Spring</b>			
		<b>lec</b>	<b>lab sem.hrs</b>
GPGN409	INVERSION	3.0	3.0
GP ELECT	GPGN Advanced Elective <sup>5</sup>	3.0	3.0
GEOL315	SEDIMENTOLOGY AND STRATIGRAPHY or 314 <sup>4</sup>		3.0
ELECT	Electives <sup>3</sup>	3.0	3.0

**12.0**

**Total Semester Hrs: 132.5**

- <sup>1</sup> Students must take GEGN205 (1 credit hour) with either GEGN203 or GEGN204 (2 credit hours).
- <sup>2</sup> Students should enroll in the Java section of CSCI261, although C++ is accepted.
- <sup>3</sup> Electives must include at least 9 hours that meet LAIS H&SS core requirements, 3 of these 9 must be at the 400-level. The remaining 9 hours are Free Electives. 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.
- <sup>4</sup> Students must take either GEOL308 or GEOL309, and either GEOL314 or GEOL315.
- <sup>5</sup> Students must take 11 credits of advanced GPGN elective courses at the 400- or 500-level.
- <sup>6</sup> Students must take either GPGN438 or GPGN439 to satisfy the senior design requirement. The multidisciplinary design course GPGN439, a 3-credit 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 (p. 42).

## 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	3.0
GPGN304	INTRO TO GRAVITY AND MAGNETIC METHODS	3.0
GPGN305	INTRODUCTION TO SEISMIC EXPLORATION	3.0
GPGN308	INTRODUCTION TO ELECTRICAL AND ELECTROMAGNETIC METHODS	3.0
GPGN404	DIGITAL SIGNAL ANALYSIS	3.0
GPGN409	INVERSION	3.0
GPGN432	FORMATION EVALUATION	4.0

GPGN470	APPLICATIONS OF SATELLITE REMOTE SENSING	3.0
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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.

## Professors

Thomas L. Davis

Roelof K. Snieder, Interim Department Head, Keck Foundation Professor of Basic Exploration Science

Ilya D. Tsvankin

Terence K. Young

## Associate Professors

Thomas M. Boyd, Interim Provost

Brandon Dugan, Baker Hughes Chair in Petrophysics and Borehole Geophysics

Yaoguo Li

Paul C. Sava, C.H. Green Chair of Exploration Geophysics

## Assistant Professors

Edwin Nissen

Andrei Swidinsky

Whitney Trainor-Guitton

## Professors Emeriti

Frank A. Hadsell

Alexander A. Kaufman

Dave Hale

Gary R. Olhoeft

Phillip R. Romig, Jr.

## Research Professors

Norman Bleistein, University Emeritus Professor

Kenneth L. Larner, University Emeritus Professor

## Research Associate Professor

Robert D. Benson

## Research Assistant Professor

Richard Krahenbuhl

## Adjunct Faculty

Timothy Collett

Gavin P. Hayes

Stephen J. Hill

Walter S. Lynn

Bruce VerWest

David J. Wald

## Distinguished Senior Scientists

Warren B. Hamilton

Misac N. Nabighian

## Courses

### GPGN198. SPECIAL TOPICS. 1-6 Semester Hr.

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### GPGN199. INDEPENDENT STUDY. 1-6 Semester Hr.

(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.

### GPGN200. INTRODUCTION TO GEOPHYSICS. 3.0 Semester Hrs.

(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 Semester Hrs.

Equivalent with GPGN321,  
(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. 3 hours lecture; 3 semester hours.

**GPGN268. GEOPHYSICAL DATA ANALYSIS. 3.0 Semester Hrs.**

Equivalent with EPIC268,

(II) Geophysical Data Analysis 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. 3 lecture hours; 3 semester hours.

**GPGN298. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**GPGN299. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

**GPGN304. INTRO TO GRAVITY AND MAGNETIC METHODS. 3.0 Semester Hrs.**

(I) This is an introductory study of gravity and magnetic 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 and magnetic 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. 2 hours lecture, 3 hours lab; 3 semester hours.

**GPGN305. INTRODUCTION TO SEISMIC EXPLORATION. 3.0 Semester Hrs.**

(II) This is an introductory study of 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 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: GPGN322, PHGN200, MATH213, MATH225, and MATH348 or PHGN311. 2 hours lecture, 3 hours lab; 3 semester hours.

**GPGN308. INTRODUCTION TO ELECTRICAL AND ELECTROMAGNETIC METHODS. 3.0 Semester Hrs.**

(II) This is an introductory course on electrical and electromagnetic methods in applied geophysics. Methods covered include: natural-source methods (self-potential, telluric, magnetotelluric, audio-magnetotelluric) and artificial-source methods (direct current resistivity, induced polarization, ground/airborne/marine electromagnetic methods, ground penetrating radar, as well as laboratory and borehole methods). The fundamental theory of electrical and electromagnetic exploration is introduced, along more practical aspects such as field acquisition procedures, data processing, and data interpretation. The application of these methods is demonstrated for a large variety of exploration goals including environmental, mining, groundwater, petroleum, geothermal, basin studies, and deep crustal investigations. Prerequisites: GPGN304, PHGN200, MATH213, MATH225, and concurrent enrollment in MATH348 or PHGN311. 2 hours lecture, 3 hours lab; 3 semester hours.

**GPGN315. SUPPORTING GEOPHYSICAL FIELD INVESTIGATIONS. 1.0 Semester Hr.**

(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. 3 hours lab, 1 semester hours.

**GPGN320. ELEMENTS OF CONTINUUM MECHANICS AND WAVE PROPAGATION. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**GPGN340. COOPERATIVE EDUCATION. 1-3 Semester Hr.**

(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.

**GPGN398. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.



**GPGN399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

(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. Knowledge of a computer programming language is assumed. 2.5 hours lecture; 1.5 hours lab, 3 semester hours.

**GPGN409. INVERSION. 3.0 Semester Hrs.**

(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. Knowledge of a programming language is assumed. 3 hours lecture, 3 semester hours.

**GPGN411. ADVANCED GRAVITY AND MAGNETIC METHODS. 4.0 Semester Hrs.**

Equivalent with GPGN414,

(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. 3 hours lecture, 3 hours lab; 4 semester hours.

**GPGN419. WELL LOG ANALYSIS AND FORMATION EVALUATION. 3.0 Semester Hrs.**

Equivalent with PEGN419,

(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 Semester Hrs.**

Equivalent with GPGN422,

(II) 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. 3 hours lecture, 3 hours lab; 4 semester hours.

**GPGN432. FORMATION EVALUATION. 4.0 Semester Hrs.**

(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 Semester Hr.**

(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 Semester Hrs.**

Equivalent with GEGN439, PEGN439,

(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.

**GPGN455. INTRODUCTION TO EARTHQUAKE SEISMOLOGY. 3.0 Semester Hrs.**

Equivalent with GPGN555,

(II) Earthquakes are amongst the most significant natural hazards faced by mankind, with millions of fatalities forecast this century. They are also our most accessible source of information on Earth's structure, rheology and tectonics, which are what ultimately govern the distribution of its natural resources. This course provides an overview of how earthquake seismology, complemented by geodesy and tectonic geomorphology, can be used to determine earthquake locations, depths and mechanisms; understand Earth's tectonics and rheology; establish long-term earthquake histories and forecast future recurrence; and mitigate against seismic hazards. Prerequisites: GPGN320. 3 hours lecture; 3 semester hours.

**GPGN461. SEISMIC DATA PROCESSING I. 4.0 Semester Hrs.**

Equivalent with GPGN452,

(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 Semester Hrs.**

(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. 2 hours lecture, 2 hours lab; 3 semester hours.

**GPGN471. GEODYNAMICS AND GEOLOGY. 2.0 Semester Hrs.**

(I) Earth's evolving internal dynamics and properties have controlled time-varying crustal geologic processes and their products. All terrestrial planets fractionated synchronously with accretion, but only Earth continued strongly active. Much geology, from ancient granite and greenstone to recently enabled plate-tectonics, will be illustrated in the context of coevolving deep and shallow processes. Integration of geophysics, geology, and planetology will allow evaluation of popular and alternative explanations, but the sum will be contrarian, not conventional. Math and specialist vocabularies will be minimized. PREREQUISITES: CHGN121, PHGN100, PHGN200, and GEGN101. 2 lecture hours, 2 semester hours.

**GPGN475. PLANETARY GEOPHYSICS. 3.0 Semester Hrs.**

(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. 4.0 Semester Hrs.**

(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: GPGN268, GEOL308 or GEOL309, GPGN304, GPGN305, GPGN308, and GPGN315. 12 hours lab; 4 semester hours.

**GPGN498. SPECIAL TOPICS IN GEOPHYSICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**GPGN499. GEOPHYSICAL INVESTIGATION. 1-6 Semester Hr.**

(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

2016-2017

## 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, for example, 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.

## Undergraduate Humanities and Social Science

### Educational Objectives

In addition to contributing to 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.

## Music (LIMU)

Courses in Music do not count toward the Humanities & Social Sciences General Education restricted elective requirement, but may be taken for **Free Elective credit only**. **A maximum of 3.0 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.**

## Foreign Language (LIFL)

Typically, several foreign languages are taught through the LAIS Division. In order to gain basic proficiency from their foreign language study, students are encouraged to enroll for at least two semesters in whatever language(s) they elect to take. **No student is permitted to take a foreign language that is either his/her native language or second language.**

## Undergraduate Minors

At the undergraduate level, LAIS offers minors in Literature, Society, and the Environment; International Political Economy; Science, Technology, Engineering, and Policy; Humanitarian Engineering; Music, Engineering, and Recording Arts and an Individualized Undergraduate minor. See the minor tab 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 tutoring 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 Staff also offers tutoring hours at CASA. The Writing Center is located on the 1st floor of Alderson Hall in room AH133.

## Curriculum

Key to courses offered by the LAIS Division:

Course Code	Course Title
LAIS	Humanities and Social Sciences
LIFL	Foreign Language
LIMU	Music

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

- All Undergraduate students are required to take the following two core courses from the Division of Liberal Arts & International Studies:
  - LAIS100 Nature and Human Values 4 semester hours
  - LAIS200 Human Systems 3 semester hours
- All Undergraduate students are also required to take EBG201 Principles of Economics (3 semester hours) from the Division of Economics and Business.

**NOTE:** Students in the McBride Honors Program must take LAIS100, Nature and Human Values and EBG201. Please see the McBride Honors Program web site for further information.

## 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:

- Two of the three courses are midlevel courses, i.e., 200 or 300 level classes. The only exception to this rule are Foreign Language courses (see below). A 400-level course may apply to this midlevel requirement if the student has successfully completed more than one 400-level course.
- 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 EBG498. 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:
  - All courses numbered LAIS498 will satisfy the requirement.
  - Some EBG498 courses as determined on a case-by-case basis will satisfy the requirement. Consult EBG in any given semester for EBG498 courses that satisfy the requirement.

At least one of the three courses must be taken from the Division of Liberal Arts and International Studies.

A maximum of two Foreign Language courses (LIFL) may be applied toward satisfying the H&SS midlevel requirement. LIFL 498 or 499 Foreign Language courses may not be used to satisfy the 400-level course requirement.

Music (LIMU) courses may not be used to meet the H&SS requirement. They may be used for free elective credit only. A maximum of 3 semester hours of concert band chorus, physical activity, varsity athletics, or other activity credit combined may be used toward free elective credit in a degree granting program.

Single majors in Economics may not use Economics courses to meet the H&SS 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 EBG courses, listed below, to satisfy the H&SS requirement.

Except for foreign languages, no AP or IB credit can be used to meet the 9 hours of H&SS requirements. AP/IB credits will be applied as free electives.

## List of LAIS and EB Courses Satisfying the H&SS 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
LAIS324	AUDIO/ACOUSTICAL ENGINEERING AND SCIENCE	3.0
LAIS326	MUSIC THEORY	3.0
LAIS327	MUSIC TECHNOLOGY	3.0
LAIS328	BASIC MUSIC COMPOSITION AND ARRANGING	1.0
LAIS330	MUSIC TECHNOLOGY CAPSTONE	3.0
LAIS305	AMERICAN LITERATURE: COLONIAL PERIOD TO THE PRESENT	3.0
LAIS307	EXPLORATIONS IN COMPARATIVE LITERATURE	3.0
LAIS309	LITERATURE AND SOCIETY	3.0
LAIS310	MODERN EUROPEAN LITERATURE	1-3
LAIS311	BRITISH LITERATURE: MEDIEVAL TO MODERN	3.0
LAIS315	MUSICAL TRADITIONS OF THE WESTERN WORLD	3.0
LAIS320	ETHICS	3.0
LAIS322	LOGIC	3.0
LAIS323	INTRODUCTION TO SCIENCE COMMUNICATION	3.0
LAIS325	CULTURAL ANTHROPOLOGY	3.0
LAIS335	INTERNATIONAL POLITICAL ECONOMY OF LATIN AMERICA	3.0
LAIS337	INTERNATIONAL POLITICAL ECONOMY OF ASIA	3.0
LAIS339	INTERNATIONAL POLITICAL ECONOMY OF THE MIDDLE EAST	3.0
LAIS341	INTERNATIONAL POLITICAL ECONOMY OF AFRICA	3.0
LAIS344	INTERNATIONAL RELATIONS	3.0
LAIS345	INTERNATIONAL POLITICAL ECONOMY	3.0
LAIS365	HISTORY OF WAR	3.0
LAIS370	HISTORY OF SCIENCE	3.0

LAIS371	HISTORY OF TECHNOLOGY	3.0
LAIS375	ENGINEERING CULTURES	3.0
LAIS377	ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT	3.0
LAIS398	SPECIAL TOPICS	1-6
LAIS401	CREATIVE WRITING: POETRY II	3.0
LAIS404	WOMEN, LITERATURE, AND SOCIETY	3.0
LAIS406	THE LITERATURE OF WAR AND REMEMBRANCE	3.0
LAIS407	SCIENCE IN LITERATURE	3.0
LAIS408	LIFE STORIES	3.0
LAIS409	SHAKESPEAREAN DRAMA	3.0
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
LAIS446	GLOBALIZATION	3.0
LAIS448	GLOBAL ENVIRONMENTAL ISSUES	3.0
LAIS450	POLITICAL RISK ASSESSMENT	3.0
LAIS452	CORRUPTION AND DEVELOPMENT	3.0
LAIS453	ETHNIC CONFLICT IN GLOBAL PERSPECTIVE	3.0
LAIS460	GLOBAL GEOPOLITICS	3.0
LAIS475	ENGINEERING CULTURES IN THE DEVELOPING WORLD	3.0
LAIS485	CONSTITUTIONAL LAW AND POLITICS	3.0
LAIS486	SCIENCE AND TECHNOLOGY POLICY	3.0
LAIS487	ENVIRONMENTAL POLITICS AND POLICY	3.0
LAIS488	WATER POLITICS AND POLICY	3.0
LAIS489	NUCLEAR POWER AND PUBLIC POLICY	3.0
LAIS490	ENERGY AND SOCIETY	3.0
LAIS498	SPECIAL TOPICS	1-6
LIFL113	SPANISH I	3.0
LIFL123	SPANISH II	3.0
LIFL114	ARABIC I	3.0
LIFL119	FRENCH I	3.0
LIFL124	ARABIC II	3.0
LIFL115	GERMAN I	3.0
LIFL125	GERMAN II	3.0
LIFL129	FRENCH II	3.0

## LIFLx98 Special Topics

General CSM Minor/ASI requirements can be found here (p. 42).

## 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 HSS 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.

The student must 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 ASI 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.

## MINOR REQUIREMENTS

Students desiring the minor in Literature, Society & the Environment must complete eighteen hours of courses as follows:

1. One required course (3 credit-hours)

LAIS412	LITERATURE AND THE ENVIRONMENT	3.0
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2. Three 300-level elective courses, selected from the following (9 credit-hours total):

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
LAIS309	LITERATURE AND SOCIETY	3.0
LAIS310	MODERN EUROPEAN LITERATURE	3.0

## LAIS311 BRITISH LITERATURE: MEDIEVAL TO MODERN 3.0

3. Two 400-level elective courses, selected from the following (6 credit-hours total):

LAIS401	CREATIVE WRITING: POETRY II	3.0
LAIS404	WOMEN, LITERATURE, AND SOCIETY	3.0
LAIS406	THE LITERATURE OF WAR AND REMEMBRANCE	3.0
LAIS407	SCIENCE IN LITERATURE	3.0
LAIS408	LIFE STORIES	3.0
LAIS409	SHAKESPEAREAN DRAMA	3.0
LAIS410	CRITICAL PERSPECTIVES ON 20TH CENTURY LITERATURE	3.0
LAIS411	LITERATURES OF THE AFRICAN WORLD	3.0
LAIS416	FILM STUDIES	3.0
LAIS418	NARRATING THE NATION	3.0

## 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

The Science, Technology, Engineering, and Policy Minor focuses 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 Engineering Minor and ASI

LAIS Advisor: Prof. Juan Lucena.

The Humanitarian Studies Minor and ASI focuses 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.

## Music, Audio Engineering, and the Recording Arts

Program Advisor: Robert Klimek. Program Co-Advisor: Jonathan Cullision.

The Music, Audio Engineering, and the Recording Arts Minor is designed for students interested in the crossover field between music and related technical skills. Technical emphasis within this minor creates an opportunity for the student to research/experience the impact of their specific majors upon both music as an art form and music as an industry.

Throughout the minor, students are exposed to the refinements and developments that technology has created in the field of recording, production, sound reinforcement and product design, as well as, the interplay between the arts and technology. The discovery of connections between current music and sound engineering practices is stressed. The final outcome is a skilled and informed studio musician/technician in present day studio conditions. Finally, this minor is not designed to expand any current engineering curriculum, but to complement a student's education.

Students desiring a Music, Audio Engineering, and the Recording Arts Minor must complete 18 hours of courses as follows:

Four *required* music courses (12 credit-hours):

LAIS324	AUDIO/ACOUSTICAL ENGINEERING AND SCIENCE	3.0
LAIS327	MUSIC TECHNOLOGY	3.0
LAIS315	MUSICAL TRADITIONS OF THE WESTERN WORLD	3.0
LAIS330	MUSIC TECHNOLOGY CAPSTONE	3.0
<b>Total Semester Hrs</b>		<b>12.0</b>

One 400 level *required* course (3 credit hours):

LAIS429	REAL WORLD RECORDING/RESEARCH	3.0
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Three additional credit-hours:

LAIS326	MUSIC THEORY	3.0
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### Performance Enhancement (3 credit hours total)

LIMU	ENSEMBLE <sup>Two semesters</sup>	
LIMU189	INDIVIDUAL INSTRUMENTAL OR VOCAL MUSIC INSTRUCTION <sup>One semester</sup>	

## Individualized Undergraduate Minor

Program Advisor: Prof. Sandy Woodson. Students declaring an Undergraduate Individual Minor in LAIS must choose 18 restricted elective hours in LAIS 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. The curriculum of 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 allow for a maximum degree of discussion and debate on complex topics. Themes and perspectives from the humanities and the social sciences are integrated with science and engineering to develop in students a sophisticated understanding of the social context in which scientists and engineers work.

## Professors

Elizabeth Van Wie Davis

Juan C Lucena

Kenneth Osgood, Director of McBride Honors Program

## Associate Professors

Hussein A. Amery, Interim Division Director

Tina L. Gianquitto

Kathleen J. Hancock

John R. Heilbrunn

Jon Leydens

James D. Straker

## Assistant Professors

Jessica Smith, Hennebach Assistant Professor

## Teaching Professors

Sandy Woodson, Undergraduate Advisor

James V. Jesudason

Robert Klimek

Toni Lefton

## Teaching Associate Professors

Jonathan H. Cullison

Paula A. Farca

Sarah J. Hitt

Cortney E. Holles

Derrick Hudson,

Rose Pass

## Teaching Assistant Professors

Melanie Brandt,

Olivia Burgess

Joseph Horan

Rachel Osgood

Gregory Rulifson

Seth Tucker

## Professors Emeriti

W. John Cieslewicz

Wilton Eckley

T. Graham Hereford

Barbara M. Olds

Eul-Soo Pang

Anton G. Pegis

Thomas Philipose, University professor emeriti

Arthur B. Sacks

Joseph D. Sneed

## Associate Professors Emeriti

Betty J. Cannon

Kathleen H. Ochs

Laura J. Pang

Karen B. Wiley

## Courses

### HNRS198. SPECIAL TOPICS. 1-6 Semester Hr.

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.

### HNRS199. INDEPENDENT STUDY. 1-6 Semester Hr.

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.

**HNRS298. SPECIAL TOPICS. 1-6 Semester Hr.**

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.

**HNRS299. INDEPENDENT STUDY. 1-6 Semester Hr.**

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.

**HNRS305. EXPLORATIONS IN MODERN AMERICA. 3.0 Semester Hrs.**

(I, II) (WI) Honors core course that develops student skills in reading, writing, critical thinking, and oral communication. skills through the exploration of selected topics related to the social, cultural, and political ideas and events that have shaped the development of the modern United States and its role in the world. Prerequisite: Admission to the Program and LAIS100: Nature & Human Values. 3 lecture hours, 3 credit hours.

**HNRS315. EXPLORATIONS IN THE MODERN WORLD. 3.0 Semester Hrs.**

(I, II) (WI) Honors core course that develops student writing skills and critical thinking abilities through the exploration of selected topics related to the social, cultural, and political ideas and developments that have shaped the modern world. Prerequisite: Admission to the Program and LAIS100: Nature & Human Values. 3 lecture hours, 3 credit hours.

**HNRS398. SPECIAL TOPICS IN THE MCBRIDE HONORS PROGRAM IN PUBLIC AFFAIRS. 1-6 Semester Hr.**

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.

**HNRS399. INDEPENDENT STUDY. 1-6 Semester Hr.**

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.

**HNRS405. MCBRIDE PRACTICUM. 1-3 Semester Hr.**

(I, II) (WI) 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.

**HNRS425. EXPLORATIONS IN POLITICS, POLICY, AND LEADERSHIP. 3.0 Semester Hrs.**

(I, II) (WI) Study of selected topics related to policy, politics, and/or leadership through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in The Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

**HNRS430. EXPLORATIONS IN IDEAS, ETHICS, AND RELIGION. 3.0 Semester Hrs.**

(I, II) (WI) Study of selected topics related to ideas, ethics, and/or religion through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

**HNRS435. EXPLORATIONS IN CULTURE, SOCIETY, AND CREATIVE ARTS. 3.0 Semester Hrs.**

(I, II) (WI) Study of selected topics related to culture, society, and/or the creative arts through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

**HNRS440. EXPLORATIONS IN INTERNATIONAL STUDIES & GLOBAL AFFAIRS. 3.0 Semester Hrs.**

(I, II) (WI) Study of selected topics related to international studies and/or global affairs through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

**HNRS445. EXPLORATIONS IN SCIENCE, TECHNOLOGY, AND SOCIETY. 3.0 Semester Hrs.**

(I, II) (WI) Study of selected topics related to the relationships between science, technology, and society through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

**HNRS450. EXPLORATIONS IN EARTH, ENERGY, AND ENVIRONMENT. 3.0 Semester Hrs.**

(I, II) (WI) Study of selected topics related to earth, energy, and/or the environment through case studies, readings, research, and writing. This course may focus on the human dimensions or broader impacts of science, technology, engineering, or mathematics. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

**HNRS476. COMMUNITY ENGAGEMENT THROUGH SERVICE LEARNING. 3.0 Semester Hrs.**

(II) Community Engagement through Service Learning combines a traditional classroom environment with an off campus learning experience with a local non-profit or community organization. Students spend 3-4 hours per week serving the organization they choose and meet in class once per week to discuss reading assignments, present research findings, and share experiences and insights about the course material. Instructors may choose to focus on a particular topic or social issue, such as poverty and privilege, or may engage with community issues more broadly. The course focuses on several aspects of a student's learning, including intra- and interpersonal learning, discovering community, and developing communication skills and critical and interdisciplinary approaches. Course work will focus on critical reading, group discussion and deliberation, oral presentations of research, and writing assignments. Prerequisites: none. 2 hours lecture; 3-4 hours lab; 3.0 semester hours.



**HNRS497. SUMMER COURSE. 6.0 Semester Hrs.****HNRS498. SPECIAL TOPICS IN THE MCBRIDE HONORS PROGRAM IN PUBLIC AFFAIRS. 1-6 Semester Hr.**

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 Semester Hr.**

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.

**LAIS100. NATURE AND HUMAN VALUES. 4.0 Semester Hrs.**

Equivalent with LIHU100.

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.

**LAIS198. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LAIS199. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

**LAIS200. HUMAN SYSTEMS. 3.0 Semester Hrs.**

Equivalent with SYGN200,

(I, II) Part of the CSM core curriculum, following the first-year requirement of LAIS 100 Nature and Human Values. This course examines political, economic, social, and cultural systems on a global scale during the modern era. Topics covered include development patterns in key regions of the world; the causes and outcomes of globalization; and the influence of energy, technology, and resources on development. Course material presented by instructors with social science and humanities disciplinary backgrounds, with weekly readings and evaluation through exams and written essays. Prerequisite: LAIS 100. 3 hours lecture; 3 semester hours.

**LAIS220. INTRODUCTION TO PHILOSOPHY. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 credit hours.

**LAIS221. INTRODUCTION TO RELIGIONS. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS286. INTRODUCTION TO GOVERNMENT AND POLITICS. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS298. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LAIS299. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

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: LAIS 100. Prerequisite or corequisite: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS301. CREATIVE WRITING: POETRY I. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS305. AMERICAN LITERATURE: COLONIAL PERIOD TO THE PRESENT. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS307. EXPLORATIONS IN COMPARATIVE LITERATURE. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS309. LITERATURE AND SOCIETY. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS310. MODERN EUROPEAN LITERATURE. 1-3 Semester Hr.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS311. BRITISH LITERATURE: MEDIEVAL TO MODERN. 3.0 Semester Hrs.**

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. Pre-requisite: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS315. MUSICAL TRADITIONS OF THE WESTERN WORLD. 3.0 Semester Hrs.**

An introduction to music of the Western world from its beginnings to the present. Prerequisite: LAIS100. Prerequisite or corequisite: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS320. ETHICS. 3.0 Semester Hrs.**

Equivalent with BELS320,

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS322. LOGIC. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS323. INTRODUCTION TO SCIENCE COMMUNICATION. 3.0 Semester Hrs.**

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, and pre- or co-requisite of LAIS200 hours lecture; 3 semester hours.

**LAIS324. AUDIO/ACOUSTICAL ENGINEERING AND SCIENCE. 3.0 Semester Hrs.**

(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 psycho acoustic phenomena are also presented. 3 hours lecture; 3 credit hours. Prerequisite: LAIS100. Prerequisite or corequisite: LAIS200.

**LAIS325. CULTURAL ANTHROPOLOGY. 3.0 Semester Hrs.**

A study of the social behavior and cultural development of humans. Prerequisite: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS326. MUSIC THEORY. 3.0 Semester Hrs.**

(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: LAIS200.

**LAIS327. MUSIC TECHNOLOGY. 3.0 Semester Hrs.**

(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: LAIS200.

**LAIS328. BASIC MUSIC COMPOSITION AND ARRANGING. 1.0 Semester Hr.**

(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: LAIS 100; Pre-or Co-requisite: LAIS200.

**LAIS330. MUSIC TECHNOLOGY CAPSTONE. 3.0 Semester Hrs.**

(II) Project-based course designed to develop practical technological and communication skills for direct application to the music recording. 3 credit hours. Prerequisites: LAIS100, LAIS324, LAIS326, and LAIS327. Prerequisite or corequisite: LAIS200.

**LAIS335. INTERNATIONAL POLITICAL ECONOMY OF LATIN AMERICA. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS337. INTERNATIONAL POLITICAL ECONOMY OF ASIA. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS339. INTERNATIONAL POLITICAL ECONOMY OF THE MIDDLE EAST. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS341. INTERNATIONAL POLITICAL ECONOMY OF AFRICA. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS344. INTERNATIONAL RELATIONS. 3.0 Semester Hrs.**

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: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS345. INTERNATIONAL POLITICAL ECONOMY. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS365. HISTORY OF WAR. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS370. HISTORY OF SCIENCE. 3.0 Semester Hrs.**

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 LAIS200. 3 hours lecture; 3 semester hours.

**LAIS371. HISTORY OF TECHNOLOGY. 3.0 Semester Hrs.**

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 LAIS200. 3 hours lecture; 3 semester hours.

**LAIS375. ENGINEERING CULTURES. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS376. COMMUNITY ENGAGEMENT THROUGH SERVICE LEARNING. 3.0 Semester Hrs.**

(II) Community Engagement through Service Learning combines a traditional classroom environment with an off campus learning experience with a local non-profit or community organization. Students spend 3-4 hours per week serving the organization they choose and meet in class once per week to discuss reading assignments, present research findings, and share experiences and insights about the course material. Instructors may choose to focus on a particular topic or social issue, such as poverty and privilege, or may engage with community issues more broadly. The course focuses on several aspects of a student's learning, including intra- and interpersonal learning, discovering community, and developing communication skills and critical and interdisciplinary approaches. Course work will focus on critical reading, group discussion and deliberation, oral presentations of research, and writing assignments. Prerequisites: none. 2 hours lecture; 3-4 hours lab; 3.0 semester hours.

**LAIS377. ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT. 3.0 Semester Hrs.**

(I) This course is an introduction to the relationship between engineering and sustainable community development (SCD) from historical, political, ideological, ethical, cultural, and practical perspectives. Students will study and analyze different dimensions of community and sustainable development and the role that engineering might play in them. Also students will critically explore strengths and limitations of dominant methods in engineering problem solving, design, and research for working in SCD. Students will learn to research, describe, analyze and evaluate case studies in SCD and develop criteria for their evaluation. Prerequisite: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS398. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LAIS399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS404. WOMEN, LITERATURE, AND SOCIETY. 3.0 Semester Hrs.**

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 LAIS200. 3 hours seminar; 3 semester hours.

**LAIS406. THE LITERATURE OF WAR AND REMEMBRANCE. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS407. SCIENCE IN LITERATURE. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS408. LIFE STORIES. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS409. SHAKESPEAREAN DRAMA. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS410. CRITICAL PERSPECTIVES ON 20TH CENTURY LITERATURE. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS411. LITERATURES OF THE AFRICAN WORLD. 3.0 Semester Hrs.**

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: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS412. LITERATURE AND THE ENVIRONMENT. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS415. MASS MEDIA STUDIES. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS416. FILM STUDIES. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS418. NARRATING THE NATION. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS419. MEDIA AND THE ENVIRONMENT. 3.0 Semester Hrs.**

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 LAIS200. 3 hours seminar; 3 semester hours.

**LAIS421. ENVIRONMENTAL PHILOSOPHY AND POLICY. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS423. ADVANCED SCIENCE COMMUNICATION. 3.0 Semester Hrs.**

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. Prerequisite: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS424. RHETORIC, ENERGY AND PUBLIC POLICY. 3.0 Semester Hrs.**

(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: LAIS200.

**LAIS425. INTERCULTURAL COMMUNICATION. 3.0 Semester Hrs.**

(I, II) The course examines intercultural communication theory and practice. In particular, the course provides students with a window into how intercultural (mis)communication cases arise, evolve, and are resolved. Students investigate communication cases and issues across a broad range of cultural divides, such as national, ethnic, gender, and social class cultures. Some case studies are situated in engineering and applied science contexts. Prerequisites: LAIS100. Co-requisites: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS426. SCIENTIFIC CONTROVERSIES. 3.0 Semester Hrs.**

(I, II) Examines national and international, historical and contemporary scientific and engineering controversies. In particular, the course provides students with a window into how scientific controversies arise, evolve, and are resolved both within scientific circles and in the public arena. By exploring case studies of such controversies, students gain a better understanding about how scientific controversies shape and are shaped by communication as well as by public policy. Prerequisite: LAIS100. Corequisite: LAIS200. 3 hours lecture, 3 semester hours.

**LAIS429. REAL WORLD RECORDING/RESEARCH. 3.0 Semester Hrs.**

(WI) This reading and writing-intensive course explores the acoustical, musical, and technical aspects of recording a variety of live ethnomusicological music genres and/or performances, towards the purpose of learning how to research, document and capture the most accurate and authentic recording. Historical research, non-traditional recording techniques; archival documentation, and editing will all be a part of this course. Prerequisites: LAIS100 and either LAIS315 or LAIS327. Co-requisites: LAIS200. 3 semester hours.

**LAIS430. CORPORATE SOCIAL RESPONSIBILITY. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS431. RELIGION & SECURITY. 3.0 Semester Hrs.**

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: LAIS100. Prerequisite or corequisite: LAIS200. 3 hours lecture and discussion; 3 semester hours.

**LAIS435. LATIN AMERICAN DEVELOPMENT. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS437. ASIAN DEVELOPMENT. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS439. MIDDLE EAST DEVELOPMENT. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS440. WAR AND PEACE IN THE MIDDLE EAST. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS441. AFRICAN DEVELOPMENT. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS442. NATURAL RESOURCES AND WAR IN AFRICA. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS446. GLOBALIZATION. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS448. GLOBAL ENVIRONMENTAL ISSUES. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS450. POLITICAL RISK ASSESSMENT. 3.0 Semester Hrs.**

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: LAIS200. Prerequisite: At least one IPE 300- or 400-level course. 3 hours seminar; 3 semester hours.

**LAIS451. POLITICAL RISK ASSESSMENT RESEARCH SEMINAR. 1.0 Semester Hr.**

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: LAIS200. Concurrent enrollment in LAIS450. 1 hour seminar; 1 semester hour.

**LAIS452. CORRUPTION AND DEVELOPMENT. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS453. ETHNIC CONFLICT IN GLOBAL PERSPECTIVE. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS456. POWER AND POLITICS IN EURASIA. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS457. INTRODUCTION TO CONFLICT MANAGEMENT. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS460. GLOBAL GEOPOLITICS. 3.0 Semester Hrs.**

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. Prerequisite or co-requisite: LAIS200. 3 hours seminar; 3 credit hours.

**LAIS464. HISTORY OF ENERGY AND THE ENVIRONMENT. 3.0 Semester Hrs.**

(II) This course examines the major patterns of human energy use and interaction with the natural environment on a global scale from the origins of civilization to the present day. Topics analyzed include the dynamics of historical change in energy and resource use, the ways in which energy and the environment have shaped the development of past societies, cultural perceptions of energy and the environment during different historical eras, and the impact of past human activities on natural systems. Analysis of historical trends will also serve as a basis for discussions related to current issues in energy and the environment. Prerequisite: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours lecture/seminar; 3 semester hours.

**LAIS467. HISTORY OF EARTH AND ENVIRONMENTAL SCIENCES. 3.0 Semester Hrs.**

This course provides an overview of the history of some of the key sciences that help us understand the world we inhabit: geology, climatology, evolutionary biology, and ecology. As we investigate key scientific discoveries of the modern era, we will also consider the philosophical and cultural impacts of those scientific discoveries. Thus, our reading will include not only original texts by scientists, but also key literary, historical and other texts inspired by those discoveries. Prerequisites: LAIS100. Co-requisites: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS475. ENGINEERING CULTURES IN THE DEVELOPING WORLD. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS478. ENGINEERING AND SOCIAL JUSTICE. 3.0 Semester Hrs.**

(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: LAIS200.

**LAIS485. CONSTITUTIONAL LAW AND POLITICS. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS486. SCIENCE AND TECHNOLOGY POLICY. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS487. ENVIRONMENTAL POLITICS AND POLICY. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS488. WATER POLITICS AND POLICY. 3.0 Semester Hrs.**

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-requi site: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS489. NUCLEAR POWER AND PUBLIC POLICY. 3.0 Semester Hrs.**

A general introduction to research and practice concerning policies and practices relevant to the development and management of nuclear power. Prerequisite: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS490. ENERGY AND SOCIETY. 3.0 Semester Hrs.**

Equivalent with ENGY490, MNGN490,

(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: LAIS200. 3 hours lecture; 3 semester hours.



**LAIS498. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LAIS499. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

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 Semester Hrs.**

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 Semester Hrs.**

Fundamentals of spoken and written German with an emphasis on vocabulary, idiomatic expressions of daily conversation, and German culture. 3 semester hours.

**LIFL119. FRENCH I. 3.0 Semester Hrs.**

(I) French I provides basic instruction in speaking, reading, listening, and writing the French language, with emphasis in class on communicating through speaking and listening skills. French and francophone culture will also be studied. Successful completion of French I will allow students to further their french studies in level 2. 3 hours lecture, 3 semester hours.

**LIFL123. SPANISH II. 3.0 Semester Hrs.**

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 Semester Hrs.**

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 Semester Hrs.**

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.

**LIFL129. FRENCH II. 3.0 Semester Hrs.**

(II) French 2 provides continued instruction in speaking, reading, listening, and writing the French language, with emphasis in class on communicating through speaking and listening skills. French and francophone culture will also be studied. Prerequisites: LIFL119. 3 hours lecture.

**LIFL198. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIFL199. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and Spanish American culture. 3 semester hours.

**LIFL214. ARABIC III. 3.0 Semester Hrs.**

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 Semester Hrs.**

Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and German culture. 3 semester hours.

**LIFL298. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIFL299. INDEPENDENT STUDY. 6.0 Semester Hrs.**

(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 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIFL399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

**LIFL498. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIFL499. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 - FRESHMAN. 1.0 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

(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 Semester Hrs.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIMU199. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

**LIMU201. BAND - SOPHOMORE. 1.0 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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.

**LIMU298. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIMU299. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 - JUNIOR. 1.0 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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.

**LIMU398. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIMU399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

**LIMU401. BAND - SENIOR. 1.0 Semester Hr.**

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. JAZZ ENSEMBLE/PEP BAND. 1.0 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hrs.**

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 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIMU499. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

# 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 can't be grown then it must be 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

Fall		lec	lab sem.hrs	
GEEN101	EARTH AND ENVIRONMENTAL SYSTEMS		4.0	
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I		4.0	
CHGN121	PRINCIPLES OF CHEMISTRY I		4.0	
EPIC151	DESIGN (EPICS) I		3.0	
CSM101	FRESHMAN SUCCESS SEMINAR		0.5	
PAGN	PHYSICAL ACTIVITY COURSE		0.5	
Elective				
			<b>16.0</b>	

Spring		lec	lab sem.hrs	
PHGN100	PHYSICS I - MECHANICS		4.5	
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II		4.0	
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)		4.0	
LAIS100	NATURE AND HUMAN VALUES		4.0	
PAGN	PHYSICAL ACTIVITY COURSE		0.5	
Elective				
			<b>17.0</b>	

### Sophomore

Fall		lec	lab sem.hrs	
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0	4.0	
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
EBGN201	PRINCIPLES OF ECONOMICS	3.0	3.0	
CEEN241	STATICS		3.0	
EPIC251	DESIGN (EPICS) II	2.0	3.0	3.0
PAGN	PHYSICAL ACTIVITY COURSE		0.5	
Elective				
			<b>18.0</b>	

Spring		lec	lab sem.hrs	
MEGN351	FLUID MECHANICS		3.0	
MATH225	DIFFERENTIAL EQUATIONS	3.0	3.0	
MNGN210	INTRODUCTORY MINING	3.0	3.0	

LAIS200	HUMAN SYSTEMS		3.0	
MNGN317	DYNAMICS FOR MINING ENGINEERS	1.0	1.0	
CEEN311	MECHANICS OF MATERIALS		3.0	
PAGN	PHYSICAL ACTIVITY COURSE		0.5	
Elective				
			<b>16.5</b>	

Summer		lec	lab sem.hrs	
MNGN308	MINE SAFETY	1.0	1.0	
MNGN300	SUMMER FIELD SESSION	3.0	3.0	
			<b>4.0</b>	

### Junior

Fall		lec	lab sem.hrs	
MEGN361	THERMODYNAMICS I		3.0	
MNGN309	MINING ENGINEERING LABORATORY	8.0	2.0	
MNGN312	SURFACE MINE DESIGN	2.0	3.0	3.0
MNGN321	INTRODUCTION TO ROCK MECHANICS	2.0	3.0	3.0
GEOL310	EARTH MATERIALS AND RESOURCES	4.0	4.0	
FREE	Free Elective	3.0	3.0	
			<b>18.0</b>	

Spring		lec	lab sem.hrs	
LAIS/EBGN	H&SS Restricted Elective I	3.0	3.0	
EENG281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER		3.0	
MNGN314	UNDERGROUND MINE DESIGN	3.0	3.0	
MNGN316	COAL MINING METHODS	2.0	3.0	3.0
GEOL311	STRUCTURAL GEOLOGY FOR MINING ENGINEERS	2.0	2.0	
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	3.0
MNGN408	UNDERGROUND DESIGN AND CONSTRUCTION	2.0	2.0	
MNGN428	MINING ENGINEERING EVALUATION AND DESIGN REPORT I	3.0	1.0	
MNGN438	GEOSTATISTICS	2.0	3.0	3.0
MNGN322	INTRODUCTION TO MINERAL PROCESSING AND LABORATORY	3.0	2.0	3.0
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	2.0
MNGN433	MINE SYSTEMS ANALYSIS I	3.0	3.0	

MNGN427	MINE VALUATION	2.0	2.0
MNGN424	MINE VENTILATION	2.0	3.0
MNGN410	EXCAVATION PROJECT MANAGEMENT	2.0	2.0
LAIS/EBGN	H&SS Restricted Elective III	3.0	3.0
			<b>15.0</b>

**Total Semester Hrs: 139.5**

General CSM Minor/ASI requirements can be found here (p. 42).

## Minor Programs

The Mining Engineering Department offers three minor programs; the traditional mining engineering program for non-mining majors, underground construction and tunneling and 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:		6.0
MNGN312	SURFACE MINE DESIGN	
MNGN314	UNDERGROUND MINE DESIGN	
MNGN316	COAL MINING METHODS	
Other courses from mining engineering		9.0
<b>Total Semester Hrs</b>		<b>18.0</b>

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. Mark Kuchta**

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.

An explosives minor requires 18 credit hours of specially selected courses. The list of available courses can be found in the mining engineering department office.

## 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	2.0
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 Semester Hrs** **11.0**

### Department Head

Priscilla P. Nelson

### Professors

Kadri Dagdelen

Priscilla P. Nelson

M. Ugur Ozbay

### Associate Professors

Mark Kuchta

Hugh B. Miller

Masami Nakagawa

Jamal Rostami

### Assistant Professors

Elizabeth A. Holley

Rennie Kaunda

Eunhye Kim

## Research Professors

Jurgen F. Brune

M. Stephen Enders

Karl Zipf

## Research Associate Professor

Vilem Petr

## Adjunct Faculty

John W. Grubb

Wm. Mark Hart

Raymond Henn

Paul Jones

Andy Schissler

D. Erik Spiller

William R. Wilson

## Courses

### **MNGN198. SPECIAL TOPICS IN MINING ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### **MNGN199. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

INTRODUCTORY MINING (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 Semester Hrs.**

(S) A basic introduction to explosives engineering and applied explosives science for students that recently completed their freshman or sophomore years at CSM. Topics covered will include safety and explosives regulations, chemistry of explosives, explosives physics, and detonation properties. The course features a significant hands-on practical laboratory learning component with several sessions held at the Explosives Research Laboratory (ERL) in Idaho Springs. Students completing this course will be well prepared for more advanced work in MNGN333 and MNGN444. Prerequisites: PHGN100, CHGN121, CHGN122, MATH111, and MATH112. 2 hours lecture; 3 hours lab; 3 semester hours.

### **MNGN298. SPECIAL TOPICS IN MINING ENGINEERING. 6.0 Semester Hrs.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### **MNGN299. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

### **MNGN300. SUMMER FIELD SESSION. 3.0 Semester Hrs.**

(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 Semester Hr.**

(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 Semester Hrs.**

(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. 2 semester hours.

### **MNGN312. SURFACE MINE DESIGN. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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 and MNGN300. 2 hours lecture, 3 hours lab; 3 semester hours.

### **MNGN316. COAL MINING METHODS. 3.0 Semester Hrs.**

(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. Pre - requisite: MNGN210. 2 hours lecture, 3 hours lab, 3 semester hours.

**MNGN317. DYNAMICS FOR MINING ENGINEERS. 1.0 Semester Hr.**

(II) For mining engineering majors only. Absolute and relative motions, kinetics, work-energy, impulse-momentum and angular impulse-momentum. Prerequisite: MATH213/223, CEEN241. 1 hour lecture; 1 semester hour.

**MNGN321. INTRODUCTION TO ROCK MECHANICS. 3.0 Semester Hrs.**

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: CEEN241 or MNGN317. 2 hours lecture, 3 hours lab; 3 semester hours.

**MNGN322. INTRODUCTION TO MINERAL PROCESSING AND LABORATORY. 3.0 Semester Hrs.**

(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/ 210, MATH213/223. 2 hours lecture; 3 hours lab; 3 semester hours.

**MNGN333. EXPLOSIVES ENGINEERING I. 3.0 Semester Hrs.**

(I) 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 lectures from experts from government, industry and the explosives engineering community. Pre-requisites: None. 2 hours lecture; 3 hours lab. 3 semester hours.

**MNGN340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.**

(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 Semester Hrs.**

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 hours lecture; 3 semester hours.

**MNGN398. SPECIAL TOPICS IN MINING ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MNGN399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

(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 Semester Hrs.**

(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 hours.

**MNGN406. DESIGN AND SUPPORT OF UNDERGROUND EXCAVATIONS. 3.0 Semester Hrs.**

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: none. 3 hours lecture; 3 semester hours. Offered in odd years.

**MNGN407. ROCK FRAGMENTATION. 3.0 Semester Hrs.**

(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: CEEN241, concurrent enrollment. 3 hours lecture; 3 semester hours.

**MNGN408. UNDERGROUND DESIGN AND CONSTRUCTION. 2.0 Semester Hrs.**

(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: CEEN312 OR MNGN321. 2 hours of lecture; 2 semester hours.

**MNGN410. EXCAVATION PROJECT MANAGEMENT. 2.0 Semester Hrs.**

(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: MNGN 210, 2-hour lecture, 2 semester hours.



**MNGN414. MINE PLANT DESIGN. 3.0 Semester Hrs.**

(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 and MNGN314. 2 hours lecture, 3 hours lab; 3 semester hour.

**MNGN418. ADVANCED ROCK MECHANICS. 3.0 Semester Hrs.**

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. 3 hours lecture; 3 semester hours.

**MNGN421. DESIGN OF UNDERGROUND EXCAVATIONS. 3.0 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**MNGN422. FLOTATION. 2.0 Semester Hrs.**

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 Semester Hr.**

(I) Experiments to accompany the lectures in MNGN422. Co-requisite: MNGN421. 3 hours lab; 1 semester hour.

**MNGN424. MINE VENTILATION. 3.0 Semester Hrs.**

(II) Fundamentals of mine ventilation, including control of gas, dust, temperature, and humidity; ventilation network analysis and design of systems. Prerequisite: MEGN351, MEGN361 and MNGN314. 2 hours lecture, 3 hours lab; 3 semester hours.

**MNGN427. MINE VALUATION. 2.0 Semester Hrs.**

(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. 2 hours lecture; 2 semester hours.

**MNGN428. MINING ENGINEERING EVALUATION AND DESIGN REPORT I. 1.0 Semester Hr.**

(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. Co-requisites: MNGN438. 1 hour lecture; 1 semester hour.

**MNGN429. MINING ENGINEERING EVALUATION AND DESIGN REPORT II. 2.0 Semester Hrs.**

(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. Co-requisites: MNGN322 or MNGN323, MNGN427, and MNGN433. 2 hours lecture; 2 semester hours.

**MNGN431. MINING AND METALLURGICAL ENVIRONMENT. 3.0 Semester Hrs.**

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: none. 3 hours lecture; 3 semester hours.

**MNGN433. MINE SYSTEMS ANALYSIS I. 3.0 Semester Hrs.**

(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 Semester Hr.**

Projects to accompany the lectures in MNGN422. Prerequisite: MNGN422. 3 hours lab; 1 semester hour.

**MNGN436. UNDERGROUND COAL MINE DESIGN. 3.0 Semester Hrs.**

(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. 3 hours lecture, 3 hours lab; 3 semester hours.

**MNGN438. GEOSTATISTICS. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hrs.**

(II) 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: MNGN333. 2 hours lecture, 3 hours lab, 3 semester hours.

**MNGN445. ROCK SLOPE ENGINEERING. 3.0 Semester Hrs.**

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: none. 3 hours lecture; 3 semester hours.

**MNGN452. SOLUTION MINING AND PROCESSING OF ORES. 3.0 Semester Hrs.**

(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; none. 3 hours lecture; 3 semester hours. Offered in spring.

**MNGN460. INDUSTRIAL MINERALS PRODUCTION. 3.0 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours. Offered in spring.

**MNGN470. SAFETY AND HEALTH MANAGEMENT IN THE MINING INDUSTRY. 3.0 Semester Hrs.**

(I) Fundamentals of managing occupational safety and health at a mining operation. Includes tracking of accident and injury statistics, risk management, developing a safety and health management plan, meeting MSHA regulatory requirements, training, safety audits and accident investigations. 3 hours lecture; 3 semester hours.

**MNGN482. MINE MANAGEMENT. 3.0 Semester Hrs.**

(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. 2 hours lecture and 1 hour case study presentation and discussion per week; 3 hours lecture; 3 semester hours.

**MNGN490. ENERGY AND SOCIETY. 3.0 Semester Hrs.**

Equivalent with ENGY490, LAIS490,  
(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. 3 hours lecture/seminar; 3 semester hours.

**MNGN498. SPECIAL TOPICS IN MINING ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**MNGN499. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 is LEED certified. Marquez Hall is the first building on the Colorado School of Mines Campus that is funded entirely by private 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 an up-to-date computer controlled, full-scale, graphic intensive 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 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

Fall		lec	lab sem.hrs	
PAGN101	PHYSICAL EDUCATION	0.5		0.5
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS	3.0	3.0	4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I	4.0		4.0
CHGN121	PRINCIPLES OF CHEMISTRY I	3.0	3.0	4.0
EPIC151	DESIGN (EPICS) I	3.0		3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

Spring		lec	lab sem.hrs	
PHGN100	PHYSICS I - MECHANICS	3.5	3.0	4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II	4.0		4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1) or 125	3.0	3.0	4.0
LAIS100	NATURE AND HUMAN VALUES	4.0		4.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>17.0</b>

### Sophomore

Fall		lec	lab sem.hrs	
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
EPIC251	DESIGN (EPICS) II, 252, 261, 262, 263, 264, 265, 266, 267, or GPGN 268	3.0		3.0
CEEN241	STATICS			3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>18.0</b>

Spring		lec	lab sem.hrs	
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS			3.0
CEEN311	MECHANICS OF MATERIALS			3.0
PEGN251	FLUID MECHANICS	3.0		3.0
PEGN308	RESERVOIR ROCK PROPERTIES	2.0	3.0	3.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
LAIS200	HUMAN SYSTEMS			3.0
				<b>18.0</b>

Summer		lec	lab sem.hrs	
PEGN315	SUMMER FIELD SESSION I	2.0		2.0
				<b>2.0</b>

### Junior

Fall		lec	lab sem.hrs	
GEOL315	SEDIMENTOLOGY AND STRATIGRAPHY	2.0	3.0	3.0
PEGN305	COMPUTATIONAL METHODS IN PETROLEUM ENGINEERING	2.0		2.0
PEGN310	RESERVOIR FLUID PROPERTIES	2.0		2.0
PEGN311	DRILLING ENGINEERING	3.0	3.0	4.0
PEGN419	WELL LOG ANALYSIS AND FORMATION EVALUATION	2.0	3.0	3.0
LAIS/EBGN	H&SS Restricted Elective I	3.0		3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>17.5</b>

Spring		lec	lab sem.hrs	
GEOL308	INTRODUCTORY APPLIED STRUCTURAL GEOLOGY	2.0	3.0	3.0
PEGN438	PETROLEUM DATA ANALYTICS	2.0	3.0	3.0
PEGN361	COMPLETION ENGINEERING	3.0		3.0
PEGN411	MECHANICS OF PETROLEUM PRODUCTION	3.0		3.0
LAIS/EBGN	H&SS Restricted Elective II	3.0		3.0
FREE	Free Elective	3.0		3.0
				<b>18.0</b>

Summer		lec	lab sem.hrs	
PEGN316	SUMMER FIELD SESSION II	2.0		2.0
				<b>2.0</b>

### Senior

Fall		lec	lab sem.hrs	
PEGN481	PETROLEUM SEMINAR	2.0		2.0
PEGN423	PETROLEUM RESERVOIR ENGINEERING I	3.0		3.0
PEGN413	GAS MEASUREMENT AND FORMATION EVALUATION LAB		6.0	2.0
PEGN414	WELL TESTING AND ANALYSIS	3.0		3.0
PEGN422	ECONOMICS AND EVALUATION OF OIL AND GAS PROJECTS	3.0		3.0
FREE	Free Elective	3.0		3.0
				<b>16.0</b>

Spring		lec	lab sem.hrs	
PEGN424	PETROLEUM RESERVOIR ENGINEERING II	3.0		3.0
PEGN426	FORMATION DAMAGE AND STIMULATION	3.0		3.0
PEGN439	MULTIDISCIPLINARY PETROLEUM DESIGN	2.0	3.0	3.0
LAIS/EBGN	H&SS Restricted Elective III	3.0		3.0
FREE	Free Elective	3.0		3.0
				<b>15.0</b>

**Total Semester Hrs: 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 (p. 42).

## Professors

Hazim Abass

Ramona M. Graves, Dean, College of Earth Resource Sciences and Engineering

Hossein Kazemi, Chesebro' Distinguished Chair

Erdal Ozkan, Professor and Department Head, "Mick" Merelli/Cimarex Energy Distinguished Chair

Azra N. Tutuncu, Harry D. Campbell Chair

Yu-Shu Wu, CMG Chair

## Associate Professors

Alfred W. Eustes III

Jorge H. B. Sampaio Jr.

Manika Prasad

Xiaolong Yin

## Assistant Professors

Rosmer Maria Brito

Luis Zerpa

## Teaching Professor

Linda A. Battalora

## Teaching Associate Professors

Mansur Ermila

Carrie J. McClelland

Mark G. Miller

## Teaching Assistant Professor

Elio S. Dean

## Research Associate Professor

Philip H. Winterfeld

## Research Assistant Professor

Wendy Wempe

## Adjunct Professor

William W. Fleckenstein

## Professor Emeritus

Craig W. Van Kirk

## Associate Professor Emeritus

Richard Christiansen

## Courses

### PEGN102. INTRODUCTION TO PETROLEUM INDUSTRY. 3.0 Semester Hrs.

(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 Semester Hr.

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### PEGN199. INDEPENDENT STUDY. 1-6 Semester Hr.

(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 Semester Hrs.

(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. May not also receive credit for MEGN351 or CEEN310. Co-requisites: CEEN241. 3 hours lecture; 3 semester hours.

### PEGN298. SPECIAL TOPICS IN PETROLEUM ENGINEERING. 1-6 Semester Hr.

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### PEGN299. INDEPENDENT STUDY. 1-6 Semester Hr.

(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 Semester Hrs.**

(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 Semester Hrs.**

(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: CEEN241, PEGN251. 2 hours lecture, 3 hours lab; 3 semester hours.

**PEGN310. RESERVOIR FLUID PROPERTIES. 2.0 Semester Hrs.**

(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: PEGN308 (grade of C- or higher), CHGN209 (grade of C- or higher). 2 hours lecture; 2 semester hours.

**PEGN311. DRILLING ENGINEERING. 4.0 Semester Hrs.**

(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 (grade of C- or higher), PEGN315, CEEN241. 3 hours lecture, 3 hours lab; 4 semester hours.

**PEGN315. SUMMER FIELD SESSION I. 2.0 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**PEGN361. COMPLETION ENGINEERING. 3.0 Semester Hrs.**

(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. Prerequisites: PEGN311, and CEEN311 or MEGN312. 3 hours lecture; 3 semester hours.

**PEGN398. SPECIAL TOPICS IN PETROLEUM ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**PEGN399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

(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: PEGN251, PEGN308 (grade of C- or higher), PEGN310, and PEGN311. 3 hours lecture; 3 semester hours.

**PEGN413. GAS MEASUREMENT AND FORMATION EVALUATION LAB. 2.0 Semester Hrs.**

(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 TESTING AND ANALYSIS. 3.0 Semester Hrs.**

(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 Semester Hrs.**

Equivalent with GPGN419,

(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. Prerequisites: PEGN 308 (grade of C- or higher); PHGN 200 (grade of C- or higher). Co-requisites: GEOL315 or GEOL308. 2 hours lecture, 3 hours lab; 3 semester hours.

**PEGN422. ECONOMICS AND EVALUATION OF OIL AND GAS PROJECTS. 3.0 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**PEGN423. PETROLEUM RESERVOIR ENGINEERING I. 3.0 Semester Hrs.**

(II) 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: PEGN419 and (MATH225 or MATH235 or MATH222 only for non PE majors). 3 hours lecture; 3 semester hours.

**PEGN424. PETROLEUM RESERVOIR ENGINEERING II. 3.0 Semester Hrs.**

(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 and PEGN438. 3 hours lecture; 3 semester hours.

**PEGN426. FORMATION DAMAGE AND STIMULATION. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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. PETROLEUM DATA ANALYTICS. 3.0 Semester Hrs.**

(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 Semester Hrs.**

Equivalent with GEGN439, GPGN439,

(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 Semester Hrs.**

(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 Semester Hrs.**

(I) (WI) Written and oral presentations by each student on current energy topics. This course is designated as a writing intensive course (WI). Prerequisite: none. 2 hours lecture; 2 semester hours.

**PEGN490. RESERVOIR GEOMECHANICS. 3.0 Semester Hrs.**

(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: CEEN311. 3 hours lecture; 3 hours lab, 3 semester hours.

**PEGN498. SPECIAL TOPICS IN PETROLEUM ENGINEERING. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.



**PEGN499. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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

2016-2017

## Program Description

The Chemical and Biological Engineering Department 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 70 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

2016-2017

## 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:

CBEN509	ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS	3.0
CBEN516	TRANSPORT PHENOMENA	3.0
CBEN518	REACTION KINETICS AND CATALYSIS	3.0
CBEN568	INTRODUCTION TO CHEMICAL ENGINEERING RESEARCH AND TEACHING	3.0
Additional credits		18.0
<b>Total Semester Hrs</b>		<b>30.0</b>

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.

### A. Chemical/Chemical and Biochemical Engineering Fundamentals

The following courses represent the basic knowledge component of the Chemical Engineering curriculum at CSM.

CBEN201	MATERIAL AND ENERGY BALANCES	3.0
CBEN307	FLUID MECHANICS	3.0
CBEN308	HEAT TRANSFER	3.0
CBEN357	CHEMICAL ENGINEERING THERMODYNAMICS	3.0
CBEN375	MASS TRANSFER	3.0
CBEN430	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:

CBEN312/313	UNIT OPERATIONS LABORATORY	6.0
CBEN402	CHEMICAL ENGINEERING DESIGN	3.0
CBEN403	PROCESS DYNAMICS AND CONTROL	3.0
CBEN418	KINETICS AND REACTION ENGINEERING	3.0

Technical Electives for Chemical Engineering

### C. Technical Electives for Chemical Engineering

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.

#### Requirements (Chemical Engineering)

There are 10 credits specifically required for Chemical and Biochemical Engineering that are not specified for Chemical Engineering. Three of these may be any CHGN or CBEN 3XX or higher credits, 6 must be CBEN engineering credits, and 1 is an additional elective credit.

NOTE: Below is a suggested curriculum path. Electives may be taken any time they fit into your schedule, but note that not all courses are offered all semesters. Please refer to [http://chemeng.mines.edu/undergraduate\\_program.html](http://chemeng.mines.edu/undergraduate_program.html) for the most updated flowsheet.

#### Freshman

Fall		lec	lab	sem.hrs
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
EPIC151	DESIGN (EPICS) I			3.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CBEN110	FUNDAMENTALS OF BIOLOGY I			4.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

Spring		lec	lab	sem.hrs
LAIS100	NATURE AND HUMAN VALUES			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>17.0</b>

#### Sophomore

Fall		lec	lab	sem.hrs
CBEN210	INTRO TO THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I	3.0		3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY		3.0	1.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

Spring		lec	lab	sem.hrs
CBEN201	MATERIAL AND ENERGY BALANCES			3.0

CBEN202	CHEMICAL PROCESS PRINCIPLES LABORATORY		1.0	
CHGN222	ORGANIC CHEMISTRY II	3.0		3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
EPIC265	EPIC II: BIOCHEMICAL PROCESSES			3.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.5</b>

**Junior**

Fall		lec	lab	sem.hrs
CBEN307	FLUID MECHANICS			3.0
CBEN357	CHEMICAL ENGINEERING THERMODYNAMICS			3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	3.0	4.0
LAIS200	HUMAN SYSTEMS			3.0
FREE	FREE ELECTIVE			3.0
				<b>16.0</b>

Spring		lec	lab	sem.hrs
CBEN308	HEAT TRANSFER			3.0
CBEN375	MASS TRANSFER			3.0
CBEN358	CHEMICAL ENGINEERING THERMODYNAMICS LABORATORY			1.0
CBEN/CHGN ELECT	CHEMISTRY OR CHEMICAL ENGINEERING ELECTIVE**	3.0		3.0
LAIS/EBGN	H&SS RESTRICTED ELECTIVE I	3.0		3.0
FREE	FREE ELECTIVE			3.0
				<b>16.0</b>

Summer		lec	lab	sem.hrs
CBEN312	UNIT OPERATIONS LABORATORY			3.0
CBEN313	UNIT OPERATIONS LABORATORY			3.0
				<b>6.0</b>

**Senior**

Fall		lec	lab	sem.hrs
CBEN418	KINETICS AND REACTION ENGINEERING			3.0
CBEN430	TRANSPORT PHENOMENA			3.0
CBEN ELECT	400-LEVEL CHEMICAL ENGINEERING ELECTIVE*			3.0
LAIS/EBGN	H&SS RESTRICTED ELECTIVE II	3.0		3.0
FREE	FREE ELECTIVE			4.0
				<b>16.0</b>

Spring		lec	lab	sem.hrs
CBEN402	CHEMICAL ENGINEERING DESIGN			3.0
CBEN403	PROCESS DYNAMICS AND CONTROL			3.0
CBEN ELECT	400-LEVEL CHEMICAL ENGINEERING ELECTIVE*			3.0

EBGN321	ENGINEERING ECONOMICS			3.0
LAIS/EBGN	H&SS RESTRICTED ELECTIVE III			3.0
				<b>15.0</b>

**Total Semester Hrs: 134.5**

\* Six of the technical electives credits must be CBEN courses with engineering content ([http://chemeng.mines.edu/undergraduate\\_program.html](http://chemeng.mines.edu/undergraduate_program.html)), at least 3 of which must be at the 400 level.

\*\* Three of the technical electives credits may be any CBEN or CHGN credits at the 300-or higher level.

**Requirements (Chemical and Biochemical Engineering)****Freshman**

Fall		lec	lab	sem.hrs
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
EPIC151	DESIGN (EPICS) I			3.0
CBEN110	FUNDAMENTALS OF BIOLOGY I			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

Spring		lec	lab	sem.hrs
LAIS100	NATURE AND HUMAN VALUES			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>17.0</b>

**Sophomore**

Fall		lec	lab	sem.hrs
CBEN210	INTRO TO THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I	3.0		3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY		3.0	1.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	3.5	3.0	4.5
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

Spring		lec	lab	sem.hrs
CBEN201	MATERIAL AND ENERGY BALANCES			3.0
CBEN202	CHEMICAL PROCESS PRINCIPLES LABORATORY			1.0
CHGN222	ORGANIC CHEMISTRY II	3.0		3.0

EBGN201	PRINCIPLES OF ECONOMICS	3.0	3.0
EPIC265	EPIC II: BIOCHEMICAL PROCESSES	3.0	3.0
MATH225	DIFFERENTIAL EQUATIONS	3.0	3.0
PAGN	PHYSICAL ACTIVITY COURSE		0.5
Elective			
			<b>16.5</b>

**Junior**

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CBEN307	FLUID MECHANICS			3.0
CBEN357	CHEMICAL ENGINEERING THERMODYNAMICS			3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	3.0	4.0
LAIS200	HUMAN SYSTEMS			3.0
FREE	FREE ELECTIVE	3.0		3.0
				<b>16.0</b>

**Spring**

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CBEN308	HEAT TRANSFER			3.0
CBEN358	CHEMICAL ENGINEERING THERMODYNAMICS LABORATORY			1.0
CBEN375	MASS TRANSFER			3.0
CHGN428	BIOCHEMISTRY	3.0		3.0
CHGN462	MICROBIOLOGY	3.0		3.0
LAIS/EBGN	H&SS RESTRICTED ELECTIVE I	3.0		3.0
				<b>16.0</b>

**Summer**

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CBEN312	UNIT OPERATIONS LABORATORY			3.0
CBEN313	UNIT OPERATIONS LABORATORY			3.0
				<b>6.0</b>

**Senior**

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CBEN418	KINETICS AND REACTION ENGINEERING			3.0
CBEN430	TRANSPORT PHENOMENA			3.0
CBEN460	BIOCHEMICAL PROCESS ENGINEERING			3.0
CBEN461	BIOCHEMICAL PROCESS ENGINEERING LABORATORY			1.0
LAIS/EBGN	H&SS RESTRICTED ELECTIVE II	3.0		3.0
FREE	FREE ELECTIVE	3.0		3.0
				<b>16.0</b>

**Spring**

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CBEN402	CHEMICAL ENGINEERING DESIGN			3.0
CBEN403	PROCESS DYNAMICS AND CONTROL			3.0
EBGN321	ENGINEERING ECONOMICS			3.0
LAIS/EBGN	H&SS RESTRICTED ELECTIVE III	3.0		3.0

FREE	FREE ELECTIVE	3.0	3.0
			<b>15.0</b>

**Total Semester Hrs: 134.5**

General CSM Minor/ASI requirements can be found here (p. 42).

**Biomedical Engineering Minor**

To obtain a Biomedical Engineering (BME) minor, students must take at least 18 credits related to Biomedical Engineering. Two courses (8 credits) of biology are required. Two restricted requirements include Intro to Biomedical Engineering (required) and at least 3 credits of engineering electives related to BME. Two more courses (or at least 4 credits) may be chosen from the engineering and/or additional electives. The lists of electives will be modified as new related courses that fall into these categories become available.

REQUIRED courses (11 credits):

CBEN110	FUNDAMENTALS OF BIOLOGY I	4.0
CBEN120	FUNDAMENTALS OF BIOLOGY II	4.0
CBEN310	INTRODUCTION TO BIOMEDICAL ENGINEERING	3.0

Plus at least 3 credits of engineering electives:

CBEN35x/45x/x98/x99	HONORS UNDERGRADUATE RESEARCH, SPECIAL TOPICS, INDEPENDENT STUDY *	1-4
CBEN432	TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS	3.0
CBEN470	INTRODUCTION TO MICROFLUIDICS	3.0
CBEN555	POLYMER AND COMPLEX FLUIDS COLLOQUIUM	1.0
MEGN330	INTRODUCTION TO BIOMECHANICAL ENGINEERING	3.0
MEGN430	MUSCULOSKELETAL BIOMECHANICS	3.0
MEGN435	MODELING AND SIMULATION OF HUMAN MOVEMENT	3.0
or MEGN535	MODELING AND SIMULATION OF HUMAN MOVEMENT	
MEGN436	COMPUTATIONAL BIOMECHANICS	3.0
or MEGN536	COMPUTATIONAL BIOMECHANICS	
MEGN530	BIOMEDICAL INSTRUMENTATION	3.0
MEGN531	PROSTHETIC AND IMPLANT ENGINEERING	3.0
MEGN532	EXPERIMENTAL METHODS IN BIOMECHANICS	3.0
MEGN537	PROBABILISTIC BIOMECHANICS	3.0
MTGN570	BIOCOMPATIBILITY OF MATERIALS	3.0

Plus at least 4 more credits from the list above and/or the list below:

Additional elective courses related to BME:

CBEN304	ANATOMY AND PHYSIOLOGY	3.0
CBEN305	ANATOMY AND PHYSIOLOGY LAB	1.0
CBEN306	ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, 3.0 AND BRAIN	
CBEN309	ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, 1.0 AND BRAIN LABORATORY	
CBEN311	INTRODUCTION TO NEUROSCIENCE	3.0

CBEN320	CELL BIOLOGY AND PHYSIOLOGY	3.0
CBEN321	INTRO TO GENETICS	4.0
CBEN35x/45x/ x98/x99	HONORS UNDERGRADUATE RESEARCH, SPECIAL TOPICS, INDEPENDENT STUDY	1-4
CBEN411	NEUROSCIENCE, MEMORY, AND LEARNING (NEUROSCIENCE, MEMORY, AND LEARNING)	3.0
CBEN412	INTRODUCTION TO PHARMACOLOGY (INTRODUCTION TO PHARMACOLOGY)	3.0
CHGN428	BIOCHEMISTRY	3.0
CBEN431	IMMUNOLOGY FOR ENGINEERS AND SCIENTISTS	3.0
or CBEN531	IMMUNOLOGY FOR SCIENTISTS AND ENGINEERS	
CBEN454	APPLIED BIOINFORMATICS	3.0
or CBEN554	APPLIED BIOINFORMATICS	
CHGN429	BIOCHEMISTRY II	3.0
CHGN462	MICROBIOLOGY	3.0
MATH331	MATHEMATICAL BIOLOGY	3.0
MTGN472	BIOMATERIALS I	3.0
or MTGN572	BIOMATERIALS	
PHGN433	BIOPHYSICS	3.0

\*As the content of these courses varies, the course must be noted as relevant to the BME minor to count toward the minor, and noted as having sufficient engineering content to count as an engineering elective course as the engineering electives.

## Dean of the College of Applied Sciences and Engineering

Michael J. Kaufman

### Professors

John R. Dorgan

Andrew M. Herring

Carolyn A. Koh

David W. M. Marr, Department Head

J. Douglas Way

Colin A. Wolden, Weaver Distinguished Professor

David T. W. Wu, by courtesy

### Associate Professors

Sumit Agarwal

Moises A. Carreon

Keith B. Neeves

Amadeu K. Sum

### Assistant Professors

Nanette R. Boyle

Kevin J. Cash

Melissa D. Krebs

C. Mark Maupin

Ning Wu

### Teaching Associate Professors

Jason C. Ganley, Assistant Department Head

Tracy Q. Gardner

Rachel M. Morrish

Cynthia L. Norrgran

Paul D. Ogg

John M. Persichetti

Judith N. Schoonmaker

Charles R. Vestal

### Teaching Assistant Professor

C. Joshua Ramey

### Research Associate Professor

Angel Abbud-Madrid

### Research Assistant Professors

Bo Ram Lee

Stephanie Villano

### Adjunct Faculty

John L. Jechura

Sarah M. Ryan

### Professors Emeriti

Robert M. Baldwin

Annette L. Bunge

James F. Ely, University Professor Emeritus

John O. Golden

J. Thomas McKinnon

Ronald L. Miller

E. Dendy Sloan, Jr., University Professor Emeritus

Victor F. Yesavage

### Courses

**BIOL110. SEE CBEN110. 4.0 Semester Hrs.**  
Equivalent with BELS311,CBEN110,

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**CBEN110. FUNDAMENTALS OF BIOLOGY I. 4.0 Semester Hrs.**

Equivalent with BELS311, BIOL110,

(I, II) Fundamentals of Biology with Laboratory I. This course will emphasize the fundamental concepts of biology and use illustrative examples and laboratory investigations that highlight the interface of biology with engineering. The focus will be on (1) the scientific method; (2) structural, molecular, and energetic basis of cellular activities; (3) mechanisms of storage and transfer of genetic information in biological organisms; (4) a laboratory 'toolbox' that will carry them forward in their laboratory-based courses. This core course in biology will be interdisciplinary in nature and will incorporate the major themes and mission of this school - earth, energy, and the environment. Lecture Hours: 3; Lab Hours: 3; Semester Hours: 4.

**CBEN120. FUNDAMENTALS OF BIOLOGY II. 4.0 Semester Hrs.**

Equivalent with BELS313, CBEN323,

This is the continuation of Fundamentals of Biology I. Emphasis in the second semester is placed on an examination of organisms as the products of evolution and the diversity of life forms. Special attention will be given to how form fits function in animals and plants and the potential for biomimetic applications. Prerequisite: CBEN110. Fundamentals of Biology I or equivalent. 3 hours lecture; 3 hours laboratory; 4 semester hours.

**CBEN198. SPECIAL TOPICS. 6.0 Semester Hrs.**

Topical courses in chemical engineering of special interest. Prerequisite: none; 1 to 6 semester hours. Repeatable for credit under different titles.

**CBEN199. INDEPENDENT STUDY. 1-6 Semester Hr.**

Individual research or special problem projects. Topics, content, and credit hours to be agreed upon by student and supervising faculty member. Prerequisite: submission of ?Independent Study? form to CSM Registrar. 1 to 6 semester hours. Repeatable for credit.

**CBEN200. COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING. 3.0 Semester Hrs.**

Equivalent with CHEN200,

Fundamentals of computer programming as applied to the solution of chemical engineering problems. Introduction to Visual Basic, computational methods and algorithm development. Prerequisite: MATH112. 3 hours lecture; 3 semester hours.

**CBEN201. MATERIAL AND ENERGY BALANCES. 3.0 Semester Hrs.**

Equivalent with CHEN201,

(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. Prerequisites: CHGN122. Corequisites: CBEN210 (or equivalent); CBEN202, MATH213, MATH225. 3 hours lecture; 3 semester hours.

**CBEN202. CHEMICAL PROCESS PRINCIPLES LABORATORY. 1.0 Semester Hr.**

Equivalent with CHEN202,

(II) Laboratory measurements dealing with the first and second laws of thermodynamics, calculation and analysis of experimental results, professional report writing. Introduction to computer-aided process simulation. Corequisites: CBEN210 (or equivalent), CBEN201, MATH225, EPIC265 or EPIC266 or EPIC251. 3 hours laboratory; 1 credit hour.

**CBEN210. INTRO TO THERMODYNAMICS. 3.0 Semester Hrs.**

Equivalent with DCGN210,

(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. May not also receive credit for CHGN209, MEGN361, or GEGN330. Prerequisites: CHGN121, CHGN122, MATH111. Co-requisites: MATH112, PHGN100. 3 hours lecture; 3 semester hours.

**CBEN250. INTRODUCTION TO CHEMICAL ENGINEERING ANALYSIS AND DESIGN. 3.0 Semester Hrs.**

Equivalent with CHEN250,

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 CBEN210. 3 hours lecture; 3 semester hours.

**CBEN298. SPECIAL TOPICS. 1-6 Semester Hr.**

Topical courses in chemical engineering of special interest. Prerequisite: none; 1 to 6 semester hours. Repeatable for credit under different titles.

**CBEN299. INDEPENDENT STUDY. 1-6 Semester Hr.**

Individual research or special problem projects. Topics, content, and credit hours to be agreed upon by student and supervising faculty member. Prerequisite: submission of ?Independent Study? form to CSM Registrar. 1 to 6 semester hours. Repeatable for credit.

**CBEN304. ANATOMY AND PHYSIOLOGY. 3.0 Semester Hrs.**

Equivalent with BELS404, CBEN404,

(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. 3 hours lecture; 3 semester hours.

**CBEN305. ANATOMY AND PHYSIOLOGY LAB. 1.0 Semester Hr.**

Equivalent with BELS405, CBEN405,

(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: CBEN404. 3 lab hours, 1 semester hour.

**CBEN306. ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN. 3.0 Semester Hrs.**

Equivalent with BELS406, CBEN406,

(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. 3 hour lecture; 3 semester hours.

**CBEN307. FLUID MECHANICS. 3.0 Semester Hrs.**

Equivalent with CHEN307,

(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 CBEN201. 3 hours lecture; 3 semester hours.

**CBEN308. HEAT TRANSFER. 3.0 Semester Hrs.**

Equivalent with CHEN308,

(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 CBEN307. 3 hours lecture; 3 semester hours.

**CBEN309. ANATOMY AND PHYSIOLOGY: BONE, MUSCLE, AND BRAIN LABORATORY. 1.0 Semester Hr.**

Equivalent with BELS407,CBEN407,

(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 [BIOL110]. Co-requisites: must either have taken or currently taking Anatomy and Physiology BMB [CBEN406]. 3 hour lab; 1 semester hour.

**CBEN310. INTRODUCTION TO BIOMEDICAL ENGINEERING. 3.0 Semester Hrs.**

(I) Introduction to the field of Biomedical Engineering including biomolecular, cellular, and physiological principles, and areas of specialty including biomolecular engineering, biomaterials, biomechanics, bioinstrumentation and bioimaging. Prerequisites: BIOL110 and (CBEN210 or CHGN209 or MEGN361). 3 hours lecture, 3 semester hours.

**CBEN311. INTRODUCTION TO NEUROSCIENCE. 3.0 Semester Hrs.**

(I, II) This course is the general overview of brain anatomy, physiology, and function. It includes perception, motor, language, behavior, and executive function. This course will review what happens with injury and abnormalities of thought. It will discuss the overview of brain development throughout one's lifespan. Prerequisites: BIOL110, CHGN121, CHGN122, PHGN100, PHGN200. 3 hours lecture; 3 semester hours.

**CBEN312. UNIT OPERATIONS LABORATORY. 3.0 Semester Hrs.**

Equivalent with CHEN312,

(S) (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: CBEN201, CBEN202, CBEN307, CBEN308, CBEN357, CBEN375, EPIC265 or equivalent.

**CBEN313. UNIT OPERATIONS LABORATORY. 3.0 Semester Hrs.**

Equivalent with CHEN313,

(S) (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: CBEN201, CBEN202, CBEN307, CBEN308, CBEN357, CBEN375, EPIC265 or equivalent.

**CBEN315. INTRODUCTION TO ELECTROCHEMICAL ENGINEERING. 3.0 Semester Hrs.**

(II) Introduction to the field of Electrochemical Engineering including basic electrochemical principles, electrode kinetics, ionic conduction, as applied to common devices such as fuel cells, electrolyzers, redox flow cells and batteries. Prerequisites: CBEN210. 3 hours lecture; 3 semester hours.

**CBEN320. CELL BIOLOGY AND PHYSIOLOGY. 3.0 Semester Hrs.**

Equivalent with BELS402,CBEN410,ESGN402,

(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.

**CBEN321. INTRO TO GENETICS. 4.0 Semester Hrs.**

Equivalent with BELS321,ESGN321,

(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.

**CBEN322. BIOLOGY OF BEHAVIOR. 3.0 Semester Hrs.**

(II) This course relates the hard sciences of the brain and neuroscience to the psychology of human behavior. It covers such topics as decision making, learning, the brain's anatomy and physiology, psychopathology, addiction, the senses, sexuality, and brainwashing. It addresses the topics covered on the psychology section of the MCAT examination. Prerequisites: CBEN110, CHGN122, PHGN200. 3 hours lecture; 3 semester hours.

**CBEN323. GENERAL BIOLOGY II LABORATORY. 1.0 Semester Hr.**

Equivalent with BELS313,ESGN313,

(I, II) This Course provides students with laboratory exercises that complement lectures given in CBEN303, 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: CBEN303 or equivalent. 3 hours laboratory; 1 semester hour.

**CBEN340. COOPERATIVE EDUCATION. 1-3 Semester Hr.**

Equivalent with CHEN340,

Cooperative work/education experience involving employment of a chemical engineering nature in an internship spanning at least one academic semester. Prerequisite: none. 1 to 3 semester hours. Repeatable to a maximum of 6 hours.

**CBEN350. HONORS UNDERGRADUATE RESEARCH. 1-3 Semester Hr.**

Equivalent with CHEN350,

Scholarly research of an independent nature. Prerequisite: Junior standing. 1 to 3 semester hours.



**CBEN351. HONORS UNDERGRADUATE RESEARCH. 1-3 Semester Hr.**

Equivalent with CHEN351,  
Scholarly research of an independent nature. Prerequisite: junior standing. 1 to 3 semester hours.

**CBEN357. CHEMICAL ENGINEERING THERMODYNAMICS. 3.0 Semester Hrs.**

Equivalent with CHEN357,  
(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: CBEN210 (or equivalent), MATH225, grade of C- or better in CBEN201. 3 hours lecture; 3 semester hours.

**CBEN358. CHEMICAL ENGINEERING THERMODYNAMICS LABORATORY. 1.0 Semester Hr.**

Equivalent with CHEN358,  
(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: CBEN202. Corequisites: CBEN357, EPIC265 or EPIC266 or EPIC251. 3 hours laboratory; 1 semester hour.

**CBEN368. INTRODUCTION TO UNDERGRADUATE RESEARCH. 1.0 Semester Hr.**

Equivalent with CHEN368,  
(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.

**CBEN375. MASS TRANSFER. 3.0 Semester Hrs.**

Equivalent with CHEN375,  
(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 CBEN357. 3 hours lecture; 3 semester hours.

**CBEN398. SPECIAL TOPICS. 1-6 Semester Hr.**

Topical courses in chemical engineering of special interest. Prerequisite: none; 1 to 6 semester hours. Repeatable for credit under different titles.

**CBEN399. INDEPENDENT STUDY. 1-6 Semester Hr.**

Individual research or special problem projects. Topics, content, and credit hours to be agreed upon by student and supervising faculty member. Prerequisite: submission of ?Independent Study? form to CSM Registrar. 1 to 6 semester hours. Repeatable for credit.

**CBEN401. INTRODUCTION TO CHEMICAL PROCESS DESIGN. 3.0 Semester Hrs.**

Equivalent with CHEN401,  
(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: CBEN201, CBEN308, CBEN307, CBEN357, CBEN375. 3 hours lecture; 3 semester hours.

**CBEN402. CHEMICAL ENGINEERING DESIGN. 3.0 Semester Hrs.**

Equivalent with CHEN402,  
(II) 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. Prerequisites: CBEN307, CBEN308, CBEN357, CBEN358, CBEN375. Co-requisites: CBEN418, EBG321. 3 hours lecture; 3 semester hours.

**CBEN403. PROCESS DYNAMICS AND CONTROL. 3.0 Semester Hrs.**

Equivalent with CHEN403,  
(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: CBEN201, CBEN307, CBEN308, CBEN375, MATH225.

**CBEN408. NATURAL GAS PROCESSING. 3.0 Semester Hrs.**

Equivalent with CHEN408,  
(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, CBEN201, CBEN307, CBEN308, CBEN357, CBEN375. 3 hours lecture, 3 semester hours.

**CBEN409. PETROLEUM PROCESSES. 3.0 Semester Hrs.**

Equivalent with CHEN409,  
(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, CBEN201, CBEN357, CBEN375. 3 hours lecture; 3 semester hours.

**CBEN411. NEUROSCIENCE, MEMORY, AND LEARNING. 3.0 Semester Hrs.**

Equivalent with CBEN511,  
(II) This course relates the hard sciences of the brain and neuroscience to memory encoding and current learning theories. Prerequisites: CBEN110, CBEN120, CHGN221, CHGN222, PHGN100, PHGN200. 3 hours lecture, 3 semester hours.

**CBEN412. INTRODUCTION TO PHARMACOLOGY. 3.0 Semester Hrs.**

(II) This course introduces the concepts of pharmacokinetics and biopharmaceuticals. It will discuss the delivery systems for pharmaceuticals and how they change with disease states. It will cover the modeling of drug delivery, absorption, excretion, and accumulation. The course will cover the different modeling systems for drug delivery and transport. Prerequisites: CBEN110, CBEN120, CHGN121, CHGN122. 3 hours lecture; 3 semester hours.

**CBEN415. POLYMER SCIENCE AND TECHNOLOGY. 3.0 Semester Hrs.**

Equivalent with BELS415, CHEN415, CHGN430, MLGN530,  
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, CBEN357. 3 hours lecture; 3 semester hours.

**CBEN416. POLYMER ENGINEERING AND TECHNOLOGY. 3.0****Semester Hrs.**

Equivalent with CHEN416,

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: CBEN307, MATH225. 3 hours lecture; 3 semester hours.

**CBEN418. KINETICS AND REACTION ENGINEERING. 3.0 Semester Hrs.**

Equivalent with CHEN418,

(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: CBEN308, CBEN357, MATH225, CHGN221, CHGN351. 3 hours lecture; 3 semester hours.

**CBEN420. MATHEMATICAL METHODS IN CHEMICAL ENGINEERING. 3.0 Semester Hrs.**

Equivalent with CHEN420,

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, CHGN209 or CBEN210, CBEN307, CBEN357. 3 hours lecture; 3 semester hours.

**CBEN430. TRANSPORT PHENOMENA. 3.0 Semester Hrs.**

Equivalent with CHEN430,

(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: CBEN307, CBEN308, CBEN357, CBEN375, MATH225. 3 hours lecture; 3 semester hours.

**CBEN431. IMMUNOLOGY FOR ENGINEERS AND SCIENTISTS. 3.0 Semester Hrs.**

Equivalent with BELS431,

(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 [BIOL110] or equivalent. 3 Lecture hours, 3 semester hours.

**CBEN432. TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS. 3.0 Semester Hrs.**

Equivalent with BELS432, CHEN432,

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: CBEN430 or equivalent. 3 lecture hours, 3 credit hours.

**CBEN435. INTERDISCIPLINARY MICROELECTRONICS. 3.0 Semester Hrs.**

Equivalent with CHEN435, CHEN535, MLGN535, PHGN435, PHGN535,

(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, CBEN, MTGN, or EGGN. Due to lab, space the enrollment is limited to 20 students. 1.5 hours lecture, 4 hours lab; 3 semester hours.

**CBEN440. MOLECULAR PERSPECTIVES IN CHEMICAL ENGINEERING. 3.0 Semester Hrs.**

Equivalent with CHEN440,

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: CBEN307, CBEN308, CBEN357, CBEN375, CHGN351 and CHGN353, CHGN221 and CHGN222, MATH225. 3 hours lecture; 3 semester hours.

**CBEN450. HONORS UNDERGRADUATE RESEARCH. 1-3 Semester Hr.**

Equivalent with CHEN450,

Scholarly research of an independent nature. Prerequisite: senior standing. 1 to 3 semester hours.

**CBEN451. HONORS UNDERGRADUATE RESEARCH. 1-3 Semester Hr.**

Equivalent with CHEN451,

Scholarly research of an independent nature. Prerequisite: senior standing. 1 to 3 semester hours.

**CBEN454. APPLIED BIOINFORMATICS. 3.0 Semester Hrs.**

Equivalent with BELS454,

(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 [BIOL110]. 3 hour lecture; 3 semester hours.

**CBEN460. BIOCHEMICAL PROCESS ENGINEERING. 3.0 Semester Hrs.**

Equivalent with CHEN460,

(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: CBEN375, CHGN428, CHGN462. 3 hours lecture; 3 semester hours.

**CBEN461. BIOCHEMICAL PROCESS ENGINEERING LABORATORY. 1.0 Semester Hr.**

Equivalent with CHEN461,

(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: CBEN375, CHGN428, CHGN462. Co-requisite: CBEN460, 3 hours laboratory, 1 semester hour.

**CBEN469. FUEL CELL SCIENCE AND TECHNOLOGY. 3.0 Semester Hrs.**

Equivalent with CHEN469,EGGN469,MEGN469,MTGN469,

(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: MEGN361 or CBEN357 or MTGN351. 3 hours lecture; 3 semester hours.

**CBEN470. INTRODUCTION TO MICROFLUIDICS. 3.0 Semester Hrs.**

Equivalent with BELS470,CHEN470,

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: CBEN307 (or equivalent) or MEGN351 (or equivalent). 3 semester hours.

**CBEN472. INTRODUCTION TO ENERGY TECHNOLOGIES. 3.0 Semester Hrs.**

Equivalent with CHEN472,

(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: CBEN357 Chemical Engineering Thermodynamics (or equivalent). 3 lecture hours, 3 credit hours.

**CBEN480. NATURAL GAS HYDRATES. 3.0 Semester Hrs.**

Equivalent with CHEN480,

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.

**CBEN497. SPECIAL SUMMER COURSE. 15.0 Semester Hrs.****CBEN498. SPECIAL TOPICS. 1-6 Semester Hr.**

Topical courses in chemical engineering of special interest. Prerequisite: none; 1 to 6 semester hours. Repeatable for credit under different titles.

**CBEN499. INDEPENDENT STUDY. 1-6 Semester Hr.**

Individual research or special problem projects. Topics, content, and credit hours to be agreed upon by student and supervising faculty member. Prerequisite: none, submission of ?Independent Study? form to CSM Registrar. 1 to 6 semester hours. Repeatable for credit.

# Chemistry

2016-2017

## 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 strongly advised to include undergraduate research 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.

PAGN	PHYSICAL ACTIVITY COURSE	0.5		
Elective				
				<b>17.0</b>

## 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

Fall		lec	lab	sem.hrs
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
EPIC151	DESIGN (EPICS) I			3.0
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS or CBEN 110			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

### Spring

		lec	lab	sem.hrs
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
LAIS100	NATURE AND HUMAN VALUES			4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.5

### Sophomore

Fall		lec	lab	sem.hrs
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	2.0	4.0	4.5
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I	3.0		3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY		3.0	1.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

### Spring

		lec	lab	sem.hrs
LAIS200	HUMAN SYSTEMS			3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
CHGN222	ORGANIC CHEMISTRY II	3.0		3.0
CHGN224	ORGANIC CHEMISTRY II LABORATORY		3.0	1.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
CHGN335	INSTRUMENTAL ANALYSIS	3.0		3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.5</b>

### Junior

Fall		lec	lab	sem.hrs
CHGN336	ANALYTICAL CHEMISTRY	3.0		3.0
CHGN337	ANALYTICAL CHEMISTRY LABORATORY		3.0	1.0
CHGN341	INORGANIC CHEMISTRY I	3.0		3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	3.0	4.0
CHGN395	INTRODUCTION TO UNDERGRADUATE RESEARCH		3.0	1.0
LAIS/EBGN	H&SS Restricted Elective I	3.0		3.0
FREE	Free Elective	3.0		3.0
				<b>18.0</b>

### Spring

		lec	lab	sem.hrs
CHGN353	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II	3.0	3.0	4.0
CHGN323	QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY	1.0	3.0	2.0
CHGN428	BIOCHEMISTRY	3.0		3.0
TECH ELECT	Technical Elective *	3.0		3.0
TECH ELECT	Technical Elective *	3.0		3.0
				<b>15.0</b>

Summer		lec	lab	sem.hrs
CHGN490	CHEMISTRY FIELD SESSION		18.0	6.0
				<b>6.0</b>

Senior		lec	lab	sem.hrs
<b>Fall</b>				
LAIS/EBGN	H&SS Restricted Elective II	3.0		3.0
CHGN	Chemistry Elective**			3.0
ELECT				
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>

Spring		lec	lab	sem.hrs
LAIS/EBGN	H&SS Restricted Elective III	3.0		3.0
CHGN401	INORGANIC CHEMISTRY II	3.0		3.0
CHGN	Chemistry Elective**			2.0
ELECT				
TECH ELECT	Technical Elective*	3.0		3.0
FREE	Free Elective	3.0		3.0
				<b>14.0</b>

**Total Semester Hrs: 133.5**

\* Technical Electives are courses in any technical field. LAIS, PAGN, Military Science, ROTC, McBride and the business courses of EBGN are **not** accepted technical electives. Examples of possible electives that will be recommended to students are:

CEEN301	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I	3.0		
CHGN411	APPLIED RADIOCHEMISTRY	3.0		
CHGN430	INTRODUCTION TO POLYMER SCIENCE	3.0		
CHGN462	MICROBIOLOGY	3.0		
EBGN305	FINANCIAL ACCOUNTING	3.0		
EBGN306	MANAGERIAL ACCOUNTING	3.0		
EBGN310	ENVIRONMENTAL AND RESOURCE ECONOMICS	3.0		
GEGN206	EARTH MATERIALS	3.0		
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0		
MATH332	LINEAR ALGEBRA	3.0		
MNGN210	INTRODUCTORY MINING	3.0		
MTGN311	STRUCTURE OF MATERIALS	3.0		
PEGN102	INTRODUCTION TO PETROLEUM INDUSTRY	3.0		
PHGN300	PHYSICS III-MODERN PHYSICS I	3.0		
PHGN419	PRINCIPLES OF SOLAR ENERGY SYSTEMS	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 strongly advised 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.

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**

Fall		lec	lab	sem.hrs
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
EPIC151	DESIGN (EPICS) I			3.0
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS or CBEN 110			4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

Spring		lec	lab	sem.hrs
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
LAIS100	NATURE AND HUMAN VALUES			4.0
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>17.0</b>

**Sophomore**

Fall		lec	lab	sem.hrs
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	2.0	4.0	4.5
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS			3.0
CHGN221	ORGANIC CHEMISTRY I	3.0		3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY		3.0	1.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

Spring		lec	lab	sem.hrs
LAIS200	HUMAN SYSTEMS			3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
CHGN222	ORGANIC CHEMISTRY II	3.0		3.0
CHGN224	ORGANIC CHEMISTRY II LABORATORY		3.0	1.0
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
CHGN335	INSTRUMENTAL ANALYSIS	3.0		3.0

PAGN	PHYSICAL ACTIVITY COURSE	0.5		
Elective				

**16.5****Junior**

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHGN336	ANALYTICAL CHEMISTRY	3.0		3.0
CHGN337	ANALYTICAL CHEMISTRY LABORATORY	3.0	1.0	1.0
CHGN341	INORGANIC CHEMISTRY I	3.0		3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	3.0	4.0
CHGN395	INTRODUCTION TO UNDERGRADUATE RESEARCH	3.0	1.0	1.0
LAIS/EBGN	H&SS Restricted Elective I	3.0		3.0
CHEV	Environmental Elective **	3.0		3.0
ELECT				

**18.0**

<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHGN353	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II	3.0	3.0	4.0
CHGN323	QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY	1.0	3.0	2.0
CHGN428	BIOCHEMISTRY	3.0		3.0
CHEV	Environmental Elective **	3.0		3.0
ELECT				
TECH ELECT	Technical Elective *	3.0		3.0

**15.0**

<b>Summer</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHGN490	CHEMISTRY FIELD SESSION		18.0	6.0

**6.0****Senior**

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHEV	Environmental Elective **	3.0		3.0
ELECT				
CHEV	Environmental Elective **	3.0		3.0
ELECT				
CHGN	Chemistry Elective **	3.0		3.0
ELECT				
LAIS/EBGN	H&SS Restricted Elective II	3.0		3.0
FREE	Free Elective	3.0		3.0

**15.0**

<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHGN410	SURFACE CHEMISTRY	3.0		3.0
LAIS/EBGN	H&SS Restricted Elective III	3.0		3.0
CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY	3.0		3.0
CHGN	Chemistry Elective **			2.0
ELECT				
FREE	Free Elective	3.0		3.0

**14.0****Total Semester Hrs: 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.

Environmental Electives are courses that are directly or indirectly related to Environmental Chemistry. Examples include environmental CEEN courses and CHGN462 Microbiology. Students can consult their advisors for further clarification.

CHGN495 SENIOR UNDERGRADUATE RESEARCH is taught as a possible chemistry elective. Those aspiring to enter Ph.D. programs in Chemistry or related fields are strongly advised 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.

**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**

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
CBEN110	FUNDAMENTALS OF BIOLOGY I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
EPIC151	DESIGN (EPICS) I			3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				

**16.0**

<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
LAIS100	NATURE AND HUMAN VALUES			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1)			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				

**17.0****Sophomore**

<b>Fall</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III	4.0		4.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS	2.0	4.0	4.5
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS			3.0

CHGN221	ORGANIC CHEMISTRY I	3.0	3.0
CHGN223	ORGANIC CHEMISTRY I LABORATORY	3.0	1.0
PAGN Elective	PHYSICAL ACTIVITY COURSE		0.5

**16.0**

<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
LAIS200	HUMAN SYSTEMS			3.0
EBGN201	PRINCIPLES OF ECONOMICS	3.0		3.0
CHGN222	ORGANIC CHEMISTRY II	3.0		3.0
CHGN224	ORGANIC CHEMISTRY II LABORATORY	3.0	1.0	
MATH225	DIFFERENTIAL EQUATIONS	3.0		3.0
CHGN335	INSTRUMENTAL ANALYSIS	3.0		3.0
PAGN Elective	PHYSICAL ACTIVITY COURSE			0.5

**16.5**

<b>Junior</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
<b>Fall</b>				
TECH ELECT	Technical Elective*			4.0
CHGN336	ANALYTICAL CHEMISTRY	3.0		3.0
CHGN337	ANALYTICAL CHEMISTRY LABORATORY	3.0	1.0	
CHGN341	INORGANIC CHEMISTRY I	3.0		3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	3.0	4.0	4.0
CHGN395	INTRODUCTION TO UNDERGRADUATE RESEARCH	3.0	1.0	

**16.0**

<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHGN353	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II	3.0	3.0	4.0
CHGN323	QUALITATIVE ORGANIC ANALYSIS AND APPLIED SPECTROSCOPY	1.0	3.0	2.0
CHGN428	BIOCHEMISTRY	3.0		3.0
LAIS/EBGN	H&SS Restricted Elective I	3.0		3.0
CBEN120	FUNDAMENTALS OF BIOLOGY II			4.0

**16.0**

<b>Summer</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
CHGN490	CHEMISTRY FIELD SESSION	18.0		6.0

**6.0**

<b>Senior</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
<b>Fall</b>				
CHGN429	BIOCHEMISTRY II	3.0		3.0
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

**15.0**

<b>Spring</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
LAIS/EBGN	H&SS Restricted Elective III	3.0		3.0
CHGN401	INORGANIC CHEMISTRY II	3.0		3.0

CHGN ELECT	Chemistry Elective**			2.0
FREE	Free Elective		3.0	3.0
FREE	Free Elective		3.0	3.0

**14.0****Total Semester Hrs: 132.5**

\* 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. \* Possible technical electives that will be recommended to students are:

CHGN403	INTRODUCTION TO ENVIRONMENTAL CHEMISTRY	3.0
CHGN462	MICROBIOLOGY	3.0
CBEN304	ANATOMY AND PHYSIOLOGY	3.0
CBEN320	CELL BIOLOGY AND PHYSIOLOGY	3.0
CBEN321	INTRO TO GENETICS	4.0

\*\* 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 strongly advised 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.

**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 (p. 42).

## 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 (<http://bulletin.mines.edu/undergraduate/undergraduateinformation/minorasi>).

## Professors

Mark E. Eberhart

Mark P. Jensen, Grandey University Chair in Nuclear Science & Engineering

Daniel M. Knauss

James F. Ranville



Ryan M. Richards

Bettina M. Voelker

Kim R. Williams

David T. Wu , Department Head

## Associate Professors

Stephen G. Boyes

Matthew C. Posewitz

Alan S. Sellinger

## Assistant Professors

Jenifer C. Braley

Svitlana Pylypenko

Brian G. Trewyn

Shubham Vyas

Yongan Yang

## Teaching Professors

Renee L. Falconer

Mark R. Seger

## Teaching Associate Professor

Angela Sower

## Teaching Assistant Professors

Allison G. Caster

Edward A. Dempsey

## Research Professors

Donald L. Macalady

Kent J. Voorhees

## Research Assistant Professors

Christopher Cox

Fiona Davies

Yuan Yang

## Research Faculty

Jesse Hensley

Bryan Pivovar

Robert Rundberg

## Affiliated Faculty

Joseph Meyer

## Professors Emeriti

Scott W. Cowley

Stephen R. Daniel

Dean W. Dickerhoof

Kenneth W. Edwards

Ronald W. Klusman

Donald Langmuir

Patrick MacCarthy

Michael J. Pavelich

E. Craig Simmons

Thomas R. Wildeman

John T. Williams

Robert D. Witters

## Courses

### CHGN111. INTRODUCTORY CHEMISTRY. 3.0 Semester Hrs.

(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 Semester Hrs.

(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 Semester Hrs.

(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.

**CHGN125. MOLECULAR ENGINEERING & MATERIALS CHEMISTRY. 4.0 Semester Hrs.**

(I,II) Studies of the interactions of matter and energy in chemical reactions and physical processes. Building on principles from CHGN121, the course systematically explores the relationships between processes, structures and properties, starting from the atomic and molecular level. It provides a framework to apply knowledge of chemical bonding and material properties to engineering design, with an emphasis on the Engineering Grand Challenges and the discovery of new process-structure-property relationships. There is a strong focus on the underlying principles of kinetics and equilibrium, and their general applicability, strongly rooted in the first and second law of thermodynamics. Examples of these principles come primarily from solid-state systems. Laboratory experiments emphasize conceptual understanding of structure-property relationships through both hands-on and computational analysis, reinforced by quantitative chemical measurements. Prerequisite: Grade of C- or better in CHGN121. 3 hours lecture; 3 hours lab; 4 semester hours.

**CHGN198. SPECIAL TOPICS. 6.0 Semester Hrs.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**CHGN198LA. SPECIAL TOPICS. 6.0 Semester Hrs.****CHGN198LB. SPECIAL TOPICS. 6.0 Semester Hrs.****CHGN199. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

**CHGN209. INTRODUCTION TO CHEMICAL THERMODYNAMICS. 3.0 Semester Hrs.**

Equivalent with DCGN209,

(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. May not also receive credit for CBEN210, MEGN361, or GEGN330. Prerequisites: CHGN121, CHGN122 or CHGN125, MATH111, MATH112, PHGN100. 3 hours lecture; 3 semester hours.

**CHGN221. ORGANIC CHEMISTRY I. 3.0 Semester Hrs.**

(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 or CHGN125. 3 hours lecture; 3 semester hours.

**CHGN222. ORGANIC CHEMISTRY II. 3.0 Semester Hrs.**

(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 Semester Hr.**

(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 Semester Hr.**

(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 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**CHGN299. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hrs.**

(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 CHGN209 or CBEN210. 3 hours lecture; 3 semester hours.

**CHGN337. ANALYTICAL CHEMISTRY LABORATORY. 1.0 Semester Hr.**

(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 Semester Hrs.**

(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. INORGANIC CHEMISTRY I. 3.0 Semester Hrs.**

(I) The chemistry of the elements and periodic trends in reactivity is discussed. Particular concepts covered include group theory, symmetry, bonding in ionic and metallic crystal, acid-base theories, coordination chemistry, ligand field theory and radioactivity. Prerequisite: CHGN222 and CHGN209. 3 hours lecture; 3 semester hours.

**CHGN351. PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I. 4.0 Semester Hrs.**

(I,II,S) 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 CHGN 122 or CHGN 125; and Grade of C- or better in CHGN209 or CBEN210. 3 hours lecture; 3 hours lab; 4 semester hours.

**CHGN353. PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II. 4.0 Semester Hrs.**

(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 Semester Hr.**

(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. Credit: 1 semester hour.

**CHGN396. UNDERGRADUATE RESEARCH. 1-5 Semester Hr.**

(I,II,S) Individual research project for freshman, sophomores or juniors under direction of a member of the departmental faculty. Prerequisites: None. Variable credit; 1 to 5 credit hours. Repeatable for credit. Seniors should take CHGN495 instead of CHGN396.

**CHGN398. SPECIAL TOPICS IN CHEMISTRY. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**CHGN398LA. SPECIAL TOPICS LAB. 1-6 Semester Hr.****CHGN399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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. INORGANIC CHEMISTRY II. 3.0 Semester Hrs.**

(II) The chemistry of the elements and several applications are related to inorganic chemistry are considered in this course. Particular concepts covered include experimental techniques, chemistry specific to groups of elements, catalysis and industrial processes, inorganic materials and nanotechnology, and other applications of inorganic chemistry. Prerequisite: CHGN341. 3 hours lecture; 3 semester hours.

**CHGN403. INTRODUCTION TO ENVIRONMENTAL CHEMISTRY. 3.0 Semester Hrs.**

Equivalent with CHGC505,

(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, CHGN209 or CBEN210. 3 hours lecture; 3 semester hours.

**CHGN410. SURFACE CHEMISTRY. 3.0 Semester Hrs.**

Equivalent with MLGN510,

(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: CHGN209. 3 hours lecture; 3 semester hours.

**CHGN411. APPLIED RADIOCHEMISTRY. 3.0 Semester Hrs.**

(II) This course is designed for those who have a budding interest in radiochemistry and its applications. A brief overview of radioactivity and general chemistry will be provided in the first three weeks of the course. Follow-on weeks will feature segments focusing on the radiochemistry in the nuclear fuel cycle, radioisotope production, nuclear forensics and the environment. Prerequisite: CHGN121 and CHGN122. 3 hours lecture, 3 semester hours.

**CHGN422. POLYMER CHEMISTRY LABORATORY. 1.0 Semester Hr.**

(I) Prerequisites: CHGN221, CHGN223. 3 hours lab; 1 semester hour.

**CHGN428. BIOCHEMISTRY. 3.0 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**CHGN429. BIOCHEMISTRY II. 3.0 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**CHGN430. INTRODUCTION TO POLYMER SCIENCE. 3.0 Semester Hrs.**

Equivalent with CHEN415,MLGN530,

(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. Prerequisite: CHGN222. 3 hour lecture, 3 semester hours.

**CHGN462. MICROBIOLOGY. 3.0 Semester Hrs.**

Equivalent with CHGN562,ESGN580,

(II) 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. Special focus will be on pathogenic bacteriology, virology, and parasitology including disease symptoms, transmission, and treatment. Prerequisite: none. 3 hours lecture, 3 semester hours.

**CHGN475. COMPUTATIONAL CHEMISTRY. 3.0 Semester Hrs.**

(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. CHEMISTRY FIELD SESSION. 6.0 Semester Hrs.**

(S) (WI) Professional-level chemistry experience featuring modules including organic/polymer synthesis and characterization, inorganic nanomaterial investigations, computational chemistry, environmental chemical analysis, biochemistry and technical report writing.

Prerequisites: CHGN323, CHGN341, and CHGN353. 6-week summer session; 6 semester hours.

**CHGN495. UNDERGRADUATE RESEARCH. 1-5 Semester Hr.**

(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. Variable credit; 1 to 5 credit hours. Repeatable for credit.

**CHGN496A. SPECIAL SUMMER COURSE. 16.0 Semester Hrs.****CHGN497. INTERNSHIP. 1-6 Semester Hr.**

(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. Variable credit; 1 to 6 credit hours.

**CHGN498. SPECIAL TOPICS IN CHEMISTRY. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**CHGN499. INDEPENDENT STUDY. 0.5-6 Semester Hr.**

(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.

# Metallurgical and Materials Engineering

2016-2017

## 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:

<b>Freshman</b>		<b>lec</b>	<b>lab sem.hrs</b>
<b>Fall</b>			
LAIS100	NATURE AND HUMAN VALUES		4.0
CHGN121	PRINCIPLES OF CHEMISTRY I		4.0
CSM101	FRESHMAN SUCCESS SEMINAR		0.5
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS or CBEN 110		4.0
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I		4.0
PAGN	PHYSICAL ACTIVITY COURSE		0.5
Elective			
			<b>17.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1) or 125		4.0
PHGN100	PHYSICS I - MECHANICS		4.5
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II		4.0
EPIC151	DESIGN (EPICS) I		3.0
PAGN	PHYSICAL ACTIVITY COURSE		0.5
Elective			
			<b>16.0</b>
<b>Sophomore</b>			
<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>
CHGN209	INTRODUCTION TO CHEMICAL THERMODYNAMICS		3.0
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III		4.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS		4.5
MTGN202	ENGINEERED MATERIALS		3.0
PAGN	PHYSICAL ACTIVITY COURSE		0.5
Elective			
			<b>15.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
MATH225	DIFFERENTIAL EQUATIONS		3.0
TECH ELECT	Restricted Technical Elective**		3.0
CEEN241	STATICS		3.0
EPIC251	DESIGN (EPICS) II		3.0
EBGN201	PRINCIPLES OF ECONOMICS		3.0
LAIS200	HUMAN SYSTEMS		3.0

PAGN	PHYSICAL ACTIVITY COURSE		0.5	
Elective				
			<b>18.5</b>	
<b>Summer</b>		<b>lec</b>	<b>lab sem.hrs</b>	
MTGN272	PARTICULATE MATERIALS PROCESSING		3.0	
			<b>3.0</b>	
<b>Junior</b>				
<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>	
MTGN311	STRUCTURE OF MATERIALS		3.0	
MTGN311L	STRUCTURE OF MATERIALS LABORATORY		1.0	
MTGN351	METALLURGICAL AND MATERIALS THERMODYNAMICS		3.0	
MTGN381	INTRODUCTION TO PHASE EQUILIBRIA IN MATERIALS SYSTEMS		2.0	
CEEN311	MECHANICS OF MATERIALS		3.0	
LAIS/EBGN	H&SS Elective I		3.0	
FREE	Free Elective		3.0	
			<b>18.0</b>	
<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>	
MTGN334	CHEMICAL PROCESSING OF MATERIALS		3.0	
MTGN334L	CHEMICAL PROCESSING OF MATERIALS LABORATORY		1.0	
MTGN348	MICROSTRUCTURAL DEVELOPMENT		3.0	
MTGN348L	MICROSTRUCTURAL DEVELOPMENT LABORATORY		1.0	
MTGN352	METALLURGICAL AND MATERIALS KINETICS		3.0	
LAIS/EBGN	H&SS Elective II		3.0	
FREE	Free Elective		3.0	
			<b>17.0</b>	
<b>Senior</b>				
<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>	
MTGN445	MECHANICAL PROPERTIES OF MATERIALS		3.0	
MTGN445L	MECHANICAL PROPERTIES OF MATERIALS LABORATORY		1.0	
MTGN450	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS		3.0	
MTGN461	TRANSPORT PHENOMENA AND REACTOR DESIGN FOR METALLURGICAL AND MATERIALS ENGINEERS		2.0	
MTGN461L	TRANSPORT PHENOMENA AND REACTOR DESIGN LABORATORY		1.0	
MTGN	MTGN Elective		3.0	
LAIS/EBGN	H&SS Elective III (400 Level)		3.0	
			<b>16.0</b>	

<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
MTGN415	ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS		3.0
MTGN466	MATERIALS DESIGN: SYNTHESIS, CHARACTERIZATION AND SELECTION		3.0
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 Semester Hrs: 138.5**

**\*\* Restricted Electives:**

CBEN120	FUNDAMENTALS OF BIOLOGY II	4.0
CEEN301	FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I	3.0
CHGN221	ORGANIC CHEMISTRY I	3.0
CHGN335	INSTRUMENTAL ANALYSIS	3.0
CHGN336	ANALYTICAL CHEMISTRY	3.0
CHGN351	PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I	4.0
CSCI261	PROGRAMMING CONCEPTS	3.0
EENG281	INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER	3.0
ENGY200	INTRODUCTION TO ENERGY	3.0
MATH201	PROBABILITY AND STATISTICS FOR ENGINEERS	3.0
MATH332	LINEAR ALGEBRA	3.0
MATH348	ADVANCED ENGINEERING MATHEMATICS	3.0
PHGN215	ANALOG ELECTRONICS	4.0
PHGN300	PHYSICS III-MODERN PHYSICS I	3.0

**Physical and Manufacturing Metallurgy Track requires:**

Sophomore and Junior Year is the same as the MME degree

**Freshman**

	<b>lec</b>	<b>lab sem.hrs</b>
Freshman Year		33.0
		<b>33.0</b>

**Sophomore**

	<b>lec</b>	<b>lab sem.hrs</b>
Sophomore Year		36.5
		<b>36.5</b>

**Junior**

	<b>lec</b>	<b>lab sem.hrs</b>
Junior Year		35.0
		<b>35.0</b>

**Senior**

	<b>lec</b>	<b>lab sem.hrs</b>
MTGN445	MECHANICAL PROPERTIES OF MATERIALS	3.0

MTGN445L	MECHANICAL PROPERTIES OF MATERIALS LABORATORY	1.0		
MTGN450	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS	3.0		
MTGN461	TRANSPORT PHENOMENA AND REACTOR DESIGN FOR METALLURGICAL AND MATERIALS ENGINEERS	2.0		
MTGN461L	TRANSPORT PHENOMENA AND REACTOR DESIGN LABORATORY	1.0		
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			3.0
MTGN415	ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS			3.0
MTGN442	ENGINEERING ALLOYS			3.0
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 Semester Hrs: 138.5**

# Track MTGN Electives must be selected from the following courses:

MTGN300	FOUNDRY METALLURGY	2.0
MTGN300L	FOUNDRY METALLURGY LABORATORY	1.0
MTGN456	ELECTRON MICROSCOPY	2.0
MTGN456L	ELECTRON MICROSCOPY LABORATORY	1.0
MTGN464	FORGING AND FORMING	2.0
MTGN464L	FORGING AND FORMING LABORATORY	1.0
MTGN475	METALLURGY OF WELDING	2.0
MTGN475L	METALLURGY OF WELDING LABORATORY	1.0

**Ceramic and Electronic Materials Track requires:**

Sophomore and Junior Year is the same as the MME degree

**Freshman**

	<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
Freshman Year			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>

<b>Senior</b>		<b>lec</b>	<b>lab</b>	<b>sem.hrs</b>
<b>Fall</b>				
MTGN445	MECHANICAL PROPERTIES OF MATERIALS			3.0
MTGN445L	MECHANICAL PROPERTIES OF MATERIALS LABORATORY			1.0
MTGN450	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS			3.0
MTGN461	TRANSPORT PHENOMENA AND REACTOR DESIGN FOR METALLURGICAL AND MATERIALS ENGINEERS			2.0
MTGN461L	TRANSPORT PHENOMENA AND REACTOR DESIGN LABORATORY			1.0
MTGN412	CERAMIC ENGINEERING			3.0
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			3.0
MTGN415	ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS			3.0
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 Semester Hrs: 138.5**

# Track MTGN Electives must be selected from the following courses:

MTGN414	PROCESSING OF CERAMICS	3.0
MTGN456	ELECTRON MICROSCOPY	2.0
MTGN456L	ELECTRON MICROSCOPY LABORATORY	1.0
MTGN465	MECHANICAL PROPERTIES OF CERAMICS	3.0
MTGN469	FUEL CELL SCIENCE AND TECHNOLOGY	3.0
CHGN410	SURFACE CHEMISTRY	3.0
PHGN419	PRINCIPLES OF SOLAR ENERGY SYSTEMS	3.0
PHGN435	INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY	3.0

## Restricted Track MTGN Elective must be selected from the following courses:

MTGN414	PROCESSING OF CERAMICS	3.0
PHGN435	INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY	3.0

**Physicochemical Processing of Materials Track requires:**

Sophomore and Junior Year is the same as the MME degree



**Freshman**

	lec	lab sem.hrs
Freshman Year		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**

Fall	lec	lab sem.hrs
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MTGN445	MECHANICAL PROPERTIES OF MATERIALS	3.0
MTGN445L	MECHANICAL PROPERTIES OF MATERIALS LABORATORY	1.0
MTGN450	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS	3.0
MTGN461	TRANSPORT PHENOMENA AND REACTOR DESIGN FOR METALLURGICAL AND MATERIALS ENGINEERS	2.0
MTGN461L	TRANSPORT PHENOMENA AND REACTOR DESIGN LABORATORY	1.0
MTGN	Track MTGN Elective <sup>#</sup>	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	3.0
MTGN415	ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS	3.0
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 Semester Hrs: 138.5**

# Track MTGN Electives must be selected from the following courses:

MTGN430	PHYSICAL CHEMISTRY OF IRON AND STEELMAKING	3.0
MTGN431	HYDRO- AND ELECTRO-METALLURGY	3.0
MTGN432	PYROMETALLURGY	3.0
MTGN532	PARTICULATE MATERIAL PROCESSING I - COMMUNITION AND PHYSICAL SEPARATIONS	3.0
MTGN533	PARTICULATE MATERIAL PROCESSING II - APPLIED SEPARATIONS	3.0

**Biomaterials Track requires:**

Sophomore and Junior Year is the same as the MME degree

**Freshman**

	lec	lab sem.hrs
Freshman Year		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**

Fall	lec	lab sem.hrs
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MTGN445	MECHANICAL PROPERTIES OF MATERIALS	3.0
MTGN445L	MECHANICAL PROPERTIES OF MATERIALS LABORATORY	1.0
MTGN450	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS	3.0
MTGN461	TRANSPORT PHENOMENA AND REACTOR DESIGN FOR METALLURGICAL AND MATERIALS ENGINEERS	2.0
MTGN461L	TRANSPORT PHENOMENA AND REACTOR DESIGN LABORATORY	1.0
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	3.0
MTGN415	ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS	3.0
MTGN463	POLYMER ENGINEERING	3.0
MTGN570	BIOCOMPATIBILITY OF MATERIALS	3.0
LAIS/EBGN	H&SS Restricted Elective	3.0
FREE	Free Elective	3.0
		<b>18.0</b>

**Total Semester Hrs: 138.5**

# Track MTGN Elective must be selected from the following courses:

MTGN412	CERAMIC ENGINEERING	3.0
MTGN451	CORROSION ENGINEERING	3.0

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 (p. 42).

## Minor in Metallurgical and Materials Engineering

A minor program in metallurgical and materials engineering consists of a minimum of 18 credit hours of a logical sequence of courses. 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	3.0
MTGN311L	STRUCTURE OF MATERIALS LABORATORY	1.0
MTGN348	MICROSTRUCTURAL DEVELOPMENT	3.0
MTGN348L	MICROSTRUCTURAL DEVELOPMENT LABORATORY	1.0
MTGN445	MECHANICAL PROPERTIES OF MATERIALS	3.0
MTGN445L	MECHANICAL PROPERTIES OF MATERIALS LABORATORY	1.0
300- or 400- level course in metallurgical and materials engineering		3.0
<b>Total Semester Hrs</b>		<b>18.0</b>

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.

## Professors

Ivar E. Reimanis, Interim Department Head, Herman F. Coors Distinguished Professor of Ceramics

Corby G. Anderson, Harrison Western Professor

Michael J. Kaufman, Dean of CASE

Stephen Liu, American Bureau of Shipping Endowed Chair Professor of Metallurgical and Materials Engineering

Ryan P. O'Hayre

John G. Speer, John Henry Moore Distinguished Professor of Metallurgical and Materials Engineering

Patrick R. Taylor, George S. Ansell Distinguished Professor of Chemical Metallurgy

Chester J. Van Tyne, Associate Department Head

## Associate Professors

Amy Clarke

Kip O. Findley

Brian P. Gorman

Jeffrey C. King

Steven W. Thompson

## Assistant Professors

Geoff L. Brennecka

Kester Clarke

Emmanuel De Moor

Corinne E. Packard

Vladen Stevanovic

Zhenzhen Yu

## Teaching Associate Professor

Gerald Bourne

## Emeriti Professors

George S. Ansell, President Emeritus

Glen R. Edwards, University Professor Emeritus

John P. Hager, University Professor Emeritus

George Krauss, University Professor Emeritus

Gerard P. Martins

David K. Matlock, University Professor Emeritus

Brajendra Mishra, University Professor Emeritus

John J. Moore

David L. Olson, University Professor Emeritus

Dennis W. Readey, University Professor Emeritus

## Emeriti Associate Professors

Gerald L. DePoorter

Robert H. Frost

## Courses

### MTGN198. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING. 1-3 Semester Hr.

(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: none. 1 to 3 semester hours. Repeatable for credit under different titles.

### MTGN199. INDEPENDENT STUDY. 1-3 Semester Hr.

(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; Independent Study Form must be completed and submitted to Registrar. 1 to 3 semester hours. Repeatable for credit.

### MTGN202. ENGINEERED MATERIALS. 3.0 Semester Hrs.

Equivalent with SYGN202,  
(I,II,S) 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. Prerequisites: CHGN122 or CHGN125, MATH112, PHGN100. 3 hours lecture; 3 semester hours.

### MTGN272. PARTICULATE MATERIALS PROCESSING. 3.0 Semester Hrs.

(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: CHGN209 and PHGN200. 3 weeks; 3 semester hours.

### MTGN298. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING. 1-3 Semester Hr.

(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: none. 1 to 3 semester hours. Repeatable for credit under different titles.

### MTGN299. INDEPENDENT STUDY. 1-3 Semester Hr.

(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; Independent Study Form must be completed and submitted to Registrar. 1 to 3 semester hours. Repeatable for credit.

### MTGN300. FOUNDRY METALLURGY. 2.0 Semester Hrs.

(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 or PHGN210. Co-requisite: MTGN300L. 2 hours lecture; 2 semester hours.

### MTGN300L. FOUNDRY METALLURGY LABORATORY. 1.0 Semester Hr.

Equivalent with MTGN302,  
(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. 3.0 Semester Hrs.

(I) 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. Prerequisites: PHGN200 or PHGN210 and MTGN202. Co-requisite: MTGN311L. 3 hours lecture, 3 semester hours.

**MTGN311L. STRUCTURE OF MATERIALS LABORATORY. 1.0 Semester Hr.**

(I) (WI) Experiments in structure of materials to supplement the lectures of MTGN311. Co-requisite: MTGN311. 3 hours lab; 1 semester hour.

**MTGN334. CHEMICAL PROCESSING OF MATERIALS. 3.0 Semester Hrs.**

(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. Prerequisites: MTGN272, MTGN351 and (EPIC251 or EPIC252 or EPIC261 or EPIC262 or EPIC263 or EPIC264 or EPIC265 or EPIC266 or EPIC267 or EPIC268 or EPIC269 or EPIC271). Co-requisites: MTGN334L. 3 hours lecture, 3 semester hours.

**MTGN334L. CHEMICAL PROCESSING OF MATERIALS LABORATORY. 1.0 Semester Hr.**

(II) Experiments in chemical processing of materials to supplement the lectures of MTGN334. Co-requisite: MTGN334. 3 hours lab; 1 semester hour.

**MTGN340. COOPERATIVE EDUCATION. 1-3 Semester Hr.**

(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. 3.0 Semester Hrs.**

(II) 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. Co-requisite: MTGN348L. 3 hours lecture, 3 semester hours.

**MTGN348L. MICROSTRUCTURAL DEVELOPMENT LABORATORY. 1.0 Semester Hr.**

(II) (WI) Experiments in microstructural development of materials to supplement the lectures of MTGN348. Co-requisite: MTGN348. 3 hours lab; 1 semester hour.

**MTGN351. METALLURGICAL AND MATERIALS THERMODYNAMICS. 3.0 Semester Hrs.**

(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: CHGN209. 3 hours lecture, 3 semester hours.

**MTGN352. METALLURGICAL AND MATERIALS KINETICS. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hr.**

(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: none. 1 to 3 semester hours. Repeatable for credit under different titles.

**MTGN399. INDEPENDENT STUDY. 1-3 Semester Hr.**

(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; Independent Study Form must be completed and submitted to Registrar. 1 to 3 semester hours. Repeatable for credit.

**MTGN403. SENIOR THESIS. 3.0 Semester Hrs.**

(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. 3 hours per semester. Repeatable for credit to a maximum of 6 hours.

**MTGN407. STEEL BAR MANUFACTURING. 1.0 Semester Hr.**

(I) Facilities and metallurgical principles for manufacturing carbon and low alloy steel bars that are further transformed into high performance parts. Discussion of steel melting, ladle refining, casting, hot rolling, heat treatment, final processing, inspection and testing methods. Implications of process design and control on chemical uniformity, macrostructure, microstructure, internal quality, surface quality, mechanical properties and residual stresses. Review of customer processes and requirements for manufacturing parts from bars by hot or cold forging, machining, surface treating, and heat treating. Applications include crankshafts, gears, axles, drive shafts, springs, bearings, rails, line pipe, oil well casing, etc. Prerequisite: MTGN348. 1 hour lecture; 1.0 semester hour.

**MTGN412. CERAMIC ENGINEERING. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**MTGN415. ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS. 3.0 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**MTGN419. NON-CRYSTALLINE MATERIALS. 3.0 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**MTGN429. METALLURGICAL ENVIRONMENT. 3.0 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**MTGN430. PHYSICAL CHEMISTRY OF IRON AND STEELMAKING. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**MTGN432. PYROMETALLURGY. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**MTGN445. MECHANICAL PROPERTIES OF MATERIALS. 3.0 Semester Hrs.**

(I) Mechanical properties and relationships. Plastic deformation of crystalline materials. Relationships of microstructures to mechanical strength. Fracture, creep, and fatigue. Prerequisite: MTGN348. Co-requisite: MTGN445L. 3 hours lecture, 3 semester hours.

**MTGN445L. MECHANICAL PROPERTIES OF MATERIALS LABORATORY. 1.0 Semester Hr.**

(I) (WI) Laboratory sessions devoted to advanced mechanical-testing techniques to illustrate the application of the fundamentals presented in the lectures of MTGN445. Co-requisite: MTGN445. 3 hours lab; 1 semester hour.

**MTGN450. STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS. 3.0 Semester Hrs.**

(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: none. 3 hours lecture, 3 semester hours.

**MTGN451. CORROSION ENGINEERING. 3.0 Semester Hrs.**

(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: CHGN209. 3 hours lecture; 3 semester hours.

**MTGN456. ELECTRON MICROSCOPY. 2.0 Semester Hrs.**

(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. Co-requisite: MTGN456L. 2 hours lecture; 2 semester hours.

**MTGN456L. ELECTRON MICROSCOPY LABORATORY. 1.0 Semester Hr.**

Equivalent with MTGN458,

(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. 2.0 Semester Hrs.**

(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. Prerequisites: MATH225, MTGN334 and MTGN352. Co-requisite: MTGN461L. 2 hours lecture, 2 semester hours.

**MTGN461L. TRANSPORT PHENOMENA AND REACTOR DESIGN LABORATORY. 1.0 Semester Hr.**

(II) Experiments in transport phenomena and reactor design to supplement the lectures of MTGN461. Co-requisite: MTGN461. 3 hours lab; 1 semester hour.

**MTGN462. SOLID WASTE MINIMIZATION AND RECYCLING. 3.0 Semester Hrs.**

(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: CEEN301, CEEN302, and CHGN403. 3 hours lecture; 3 semester hours.

**MTGN463. POLYMER ENGINEERING. 3.0 Semester Hrs.**

(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: none. 3 hours lecture; 3 semester hours.

**MTGN464. FORGING AND FORMING. 2.0 Semester Hrs.**

(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: CEEN311 and MTGN348 or EGGN350. Co-requisite: MTGN-464L. 2 hours lecture; 2 semester hours.

**MTGN464L. FORGING AND FORMING LABORATORY. 1.0 Semester Hr.**

(II) Experiments in forging and forming to supplement the lectures of MTGN464. Co-requisite: MTGN464. 3 hours lab; 1 semester hour.

**MTGN465. MECHANICAL PROPERTIES OF CERAMICS. 3.0 Semester Hrs.**

(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. 3 hours lecture; 3 semester hours.

**MTGN466. MATERIALS DESIGN: SYNTHESIS, CHARACTERIZATION AND SELECTION. 3.0 Semester Hrs.**

(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 design activities including oral- and written? reports. Prerequisite: MTGN351, MTGN352, MTGN445 and MTGN461. 1 hour lecture, 6 hours lab; 3 semester hours.

**MTGN469. FUEL CELL SCIENCE AND TECHNOLOGY. 3.0 Semester Hrs.**

Equivalent with CHEN469, EGGN469,

(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: MEGN361 or CBEN357 or MTGN351. 3 hours lecture; 3 semester hours.

**MTGN472. BIOMATERIALS I. 3.0 Semester Hrs.**

(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 Semester Hrs.**

(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: MTGN475L. 2 hours lecture; 2 semester hours.

**MTGN475L. METALLURGY OF WELDING LABORATORY. 1.0 Semester Hr.**

Equivalent with MTGN477,

(I) Experiments designed to supplement the lectures in MTGN475. Co-requisite: MTGN475. 3 hours lab; 1 semester hour.

**MTGN497. SUMMER PROGRAMS. 6.0 Semester Hrs.****MTGN498. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING. 1-3 Semester Hr.**

(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: none. 1 to 3 semester hours. Repeatable for credit under different titles.

**MTGN498LB. SPECIAL TOPICS LAB. 1-3 Semester Hr.**

**MTGN498LC. SPECIAL TOPICS LAB. 1-3 Semester Hr.**

**MTGN499. INDEPENDENT STUDY. 1-3 Semester Hr.**

(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; 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

2016-2017

## 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)

### Freshman

Fall		lec	lab	sem.hrs
MATH111	CALCULUS FOR SCIENTISTS AND ENGINEERS I			4.0
CHGN121	PRINCIPLES OF CHEMISTRY I			4.0
LAIS100	NATURE AND HUMAN VALUES			4.0
CSM101	FRESHMAN SUCCESS SEMINAR			0.5
GEGN101	EARTH AND ENVIRONMENTAL SYSTEMS, CBEN 110, or CSCI 101 <sup>1</sup> If the student chooses to complete CSCI101 (3 credits) for the Distributed Science requirement, one additional credit hour of free elective will need to be completed to meet the 4 total hours required.			4.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>17.0</b>

Spring		lec	lab	sem.hrs
MATH112	CALCULUS FOR SCIENTISTS AND ENGINEERS II			4.0
CHGN122	PRINCIPLES OF CHEMISTRY II (SC1) or 125			4.0
PHGN100	PHYSICS I - MECHANICS			4.5
EPIC151	DESIGN (EPICS) I			3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>16.0</b>

### Sophomore

Fall		lec	lab	sem.hrs
MATH213	CALCULUS FOR SCIENTISTS AND ENGINEERS III			4.0
PHGN200	PHYSICS II- ELECTROMAGNETISM AND OPTICS			4.5
EPIC269	EPICS II: ENGINEERING PHYSICS, 251, 252, 261, 262, 263, 264, 265, 266, 267, or GPGN 268			3.0
LAIS200	HUMAN SYSTEMS			3.0
PAGN	PHYSICAL ACTIVITY COURSE			0.5
Elective				
				<b>15.0</b>

Spring		lec	lab	sem.hrs
MATH225	DIFFERENTIAL EQUATIONS			3.0
MATH332	LINEAR ALGEBRA			3.0
CBEN210	INTRO TO THERMODYNAMICS			3.0



PHGN310	HONORS PHYSICS III-MODERN PHYSICS or 300		3.0
PHGN215	ANALOG ELECTRONICS		4.0
PAGN	PHYSICAL ACTIVITY COURSE		0.5
Elective			
			<b>16.5</b>
<b>Summer</b>		<b>lec</b>	<b>lab sem.hrs</b>
PHGN384	FIELD SESSION TECHNIQUES IN PHYSICS		6.0
			<b>6.0</b>
<b>Junior</b>			
<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>
PHGN315	ADVANCED PHYSICS LAB I		2.0
PHGN311	INTRODUCTION TO MATHEMATICAL PHYSICS		3.0
LAIS/EBGN	H&SS GenEd Restricted Elective I		3.0
PHGN317	SEMICONDUCTOR CIRCUITS-DIGITAL		3.0
PHGN350	INTERMEDIATE MECHANICS		4.0
			<b>15.0</b>
<b>Spring</b>		<b>lec</b>	<b>lab sem.hrs</b>
PHGN361	INTERMEDIATE ELECTROMAGNETISM		3.0
PHGN320	MODERN PHYSICS II: BASICS OF QUANTUM MECHANICS		4.0
PHGN326	ADVANCED PHYSICS LAB II		2.0
PHGN341	THERMAL PHYSICS		3.0
EBGN201	PRINCIPLES OF ECONOMICS		3.0
			<b>15.0</b>
<b>Senior</b>			
<b>Fall</b>		<b>lec</b>	<b>lab sem.hrs</b>
PHGN471	SENIOR DESIGN PRINCIPLES I		0.5
PHGN481	SENIOR DESIGN PRACTICE		2.5
PHGN462	ELECTROMAGNETIC WAVES AND OPTICAL PHYSICS		3.0
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 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 Semester Hrs: 130.5**

## Combined Baccalaureate/Masters and Baccalaureate/Doctoral Degree Programs

The Physics Department, independently, and in collaboration with the Department of Applied Mathematics and Statistics, the Department

of Mechanical Engineering, the Department of Electrical Engineering and Computer Science, the Materials Science Program, and the Nuclear Science and Engineering Program offers combined BS/MS degree programs in which students obtain an undergraduate degree in Engineering Physics, in as few as four years, as well as a masters degree in Applied Physics, in an Engineering discipline, in Materials Science, or in Mathematics, after an additional year of study. There are three engineering tracks, three physics tracks, a materials science track, and a mathematics track. These programs emphasize a strong background in fundamentals of science, in addition to practical experience within an applied science, 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 physics, engineering, and materials science 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, materials science, 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 (p. 42).

## 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	3.0
or PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	

### Minor (18 semester hours minimum)

PHGN100	PHYSICS I - MECHANICS	3.0
or PHGN200	PHYSICS II-ELECTROMAGNETISM AND OPTICS	
PHGN300	PHYSICS III-MODERN PHYSICS I	3.0
or PHGN310	HONORS PHYSICS III-MODERN PHYSICS	
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	

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.

## Biophysics Minor

To obtain a Biophysics Minor, students must take at least 18.0 credits related to Biophysics. Two courses (8.0 credits) of Biology are required. Two additional requirements include Biophysics (PHGN433) and Laser Physics (PHGN480). Two more courses (or at least 4.0 credits) may be chosen from the list below. The list of electives will be modified as new related courses that fall into these categories become available. While the current emphasis of the Biophysics Minor is on optical techniques, we intend to add alternative tracks, for example radiologic (nuclear) techniques.

### Required Courses (14.0 Credits)

CBEN110	FUNDAMENTALS OF BIOLOGY I	4.0
CBEN120	FUNDAMENTALS OF BIOLOGY II	4.0
PHGN433	BIOPHYSICS	3.0
PHGN480	LASER PHYSICS	3.0

### Two Elective courses (at least 4.0 credits) from the list below:

PHGN466	MODERN OPTICAL ENGINEERING	3.0
or PHGN566	MODERN OPTICAL ENGINEERING	
PHGN570	FOURIER AND PHYSICAL OPTICS	3.0
CBEN310	INTRODUCTION TO BIOMEDICAL ENGINEERING	3.0
CBEN311	INTRODUCTION TO NEUROSCIENCE	3.0
CBEN431	IMMUNOLOGY FOR ENGINEERS AND SCIENTISTS	3.0
or CBEN531	IMMUNOLOGY FOR SCIENTISTS AND ENGINEERS	
CBEN454	APPLIED BIOINFORMATICS	3.0
or CBEN554	APPLIED BIOINFORMATICS	
MATH331	MATHEMATICAL BIOLOGY	3.0
NUGN535	INTRODUCTION TO HEALTH PHYSICS	3.0
PHGN504	RADIATION DETECTION AND MEASUREMENT	3.0
CHGN428	BIOCHEMISTRY	3.0
MEGN430	MUSCULOSKELETAL BIOMECHANICS	3.0
or MEGN530	BIOMEDICAL INSTRUMENTATION	
CBEN470	INTRODUCTION TO MICROFLUIDICS	3.0
MEGN530	BIOMEDICAL INSTRUMENTATION	3.0
MEGN436	COMPUTATIONAL BIOMECHANICS	3.0
or MEGN536	COMPUTATIONAL BIOMECHANICS	

## Professors

Lincoln D. Carr

Reuben T. Collins

Charles G. Durfee III

Uwe Greife

Frank V. Kowalski

Mark T. Lusk

Frederic Sarazin

John A. Scales

Jeff A. Squier, Department Head

P. Craig Taylor

## Associate Professors

Timothy R. Ohno

Lawrence R. Wiencke

David M. Wood

## Assistant Professors

Kyle G. Leach

Susanta K. Sarkar

Eric S. Toberer

Jeremy D. Zimmerman

## Teaching Professors

Alex T. Flournoy

Patrick B. Kohl

H. Vincent Kuo

Todd G. Ruskell

Charles A. Stone

Matt Young

## Teaching Associate Professor

Kristine E. Callan

## Research Professors

Mark W. Coffey

Jonathan L. Mace

Zeev Shayer

## Research Associate Professor

James E. Bernard

## Research Assistant Professor

P. David Flammer

## Professors Emeriti

F. Edward Cecil

Thomas E. Furtak

James A. McNeil

Don L. Williamson

## Associate Professors Emeriti

William B. Law

Arthur Y. Sakakura

## Courses

### PHGN100. PHYSICS I - MECHANICS. 4.5 Semester Hrs.

(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. Co-requisites: MATH112 or MATH113 or MATH122. 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 Semester Hr.

(I, II) Pilot course or special topics course. Prerequisite: none. Credit to be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

### PHGN199. INDEPENDENT STUDY. 1-6 Semester Hr.

(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 Semester Hrs.

(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 or MATH214 or MATH223. 2 hours lecture; 4 hours studio; 4.5 semester hours.

### PHGN215. ANALOG ELECTRONICS. 4.0 Semester Hrs.

(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 Semester Hr.

(I, II) Pilot course or special topics course. Prerequisite: none. Credit to be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

### PHGN299. INDEPENDENT STUDY. 1-6 Semester Hr.

(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 Semester Hrs.

Equivalent with PHGN310,

(I) 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. 3 hours lecture; 3 semester hours.

### PHGN310. HONORS PHYSICS III-MODERN PHYSICS. 3.0 Semester Hrs.

Equivalent with PHGN300,

(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. 3 hours lecture; 3 semester hours.

### PHGN311. INTRODUCTION TO MATHEMATICAL PHYSICS. 3.0 Semester Hrs.

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: PHGN300/310, MATH225, and MATH332. 3 hours lecture; 3 semester hours.

### PHGN315. ADVANCED PHYSICS LAB I. 2.0 Semester Hrs.

(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: PHGN300/310, PHGN384. 1 hour lecture, 3 hours lab; 2 semester hours.

### PHGN317. SEMICONDUCTOR CIRCUITS- DIGITAL. 3.0 Semester Hrs.

(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 Semester Hrs.

(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 or PHGN310 and PHGN311. 4 hours lecture; 4 semester hours.

**PHGN324. INTRODUCTION TO ASTRONOMY AND ASTROPHYSICS.****3.0 Semester Hrs.**

(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 Semester Hrs.**

(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.

**PHGN340. COOPERATIVE EDUCATION. 1-3 Semester Hr.**

(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 Semester Hrs.**

(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: CHGN209 or CBEN210 and PHGN311. 3 hours lecture; 3 semester hours.

**PHGN350. INTERMEDIATE MECHANICS. 4.0 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hr.**

(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: PHGN300/310, PHGN215. (6 credit hours).

**PHGN398. SPECIAL TOPICS. 1-6 Semester Hr.**

(I, II) Pilot course or special topics course. Prerequisite: none. Credit to be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

**PHGN399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hr.**

(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.

**PHGN418. GENERAL RELATIVITY. 3.0 Semester Hrs.**

(II) Introduction to Einstein's theory of gravitation. Requisite mathematics introduced and developed including tensor calculus and differential geometry. Formulation of Einstein field and geodesic equations. Development and analysis of solutions including stellar, black hole and cosmological geometries. Prerequisite: PHGN350. 3 hours lecture; 3 semester hours.

**PHGN419. PRINCIPLES OF SOLAR ENERGY SYSTEMS. 3.0 Semester Hrs.**

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 Semester Hrs.**

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: PHGN300/310. 3 hours lecture; 3 semester hours.

**PHGN423. PARTICLE PHYSICS. 3.0 Semester Hrs.**

(II) Introduction to the Standard Model of particle physics including: experimental methods, motivation and evaluation of amplitudes from Feynman diagrams with applications to scattering cross-sections and decay rates, organization of interactions based on underlying gauge-symmetry principles, Dirac equation and relativistic spinors, C, P and T symmetries, renormalization, spontaneous symmetry breaking and the Higgs mechanism for mass generation. Prerequisites: PHGN350. Co-requisites: PHGN320. 3 hour lecture.

**PHGN424. ASTROPHYSICS. 3.0 Semester Hrs.**

(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: PHGN300/310. 3 hours lecture; 3 semester hours.

**PHGN433. BIOPHYSICS. 3.0 Semester Hrs.**

Equivalent with BELS333,PHGN333,

(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: CBEN110. 3 hours lecture; 3 semester hours.

**PHGN435. INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY. 3.0 Semester Hrs.**

Equivalent with

CBEN435,CBEN535,CHEN435,CHEN535,MLGN535,PHGN535,

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. 1.5 hours lecture, 4 hours lab; 3 semester hours.

**PHGN440. SOLID STATE PHYSICS. 3.0 Semester Hrs.**

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 Semester Hrs.**

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. 3 hours lecture; 3 semester hours.

**PHGN450. COMPUTATIONAL PHYSICS. 3.0 Semester Hrs.**

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 Semester Hrs.**

(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 Semester Hrs.**

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. 3 hours lecture; 3 semester hours.

**PHGN471. SENIOR DESIGN PRINCIPLES I. 0.5 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hrs.**

(I) Theory and application of the following: Interaction of light with atoms: absorption, gain, rate equations and line broadening. Propagation, control and measurement of light waves: Gaussian beams, optical resonators and wave guides, interferometers. Laser design and operation: pumping, oscillation, and dynamics (Q-switching and mode-locking). Introduction to ultrafast optics. Laboratory: alignment and characterization of laser systems. Prerequisites: PHGN320. Co-requisites: PHGN462. 3 hours lecture; 3 semester hours.

**PHGN481. SENIOR DESIGN PRACTICE. 2.5 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hrs.**

(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 Semester Hrs.****PHGN498. SPECIAL TOPICS. 1-6 Semester Hrs.**

(I, II) Pilot course or special topics course. Prerequisite: none. Credit to be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

**PHGN499. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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

Two-year, Three-year and Four-year college scholarships are available to eligible high school seniors, who apply before December 1 of their senior year. 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 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) (<http://www.afrotc.com>).

### Registration and Credits

Air Force ROTC serves as free-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 [afrotc.colorado.edu](http://afrotc.colorado.edu) (<http://www.colorado.edu/afrotc>), 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.

### 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) (<http://afrotc.colorado.edu>).

General CSM Minor/ASI requirements can be found here (p. 42).

### 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
<b>Total Semester Hrs</b>		<b>20.0</b>

### 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.



## Military Science

2016/2017

### 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 Knox, Kentucky, 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

Three-year and Four-year college scholarships are available to eligible 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. 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 free-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 (p. 42).

### 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	2.0
MSGN104	ADVENTURES IN LEADERSHIP II	2.0
MSGN203	METHODS OF LEADERSHIP	2.0
MSGN204	METHODS OF LEADERSHIP AND MANAGEMENT II	2.0
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
<b>Total Semester Hrs</b>		<b>22.0</b>

Note: In order to Commission as a 2nd Lieutenant in the US Army, completion of a Military History Course (LAIS365) is also required.

**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 AND MANAGEMENT I. 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 80hours 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. ADAPTIVE LEADERSHIP. 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. LEADERSHIP IN A COMPLEX WORLD. 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).

**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

### 2016-2017

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.

Marv Kay Stadium at Harry D. Campbell Field

Opened in 2015, the state-of-the-art Marv Kay Stadium features seating for 4,090, fan-friendly amenities, and lights for night games and practices. The playing field is a synthetic surface named in honor of Harry D. Campbell, Class of 1939.

### Korell Athletic Center

Attached to Marv Kay Stadium, the Korell Athletic Center houses weight training and sports medicine facilities for Mines Athletics, as well as locker rooms and coaching staff offices for football, track & field, and cross country. The second floor includes flexible meeting and classroom space.

### 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.

### Stermole Soccer Stadium

Synthetic surface which provides a practice and playing venue for men's and women's NCAA soccer. The stadium seats 500 and features a support building with locker rooms, meeting space, and a press box.

### Required Physical Activity

Each student at Colorado School of Mines is required to complete four separate semesters of Physical Activity classes (PAGN) of their choice. Each semester must carry at least 0.5 credit hours for a minimum total of 2.0 credit hours.

Exceptions:

1. A medical excuse verified by a physician;
2. Veterans, honorably or generally discharged from the armed forces (Student needs to provide Form DD-214 to the Registrar's Office.);
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, the Physical Activity requirement is fulfilled during the first two years of attendance. Transfer students should check with the Registrar's Office regarding applicable courses in physical activity. Participation in intercollegiate athletics or club sports may be used for required semesters and hours of physical activity on a one-to-one basis. ROTC students may use their ROTC registration to meet the physical education requirement, where one semester of ROTC will meet one semester of the PAGN requirement.

Students who wish to continue taking physical activity after completing PAGN requirements may continue to apply PAGN credit towards their Free Elective. However, a maximum of 3.0 activity credits in total may apply toward Free Elective.

Some of the 200-level courses may require off campus transportation, please check with Department of Athletics. All students enrolled in physical activity shall provide their own gym uniform, athletic shoes, sunscreen or swimming suit. Lockers are available by request in the administrative offices on the third floor of Volk Gym.

### 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.

## Athletic Director

David Hansburg, Director of Athletics

## Associate Athletic Director

Dixie Cirillo, Physical Education Coordinator, Associate Athletic Director

Eric Stahl, 2014, Associate Athletic Director

## Assistant Directors

Tim Flynn, Assistant AD for Communications

Charles O'Dell, Assistant Athletic Director

Robert Thompson, Assistant Director of Athletics

## Recreation Sports

Nate Bondi, Director of Outdoor Recreation

John Howard, Director of Club and Intramural Sports

Margie Rogers, Assistant Director Rec Center

Robert Thompson, Student Recreation Center Director

## Administrative Assistant

Carolyn Dennee, Administrative Assistant

## Coaches

Gregg Brandon, Head Football Coach

Austin DeVoe, Head Wrestling Coach

Kevin Fickes, Head Women's Soccer Coach

Leah Glasgow, Head Softball Coach

Jerod Goodale, Head Baseball Coach

Tyler Kimble, Head Golf Coach

Frank Kohlenstein, Head Men's Soccer Coach

Pryor Orser, Head Men's Basketball Coach

Nate Rothman, Head Swimming and Diving Coach

Chris Siemers, Head Cross Country Coach

Brittany Simpson, Head Women's Basketball Coach

Jamie Skadeland, Head Volleyball Coach

Matt Sparks, Head Track and Field Coach

## Assistant Coaches

Ashleigh Ackerman, Assistant Women's Basketball Coach

Tim Brandon, Assistant Football Coach

Isaac Carter, Assistant Football Coach

Nick Fulton, Assistant Football Coach

Clement Grinstead, Assistant Football Coach

Michael Gusbeth, Assistant Track Coach

Shannon McDonnell, Assistant Women's Soccer Coach

Michael McGlinchey, Assistant Football Coach

Kellen Mitts, Assistant Baseball Coach

Greg Mulholland, Assistant Men's Soccer Coach

Brandon Moore, Assistant Football Coach

Robert O'Brein, Assistant Football Coach

Tyson Reiner, Assistant Wrestling Coach

Heather Roberts, Assistant Volleyball Coach

Brad Schick, Assistant Men's Basketball Coach

Leslie Seymour, Assistant Women's Basketball Coach

Mike Slife, Assistant Football Coach

Dustin Washburn, Assistant Football Coach

## Head Athletic Trainer

Jennifer McIntosh, Head Athletic Trainer

## Assistant Athletics Trainers

Jessica Hoyt, Assistant Athletic Trainer

Jacob Pope, Assistant Athletic Trainer

John Thomas, Assistant Athletic Trainer

Andy Vanous, Assistant Athletic Trainer

## Equipment Manager

Darren Townsend, Equipment Manager

## Sports Information

Trey Bloomer, Assist SID

Tim Flynn, Assistant AD for Communications

## Courses

### **PAGN101. PHYSICAL EDUCATION. 0.5 Semester Hrs.**

(I) 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. 2 hours lab; 0.5 semester hours. Repeatable for credit.

### **PAGN102. PHYSICAL EDUCATION. 0.5 Semester Hrs.**

(II) Sections in physical fitness and team sports, relating to personal health and wellness activities. 2 hours lab; 0.5 semester hours. Repeatable for credit.

### **PAGN151. VARSITY BASEBALL. 1.0 Semester Hr.**

(I, II) 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. 3 hours lab; 1 semester hour. Repeatable for credit.

### **PAGN153. VARSITY MEN'S BASKETBALL. 1.0 Semester Hr.**

(I, II) 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. 3 hours lab; 1 semester hour. Repeatable for credit.

### **PAGN154. VARSITY WOMEN'S BASKETBALL. 1.0 Semester Hr.**

(I, II) 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. 3 hours lab; 1 semester hour. Repeatable for credit.

### **PAGN157. VARSITY CROSS COUNTRY. 1.0 Semester Hr.**

(I, II) 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. 3 hours lab; 1 semester hour. Repeatable for credit.

### **PAGN159. VARSITY FOOTBALL. 1.0 Semester Hr.**

(I, II) 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. 3 hours lab; 1 semester hour. Repeatable for credit.

### **PAGN161. VARSITY GOLF. 1.0 Semester Hr.**

(I, II) 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. 3 hours lab; 1 semester hour. Repeatable for credit.

### **PAGN167. VARSITY MEN'S SOCCER. 1.0 Semester Hr.**

(I, II) 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. 3 hours lab; 1 semester hour. Repeatable for credit.

### **PAGN168. VARSITY WOMEN'S SOCCER. 1.0 Semester Hr.**

(I, II) 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. 3 hours lab; 1 semester hour. Repeatable for credit.

### **PAGN169. VARSITY SWIMMING. 1.0 Semester Hr.**

(I, II) 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. 3 hours lab; 1 semester hour. Repeatable for credit.

### **PAGN173. VARSITY TRACK AND FIELD. 1.0 Semester Hr.**

(I, II) 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. 3 hours lab; 1 semester hour. Repeatable for credit.

### **PAGN175. VARSITY WRESTLING. 1.0 Semester Hr.**

(I, II) 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. 3 hours lab; 1 semester hour. Repeatable for credit.

### **PAGN177. VARSITY VOLLEYBALL. 1.0 Semester Hr.**

(I, II) 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. 3 hours lab; 1 semester hour. Repeatable for credit.

### **PAGN179. VARSITY SOFTBALL. 1.0 Semester Hr.**

(I, II) 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. 3 hours lab; 1 semester hour. Repeatable for credit.

### **PAGN198. SPECIAL TOPICS. 0.5-6 Semester Hr.**

(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. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

### **PAGN201. PERSONAL WELLNESS. 1.0 Semester Hr.**

(I, II) 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. 2 hours lecture; 1 semester hour. Repeatable for credit.

### **PAGN202. INDOOR SOCCER. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

### **PAGN203. TECHNIQUES OF RELAXATION. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; .5 semester hours. Repeatable for credit.

### **PAGN204. FLY FISHING. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

### **PAGN205. BEGINNING KARATE. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

### **PAGN206. INTERMEDIATE KARATE. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

### **PAGN207. TRAIL RUNNING. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

### **PAGN208. KAYAKING. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

### **PAGN209. AIKIDO. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN210. HIKING. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN211. BEGINNING SWIMMING. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN212. INTERMEDIATE SWIMMING. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN221. BEGINNING WEIGHT TRAINING. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN222. ADVANCED WEIGHT TRAINING. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN223. DISTANCE RUNNING. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN232. YOGA. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN235. WORKOUTS AND WELLNESS. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN241. WOMEN'S WEIGHT TRAINING. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN242. WOMEN'S RAQUETBALL. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN251. GOLF. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN255. MOUNTAIN BIKING. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN257. INTRODUCTION TO ROCK CLIMBING. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN258. WOMEN'S ROCK CLIMBING. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN271. BEGINNING BADMINTON. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN272. ADVANCED BADMINTON. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN273. BEGINNING BASKETBALL. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN274. ADVANCED BASKETBALL. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN275. VOLLEYBALL. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN277. BEGINNING RACQUETBALL. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN279. HANDBALL. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN280. CLUB SPORTS. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN281. ADVANCED HANDBALL. 0.5 Semester Hrs.**

(I, II) Students enrolling in these courses may be required to furnish their own equipment. 2 hours lab; 0.5 semester hours. Repeatable for credit.

**PAGN298. SPECIAL TOPICS. 0.5-6 Semester Hr.**

(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. Variable credit; 0.5 to 6 semester hours. Repeatable for credit under different titles.

**PAGN398. SPECIAL TOPICS. 0.5-6 Semester Hr.**

(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. Variable credit; 0.5 to 6 credit hours. Repeatable for credit under different titles.

**PAGN498. SPECIAL TOPICS. 0.5-6 Semester Hr.**

(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. Variable credit; 0.5 to 6 credit hours. Repeatable for credit under different titles.

# Energy

**General CSM Minor/ASI requirements can be found here (p. 42).**

<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, several CSM departments have come together to offer Minor and Area of Special Interest (ASI) 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 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 here (p. 42).

## Program Requirements

### Minor in Energy:

The Minor in Energy requires a minimum of 18 credit hours of acceptable course work. All Energy Minors must take 9 credit hours:

ENGY200	INTRODUCTION TO ENERGY	3.0
EBGN330	ENERGY ECONOMICS	3.0
or ENGY330	ENERGY ECONOMICS	
ENGY490	ENERGY AND SOCIETY *	3.0
or LAIS424	RHETORIC, ENERGY AND PUBLIC POLICY	

\* Either ENGY490 or LAIS424 can serve as the policy capstone course.

### Introductory Courses

ENGY200	INTRODUCTION TO ENERGY	3.0
EBGN330	ENERGY ECONOMICS	3.0
or ENGY330	ENERGY ECONOMICS	
<b>Total Semester Hrs</b>		<b>6.0</b>

### Energy-related Courses: Fossil Energy Track

PEGN102	INTRODUCTION TO PETROLEUM INDUSTRY	3.0
Select three of the following:		9.0

ENGY310	FOSSIL ENERGY	
CBEN408	NATURAL GAS PROCESSING	
CBEN409	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	
PEGN438 or MNGN438	PETROLEUM DATA ANALYTICS GEOSTATISTICS	

ENGY310	FOSSIL ENERGY	
ENGY320	RENEWABLE ENERGY	
ENGY340	NUCLEAR ENERGY	
ENGY350	INTRODUCTION TO GEOTHERMAL ENERGY	
CBEN472	INTRODUCTION TO ENERGY TECHNOLOGIES	
EENG389	FUNDAMENTALS OF ELECTRIC MACHINERY	
MEGN461	THERMODYNAMICS II	
ECCN589	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	
LAIS489	NUCLEAR POWER AND PUBLIC POLICY	
LAIS486	SCIENCE AND TECHNOLOGY POLICY	

### Policy course (required for all Energy minors)

ENGY490	ENERGY AND SOCIETY	3.0
or LAIS490	ENERGY AND SOCIETY	

**Total Semester Hrs** **3.0**

The Area of Special Interest in Energy requires a minimum of 12 credit hours of acceptable course work:

ENGY200	INTRODUCTION TO ENERGY	3.0
EBGN330	ENERGY ECONOMICS	3.0
or ENGY330	ENERGY ECONOMICS	
Two additional energy-related courses		6.0

**Total Semester Hrs** **12.0**

ENGY200	INTRODUCTION TO ENERGY	3.0
ENGY310	FOSSIL ENERGY	3.0
ENGY320	RENEWABLE ENERGY	3.0
ENGY330	ENERGY ECONOMICS	3.0



ENGY340	NUCLEAR ENERGY	3.0
ENGY350	INTRODUCTION TO GEOTHERMAL ENERGY	3.0
ENGY490	ENERGY AND SOCIETY	3.0
ENGY497	SUMMER PROGRAMS	6.0

## Professors

Murray W. Hitzman , Department of Geology and Geological Engineering,  
Charles F. Fogarty Professor of Economics Geology

Reuben Collins, Department of Physics

John Curtis, Department of Geology and Geological Engineering

Carol Dahl, Division of Economics and Business

Roderick G. Eggert, Division of Economics and Business, Division  
Director

Ramona M. Graves, Department of Petroleum Engineering, Interim  
Department Head

Carl Mitcham, Division of Liberal Arts and International Studies

Masami Nakagawa, Department of Mining Engineering

P.K. Sen, Division of Engineering

Roel Snieder, Department of Geophysics, Keck Foundation Professor of  
Basic Exploration Science

P. Craig Taylor, Department of Physics

## Associate Professors

Linda Figueroa, Division of Environmental Science and Engineering

John Heilbrunn, Division of Liberal Arts and International Studies

Andrew M. Herring, Department of Chemical Engineering

Kathryn Johnson, Department of Mechanical Engineering

Joseph Beach Jr., Department of Physics, Research

Timothy R. Ohno, Minor and Area of Special Interest Only, Director

Marcelo Simoes, Division of Engineering

Neal Sullivan, Associate Professor

## Assistant Professors

Eric Toberer , Department of Physics

Jason A. Delborne, Division of Liberal Arts and International Studies

Daniel Kaffine, Division of Economics and Business

Jeffrey C. King, Department of Metallurgical and Materials Engineering

Jennifer Schneider, Division of Liberal Arts and International Studies

## Teaching Professor

Charles Stone, Department of Physics

## Teaching Associate Professors

Linda Battalora , Department of Petroleum Engineering

John M. Persichetti, Department of Chemical Engineering

## Humanitarian Engineering

**General CSM Minor/ASI requirements can be found here** (<http://bulletin.mines.edu/undergraduate/undergraduateinformation/minorasi>).

## Program Mission

To teach students how engineering can contribute to co-creating just and sustainable solutions for communities.

## Program Educational Objectives

To achieve its mission -- *teach students how engineering can contribute to co-creating just and sustainable solutions for communities* -- HE graduates will be able to

- *Reflect critically on the practices of engineering* to know why, how, when and whether to use engineering in the co-creation of just and sustainable solutions.
- *Serve communities effectively and responsibly* in collaboratively identifying problems and defining and providing solutions that are just and sustainable.
- *Design and build technologies* that promote just and sustainable solutions.
- *Map career trajectories* (corporate, public, NGOs, academic) that will enable them to work as engineers for just and sustainable solutions.

## Programs Offered

- Minor in Humanitarian Engineering (18 credit hours)
- Area of Special Interest in Humanitarian Engineering (12 credit)

## Program Requirements

### 1.Humanitarian Engineering Minor Program (18 credit hours)

#### Intro Course (3 cr)

LAIS377	ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT	3.0
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#### Area I Community, Culture & Social Justice (6 cr) Select two of the following:

LAIS325	CULTURAL ANTHROPOLOGY	3.0
LAIS430	CORPORATE SOCIAL RESPONSIBILITY	3.0
LAIS475	ENGINEERING CULTURES IN THE DEVELOPING WORLD	3.0
LAIS478	ENGINEERING AND SOCIAL JUSTICE	3.0
LAIS490	ENERGY AND SOCIETY	3.0

#### Area II Engineering by Doing (EbD) (6 cr) Both courses below are required:

EGGN301	HUMAN-CENTERED PROBLEM DEFINITION (Required)	3.0
EGGN401	PROJECTS FOR PEOPLE (Required)	3.0

**Capstone Course (3 cr)**

EGGN492	SENIOR DESIGN II (for CECS students)	3.0
CEEN477	SUSTAINABLE ENGINEERING DESIGN (non CECS students)	3.0

**2. Area of Special Interest in Humanitarian Engineering (12 credit hours)****Intro Course (3 cr)**

LAIS377	ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT	3.0
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**Area I Community, Culture & Social Justice (6 cr) Select two of the following:**

LAIS325	CULTURAL ANTHROPOLOGY	3.0
or HNRS305	EXPLORATIONS IN MODERN AMERICA	
LAIS430	CORPORATE SOCIAL RESPONSIBILITY	3.0
LAIS475	ENGINEERING CULTURES IN THE DEVELOPING WORLD	3.0
LAIS478	ENGINEERING AND SOCIAL JUSTICE	3.0
LAIS490	ENERGY AND SOCIETY	3.0

**Capstone Course (3 cr)**

CEEN477	SUSTAINABLE ENGINEERING DESIGN	3.0
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**Co-Curricular Activities**

Students interested in the Humanitarian Engineering (HE) Program are strongly encouraged to join Engineers without Borders (EWB) in their first year at CSM to begin understanding the role of engineering in community development. HE students are also encouraged to attend the HE Lecture Series to gain new perspectives on the role of engineers in co-developing solutions to problems faced by communities in the US and abroad.

**4. Senior Design Projects**

During their senior year capstone experience, HE students must select HE projects in areas such as Community Development or Assistive Technologies for People with Disabilities. Projects which are approved for use towards the minor are indicated in the project list provided in EGGN491. HE students will be given priority on these projects and will be supported by a Social Context Consultant with whom they will interact regularly to make sure that their design addresses human- and/or community-centered needs as well as technical requirements.

CEEN477	SUSTAINABLE ENGINEERING DESIGN	3.0
LAIS325	CULTURAL ANTHROPOLOGY	3.0
LAIS430	CORPORATE SOCIAL RESPONSIBILITY	3.0
LAIS475	ENGINEERING CULTURES IN THE DEVELOPING WORLD	3.0
LAIS478	ENGINEERING AND SOCIAL JUSTICE	3.0
LAIS490	ENERGY AND SOCIETY	3.0
EGGN301	HUMAN-CENTERED PROBLEM DEFINITION	3.0
EGGN401	PROJECTS FOR PEOPLE	3.0

**Professor**

Juan Lucena, Humanitarian Engineering Program Director, Division of Liberal Arts and International Studies

**Associate professor**

Junko Munakata-Marr, Shultz Faculty Fellow & Civil and Environmental Engineering Department, College of Engineering and Computational Science

**Assistant professors**

Doug Van Bossuyt, Shultz Faculty Fellow & Mechanical Engineering Department, College of Engineering and Computational Science

Jessica Smith, Hennebach Assistant Professor of Energy Policy, Division of Liberal Arts and International Studies

**Teaching Associate Professors**

Jered Dean, Senior Design Director, College of Engineering and Computational Science

Leslie Light, Design EPICS Director, College of Engineering and Computational Science

Mirna Mattjik, Program Coordinator & First Year Engineering Design Instructor, College of Engineering and Computational Science

Greg Rulifson, Engineering for Sustainable Community Development Course Instructor, Division of Liberal Arts and International Studies

**Adjunct Faculty**

Susan Anderson, Human Centered Problem Definition Course Instructor

Rachel Fleming, Anthropologist

Ben Teschner, Corporate Social Responsibility Project Manager & Project for People Course Instructor

Marnie Thompson, Anthropologist

**Lecturer**

David Frossard, Engineering for Sustainable Community Development Course Instructor

**Research Associate Professor**

Nicole Smith, Energy and Society Course Instructor, Division of Liberal Arts and International Studies

**Guy T. McBride, Jr. Honors Program in Public Affairs****2016-2017**

**General CSM Minor/ASI requirements can be found here (p. 42).**

**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 2013, the new 21 credit hour curriculum has been modified for all students.

The Program is delivered primarily in an interdisciplinary seminar format that maximizes discussion and debate. Seminars are 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 the 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

Students typically begin the Program in the fall of their sophomore year, although in some cases transfer students and juniors may join the program. Students 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/>), and participating in an interview.

Note: Students must complete LAIS100 Nature and Human Values prior to, or concurrently with, enrolling in the first course, HNRS305 Explorations in Modern America.

## H & SS Core Curriculum Requirements

Students completing the McBride Honors Program are required to complete LAIS100, "Nature and Human Values," and EBGN201, "Principles of Economics." McBride students are exempt from completing LAIS200, "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. Transfer students should expect to complete

the entire McBride curriculum, 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 in consultation with McBride faculty.

## Curriculum

The Curriculum Effective for Students Beginning Fall 2013

Each elective will follow a specific theme that provides an in-depth look at a particular problem or case study relating to the overarching topic of the course. These specific themes will change frequently. Prior to registration each semester, the course theme and description will be announced to all McBride students via email and posted on the McBride website. Students may take a given course twice if and only if the course theme is different.

Honors Core Courses (6 credits):

HNRS305	EXPLORATIONS IN MODERN AMERICA	3.0
HNRS315	EXPLORATIONS IN THE MODERN WORLD	3.0

Honors Practicum Requirement (3 credits):

HNRS405	MCBRIDE PRACTICUM	1-3
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Honors Electives (12 credits):

HNRS425	EXPLORATIONS IN POLITICS, POLICY, AND LEADERSHIP	3.0
HNRS430	EXPLORATIONS IN IDEAS, ETHICS, AND RELIGION	3.0
HNRS435	EXPLORATIONS IN CULTURE, SOCIETY, AND CREATIVE ARTS	3.0
HNRS440	EXPLORATIONS IN INTERNATIONAL STUDIES & GLOBAL AFFAIRS	3.0
HNRS445	EXPLORATIONS IN SCIENCE, TECHNOLOGY, AND SOCIETY	3.0
HNRS450	EXPLORATIONS IN EARTH, ENERGY, AND ENVIRONMENT	3.0
Special Topics		
HNRS398	SPECIAL TOPICS IN THE MCBRIDE HONORS PROGRAM IN PUBLIC AFFAIRS	1-6
HNRS498	SPECIAL TOPICS IN THE MCBRIDE HONORS PROGRAM IN PUBLIC AFFAIRS	1-6
HNRS499	INDEPENDENT STUDY	1-6

## Professor

Dr. Kenneth A. Osgood, Liberal Arts & International Studies, Program Director

## Teaching Associate Professor

Dr. Sarah Hitt, Assistant Program Director

## Courses

### HNRS198. SPECIAL TOPICS. 1-6 Semester Hr.

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.

### HNRS199. INDEPENDENT STUDY. 1-6 Semester Hr.

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.

### HNRS298. SPECIAL TOPICS. 1-6 Semester Hr.

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.

### HNRS299. INDEPENDENT STUDY. 1-6 Semester Hr.

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.

**HNRS305. EXPLORATIONS IN MODERN AMERICA. 3.0 Semester Hrs.**

(I, II) (WI) Honors core course that develops student skills in reading, writing, critical thinking, and oral communication. skills through the exploration of selected topics related to the social, cultural, and political ideas and events that have shaped the development of the modern United States and its role in the world. Prerequisite: Admission to the Program and LAIS100: Nature & Human Values. 3 lecture hours, 3 credit hours.

**HNRS315. EXPLORATIONS IN THE MODERN WORLD. 3.0 Semester Hrs.**

(I, II) (WI) Honors core course that develops student writing skills and critical thinking abilities through the exploration of selected topics related to the social, cultural, and political ideas and developments that have shaped the modern world. Prerequisite: Admission to the Program and LAIS100: Nature & Human Values. 3 lecture hours, 3 credit hours.

**HNRS398. SPECIAL TOPICS IN THE MCBRIDE HONORS PROGRAM IN PUBLIC AFFAIRS. 1-6 Semester Hr.**

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.

**HNRS399. INDEPENDENT STUDY. 1-6 Semester Hr.**

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.

**HNRS405. MCBRIDE PRACTICUM. 1-3 Semester Hr.**

(I, II) (WI) 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.

**HNRS425. EXPLORATIONS IN POLITICS, POLICY, AND LEADERSHIP. 3.0 Semester Hrs.**

(I, II) (WI) Study of selected topics related to policy, politics, and/or leadership through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in The Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

**HNRS430. EXPLORATIONS IN IDEAS, ETHICS, AND RELIGION. 3.0 Semester Hrs.**

(I, II) (WI) Study of selected topics related to ideas, ethics, and/or religion through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

**HNRS435. EXPLORATIONS IN CULTURE, SOCIETY, AND CREATIVE ARTS. 3.0 Semester Hrs.**

(I, II) (WI) Study of selected topics related to culture, society, and/or the creative arts through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

**HNRS440. EXPLORATIONS IN INTERNATIONAL STUDIES & GLOBAL AFFAIRS. 3.0 Semester Hrs.**

(I, II) (WI) Study of selected topics related to international studies and/or global affairs through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

**HNRS445. EXPLORATIONS IN SCIENCE, TECHNOLOGY, AND SOCIETY. 3.0 Semester Hrs.**

(I, II) (WI) Study of selected topics related to the relationships between science, technology, and society through case studies, readings, research, and writing. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

**HNRS450. EXPLORATIONS IN EARTH, ENERGY, AND ENVIRONMENT. 3.0 Semester Hrs.**

(I, II) (WI) Study of selected topics related to earth, energy, and/or the environment through case studies, readings, research, and writing. This course may focus on the human dimensions or broader impacts of science, technology, engineering, or mathematics. Prerequisites: HNRS305: Explorations in Modern America and HNRS315: Explorations in the Modern World. Repeatable for credit up to a maximum of 6 hours. 3 lecture hours, 3 credit hours.

**HNRS476. COMMUNITY ENGAGEMENT THROUGH SERVICE LEARNING. 3.0 Semester Hrs.**

(II) Community Engagement through Service Learning combines a traditional classroom environment with an off campus learning experience with a local non-profit or community organization. Students spend 3-4 hours per week serving the organization they choose and meet in class once per week to discuss reading assignments, present research findings, and share experiences and insights about the course material. Instructors may choose to focus on a particular topic or social issue, such as poverty and privilege, or may engage with community issues more broadly. The course focuses on several aspects of a student's learning, including intra- and interpersonal learning, discovering community, and developing communication skills and critical and interdisciplinary approaches. Course work will focus on critical reading, group discussion and deliberation, oral presentations of research, and writing assignments. Prerequisites: none. 2 hours lecture; 3-4 hours lab; 3.0 semester hours.

**HNRS497. SUMMER COURSE. 6.0 Semester Hrs.****HNRS498. SPECIAL TOPICS IN THE MCBRIDE HONORS PROGRAM IN PUBLIC AFFAIRS. 1-6 Semester Hr.**

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 Semester Hr.**

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.

**LAIS100. NATURE AND HUMAN VALUES. 4.0 Semester Hrs.**

Equivalent with LIHU100,

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.

**LAIS198. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LAIS199. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

**LAIS200. HUMAN SYSTEMS. 3.0 Semester Hrs.**

Equivalent with SYGN200,

(I, II) Part of the CSM core curriculum, following the first-year requirement of LAIS 100 Nature and Human Values. This course examines political, economic, social, and cultural systems on a global scale during the modern era. Topics covered include development patterns in key regions of the world; the causes and outcomes of globalization; and the influence of energy, technology, and resources on development. Course material presented by instructors with social science and humanities disciplinary backgrounds, with weekly readings and evaluation through exams and written essays. Prerequisite: LAIS 100. 3 hours lecture; 3 semester hours.

**LAIS220. INTRODUCTION TO PHILOSOPHY. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 credit hours.

**LAIS221. INTRODUCTION TO RELIGIONS. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS286. INTRODUCTION TO GOVERNMENT AND POLITICS. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS298. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LAIS299. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

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: LAIS 100. Prerequisite or corequisite: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS301. CREATIVE WRITING: POETRY I. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS305. AMERICAN LITERATURE: COLONIAL PERIOD TO THE PRESENT. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS307. EXPLORATIONS IN COMPARATIVE LITERATURE. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS309. LITERATURE AND SOCIETY. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS310. MODERN EUROPEAN LITERATURE. 1-3 Semester Hr.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS311. BRITISH LITERATURE: MEDIEVAL TO MODERN. 3.0 Semester Hrs.**

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. Pre-requisite: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS315. MUSICAL TRADITIONS OF THE WESTERN WORLD. 3.0 Semester Hrs.**

An introduction to music of the Western world from its beginnings to the present. Prerequisite: LAIS100. Prerequisite or corequisite: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS320. ETHICS. 3.0 Semester Hrs.**

Equivalent with BELS320,

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS322. LOGIC. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS323. INTRODUCTION TO SCIENCE COMMUNICATION. 3.0 Semester Hrs.**

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, and pre- or co-requisite of LAIS200 hours lecture; 3 semester hours.

**LAIS324. AUDIO/ACOUSTICAL ENGINEERING AND SCIENCE. 3.0 Semester Hrs.**

(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 psycho acoustic phenomena are also presented. 3 hours lecture; 3 credit hours. Prerequisite: LAIS100. Prerequisite or corequisite: LAIS200.

**LAIS325. CULTURAL ANTHROPOLOGY. 3.0 Semester Hrs.**

A study of the social behavior and cultural development of humans. Prerequisite: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS326. MUSIC THEORY. 3.0 Semester Hrs.**

(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: LAIS200.

**LAIS327. MUSIC TECHNOLOGY. 3.0 Semester Hrs.**

(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: LAIS200.

**LAIS328. BASIC MUSIC COMPOSITION AND ARRANGING. 1.0 Semester Hr.**

(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: LAIS 100; Pre-or Co-requisite: LAIS200.

**LAIS330. MUSIC TECHNOLOGY CAPSTONE. 3.0 Semester Hrs.**

(II) Project-based course designed to develop practical technological and communication skills for direct application to the music recording. 3 credit hours. Prerequisites: LAIS100, LAIS324, LAIS326, and LAIS327. Prerequisite or corequisite: LAIS200.

**LAIS335. INTERNATIONAL POLITICAL ECONOMY OF LATIN AMERICA. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS337. INTERNATIONAL POLITICAL ECONOMY OF ASIA. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS339. INTERNATIONAL POLITICAL ECONOMY OF THE MIDDLE EAST. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS341. INTERNATIONAL POLITICAL ECONOMY OF AFRICA. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS344. INTERNATIONAL RELATIONS. 3.0 Semester Hrs.**

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: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS345. INTERNATIONAL POLITICAL ECONOMY. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS365. HISTORY OF WAR. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS370. HISTORY OF SCIENCE. 3.0 Semester Hrs.**

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 LAIS200. 3 hours lecture; 3 semester hours.

**LAIS371. HISTORY OF TECHNOLOGY. 3.0 Semester Hrs.**

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 LAIS200. 3 hours lecture; 3 semester hours.

**LAIS375. ENGINEERING CULTURES. 3.0 Semester Hrs.**

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: LAIS200. 3 hours lecture; 3 semester hours.



**LAIS376. COMMUNITY ENGAGEMENT THROUGH SERVICE LEARNING. 3.0 Semester Hrs.**

(II) Community Engagement through Service Learning combines a traditional classroom environment with an off campus learning experience with a local non-profit or community organization. Students spend 3-4 hours per week serving the organization they choose and meet in class once per week to discuss reading assignments, present research findings, and share experiences and insights about the course material. Instructors may choose to focus on a particular topic or social issue, such as poverty and privilege, or may engage with community issues more broadly. The course focuses on several aspects of a student's learning, including intra- and interpersonal learning, discovering community, and developing communication skills and critical and interdisciplinary approaches. Course work will focus on critical reading, group discussion and deliberation, oral presentations of research, and writing assignments. Prerequisites: none. 2 hours lecture; 3-4 hours lab; 3.0 semester hours.

**LAIS377. ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT. 3.0 Semester Hrs.**

(I) This course is an introduction to the relationship between engineering and sustainable community development (SCD) from historical, political, ideological, ethical, cultural, and practical perspectives. Students will study and analyze different dimensions of community and sustainable development and the role that engineering might play in them. Also students will critically explore strengths and limitations of dominant methods in engineering problem solving, design, and research for working in SCD. Students will learn to research, describe, analyze and evaluate case studies in SCD and develop criteria for their evaluation. Prerequisite: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS398. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LAIS399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS404. WOMEN, LITERATURE, AND SOCIETY. 3.0 Semester Hrs.**

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 LAIS200. 3 hours seminar; 3 semester hours.

**LAIS406. THE LITERATURE OF WAR AND REMEMBRANCE. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS407. SCIENCE IN LITERATURE. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS408. LIFE STORIES. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS409. SHAKESPEAREAN DRAMA. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS410. CRITICAL PERSPECTIVES ON 20TH CENTURY LITERATURE. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS411. LITERATURES OF THE AFRICAN WORLD. 3.0 Semester Hrs.**

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: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS412. LITERATURE AND THE ENVIRONMENT. 3.0 Semester Hrs.**

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 LAIS200. 3 hours seminar; 3 semester hours.

**LAIS415. MASS MEDIA STUDIES. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS416. FILM STUDIES. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS418. NARRATING THE NATION. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS419. MEDIA AND THE ENVIRONMENT. 3.0 Semester Hrs.**

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 LAIS200. 3 hours seminar; 3 semester hours.

**LAIS421. ENVIRONMENTAL PHILOSOPHY AND POLICY. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS423. ADVANCED SCIENCE COMMUNICATION. 3.0 Semester Hrs.**

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. Prerequisite: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS424. RHETORIC, ENERGY AND PUBLIC POLICY. 3.0 Semester Hrs.**

(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: LAIS200.

**LAIS425. INTERCULTURAL COMMUNICATION. 3.0 Semester Hrs.**

(I, II) The course examines intercultural communication theory and practice. In particular, the course provides students with a window into how intercultural (mis)communication cases arise, evolve, and are resolved. Students investigate communication cases and issues across a broad range of cultural divides, such as national, ethnic, gender, and social class cultures. Some case studies are situated in engineering and applied science contexts. Prerequisites: LAIS100. Co-requisites: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS426. SCIENTIFIC CONTROVERSIES. 3.0 Semester Hrs.**

(I, II) Examines national and international, historical and contemporary scientific and engineering controversies. In particular, the course provides students with a window into how scientific controversies arise, evolve, and are resolved both within scientific circles and in the public arena. By exploring case studies of such controversies, students gain a better understanding about how scientific controversies shape and are shaped by communication as well as by public policy. Prerequisite: LAIS100. Corequisite: LAIS200. 3 hours lecture, 3 semester hours.

**LAIS429. REAL WORLD RECORDING/RESEARCH. 3.0 Semester Hrs.**

(WI) This reading and writing-intensive course explores the acoustical, musical, and technical aspects of recording a variety of live ethnomusicological music genres and/or performances, towards the purpose of learning how to research, document and capture the most accurate and authentic recording. Historical research, non-traditional recording techniques; archival documentation, and editing will all be a part of this course. Prerequisites: LAIS100 and either LAIS315 or LAIS327. Co-requisites: LAIS200. 3 semester hours.

**LAIS430. CORPORATE SOCIAL RESPONSIBILITY. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS431. RELIGION & SECURITY. 3.0 Semester Hrs.**

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: LAIS100. Prerequisite or corequisite: LAIS200. 3 hours lecture and discussion; 3 semester hours.

**LAIS435. LATIN AMERICAN DEVELOPMENT. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS437. ASIAN DEVELOPMENT. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS439. MIDDLE EAST DEVELOPMENT. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS440. WAR AND PEACE IN THE MIDDLE EAST. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS441. AFRICAN DEVELOPMENT. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS442. NATURAL RESOURCES AND WAR IN AFRICA. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS446. GLOBALIZATION. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS448. GLOBAL ENVIRONMENTAL ISSUES. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS450. POLITICAL RISK ASSESSMENT. 3.0 Semester Hrs.**

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: LAIS200. Prerequisite: At least one IPE 300- or 400-level course. 3 hours seminar; 3 semester hours.

**LAIS451. POLITICAL RISK ASSESSMENT RESEARCH SEMINAR. 1.0 Semester Hr.**

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: LAIS200. Concurrent enrollment in LAIS450. 1 hour seminar; 1 semester hour.

**LAIS452. CORRUPTION AND DEVELOPMENT. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS453. ETHNIC CONFLICT IN GLOBAL PERSPECTIVE. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS456. POWER AND POLITICS IN EURASIA. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS457. INTRODUCTION TO CONFLICT MANAGEMENT. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS460. GLOBAL GEOPOLITICS. 3.0 Semester Hrs.**

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. Prerequisite or co-requisite: LAIS200. 3 hours seminar; 3 credit hours.

**LAIS464. HISTORY OF ENERGY AND THE ENVIRONMENT. 3.0 Semester Hrs.**

(II) This course examines the major patterns of human energy use and interaction with the natural environment on a global scale from the origins of civilization to the present day. Topics analyzed include the dynamics of historical change in energy and resource use, the ways in which energy and the environment have shaped the development of past societies, cultural perceptions of energy and the environment during different historical eras, and the impact of past human activities on natural systems. Analysis of historical trends will also serve as a basis for discussions related to current issues in energy and the environment. Prerequisite: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours lecture/seminar; 3 semester hours.

**LAIS467. HISTORY OF EARTH AND ENVIRONMENTAL SCIENCES. 3.0 Semester Hrs.**

This course provides an overview of the history of some of the key sciences that help us understand the world we inhabit: geology, climatology, evolutionary biology, and ecology. As we investigate key scientific discoveries of the modern era, we will also consider the philosophical and cultural impacts of those scientific discoveries. Thus, our reading will include not only original texts by scientists, but also key literary, historical and other texts inspired by those discoveries. Prerequisites: LAIS100. Co-requisites: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS475. ENGINEERING CULTURES IN THE DEVELOPING WORLD. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS478. ENGINEERING AND SOCIAL JUSTICE. 3.0 Semester Hrs.**

(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: LAIS200.

**LAIS485. CONSTITUTIONAL LAW AND POLITICS. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS486. SCIENCE AND TECHNOLOGY POLICY. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS487. ENVIRONMENTAL POLITICS AND POLICY. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS488. WATER POLITICS AND POLICY. 3.0 Semester Hrs.**

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: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS489. NUCLEAR POWER AND PUBLIC POLICY. 3.0 Semester Hrs.**

A general introduction to research and practice concerning policies and practices relevant to the development and management of nuclear power. Prerequisite: LAIS100. Prerequisite or co-requisite: LAIS200. 3 hours seminar; 3 semester hours.

**LAIS490. ENERGY AND SOCIETY. 3.0 Semester Hrs.**

Equivalent with ENGY490, MNGN490, (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: LAIS200. 3 hours lecture; 3 semester hours.

**LAIS498. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LAIS499. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

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 Semester Hrs.**

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 Semester Hrs.**

Fundamentals of spoken and written German with an emphasis on vocabulary, idiomatic expressions of daily conversation, and German culture. 3 semester hours.

**LIFL119. FRENCH I. 3.0 Semester Hrs.**

(I) French I provides basic instruction in speaking, reading, listening, and writing the French language, with emphasis in class on communicating through speaking and listening skills. French and francophone culture will also be studied. Successful completion of French I will allow students to further their french studies in level 2. 3 hours lecture, 3 semester hours.

**LIFL123. SPANISH II. 3.0 Semester Hrs.**

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 Semester Hrs.**

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 Semester Hrs.**

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.

**LIFL129. FRENCH II. 3.0 Semester Hrs.**

(II) French 2 provides continued instruction in speaking, reading, listening, and writing the French language, with emphasis in class on communicating through speaking and listening skills. French and francophone culture will also be studied. Prerequisites: LIFL119. 3 hours lecture.

**LIFL198. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIFL199. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 Semester Hrs.**

Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and Spanish American culture. 3 semester hours.

**LIFL214. ARABIC III. 3.0 Semester Hrs.**

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 Semester Hrs.**

Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and German culture. 3 semester hours.

**LIFL298. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIFL299. INDEPENDENT STUDY. 6.0 Semester Hrs.**

(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 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIFL399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

**LIFL498. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIFL499. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 - FRESHMAN. 1.0 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

(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 Semester Hrs.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIMU199. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

**LIMU201. BAND - SOPHOMORE. 1.0 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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.

**LIMU298. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIMU299. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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 - JUNIOR. 1.0 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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.

**LIMU398. SPECIAL TOPICS. 1-6 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIMU399. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

**LIMU401. BAND - SENIOR. 1.0 Semester Hr.**

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. JAZZ ENSEMBLE/PEP BAND. 1.0 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hr.**

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 Semester Hrs.**

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 Semester Hr.**

(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: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

**LIMU499. INDEPENDENT STUDY. 1-6 Semester Hr.**

(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.

## Operations Research

### 2016-2017

#### 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	3.0
CSCI404	ARTIFICIAL INTELLIGENCE	3.0
CSCI406	ALGORITHMS	3.0
MATH406	ALGORITHMS	3.0
MATH332	LINEAR ALGEBRA	3.0
EBGN455	LINEAR PROGRAMMING	3.0
EENG307	INTRODUCTION TO FEEDBACK CONTROL SYSTEMS	3.0
EENG417	MODERN CONTROL DESIGN	3.0
MEGN502	ADVANCED ENGINEERING ANALYSIS	3.0
MEGN588	INTEGER OPTIMIZATION	3.0

### Stochastic Modeling (minimum of one)

EBGN459	SUPPLY CHAIN MANAGEMENT	3.0
EBGN461	STOCHASTIC MODELS IN MANAGEMENT SCIENCE	3.0
EBGN528	INDUSTRIAL SYSTEMS SIMULATION	3.0
EBGN560	DECISION ANALYSIS	3.0
MATH424	INTRODUCTION TO APPLIED STATISTICS	3.0
MATH438	STOCHASTIC MODELS	3.0
MNGN438	GEOSTATISTICS	3.0
PEGN438	PETROLEUM GEOSTATISTICS	3.0
MTGN450	STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS	3.0

### Survey Course (Maximum of one)

EBGN325	OPERATIONS RESEARCH	3.0
MNGN433	MINE SYSTEMS ANALYSIS I	3.0

## Space and Planetary Science and Engineering

### 2016-2017

**General CSM Minor/ASI requirements can be found here (p. 42).**

#### Programs Offered

Area of Special Interest in Space and Planetary Science and Engineering

#### Program Description

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 SPSE Program Director, Dr. Angel Abbud-Madrid, at [aabbudma@mines.edu](mailto:aabbudma@mines.edu). ([aabbudma@mines.edu](mailto:aabbudma@mines.edu))

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.

## General CSM Minor/ASI requirements can be found here (p. 42).

### 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	3.0
EGGN408	INTRODUCTION TO SPACE EXPLORATION	1.0
EGGN491	SENIOR DESIGN I	3.0
EGGN492	SENIOR DESIGN II	3.0
GEGN469	ENGINEERING GEOLOGY DESIGN	3.0
GEOL410	PLANETARY GEOLOGY	2.0
GPGN438	GEOPHYSICS PROJECT DESIGN	1-3
GPGN470	APPLICATIONS OF SATELLITE REMOTE SENSING	3.0
or GEOL470	APPLICATIONS OF SATELLITE REMOTE SENSING	
GPGN475	PLANETARY GEOPHYSICS	3.0
PHGN324	INTRODUCTION TO ASTRONOMY AND ASTROPHYSICS	3.0
PHGN424	ASTROPHYSICS	3.0
PHGN471 & PHGN481	SENIOR DESIGN PRINCIPLES I and SENIOR DESIGN PRACTICE	3.0
PHGN472 & PHGN482	SENIOR DESIGN PRINCIPLES II and SENIOR DESIGN PRACTICE	3.0

### Professors

Uwe Greife , Department of Physics

Thomas Furtack , Department of Physics, Department Head

Thomas Furtak, Minors and Areas of Special Interest Only, SPSE Program Advisor

Gary R. Olhoeft, Department of Geophysics and Geophysical Engineering

### Assistant professors

Jeffrey C. Andrews-Hanna, Minors and Areas of Special Interest Only, SPSE Director

Jeffrey C. Andrews-Hanna, Department of Geophysics and Geophysical Engineering

John R. Spear, Department of Environmental Science and Engineering

### Professor emeritus

F. Edward Cecil, Department of Physics

### Teaching professor

Joel G. Duncan , Department of Geology and Geological Engineering

### Teaching associate professor

Cynthia Norrgran , Department of Chemical Engineering

### Research professor

Robert D. Knecht, Department of Chemical Engineering, Teaching Professor in EPICS

### Associate research professor

Angel Abbud-Madrid, Minors and Areas of Special Interest Only, SPSE Associate Director

### Assistant research professor

Christopher Dryer, Department of Engineering

### Distinguished senior scientist

Warren Hamilton, Department of Geophysics and Geophysical Engineering

## Underground Construction & Tunneling

General CSM Minor/ASI requirements can be found here (p. 42).

### Programs Offered

Minor in Underground Construction and Tunneling (18.0 credit hours) and an Area of Special Interest (ASI) (12.0 credit hours).

### Program Educational Objectives

Underground Construction and Tunneling is a growing discipline involving knowledge in the disciplines of mining engineering, geological engineering and civil engineering, among others. The Departments of Mining Engineering, Geology & Geological Engineering and Civil and Environmental Engineering offer an interdisciplinary Minor or Area of Special Interest (ASI) course of study that allows students from these departments to take a suite of courses providing them with a basis for work and further study in this field.

The objectives of the minor and ASI are to supplement an engineering background with a formal approach to subsurface engineering that includes site characterization, design and construction of underground

infrastructure, including water, storm water, highway or subway tunnels and subsurface facilities.

**General CSM Minor/ASI requirements can be found here (p. 42).**

## Curriculum

The Underground Construction & Tunneling minor consists of a minimum of 18 credit hours of coursework from the list below. An Area of Special Interest (ASI) in Underground Construction & Tunneling requires 12 credit hours of coursework from the list below. A student's advisor may authorize a student's Minor or Area of Special Interest (ASI) application. For questions about the minor and to request consideration of additional courses including independent study, students should meet with a UC&T faculty member. The petition process requires one month to complete.

### Program Requirements:

#### Required Courses (Minor)

CEEN312	SOIL MECHANICS	3.0
MNGN321	INTRODUCTION TO ROCK MECHANICS	3.0
MNGN404	TUNNELING	3.0
GEGN466	GROUNDWATER ENGINEERING	3.0
or GEGN467	GROUNDWATER ENGINEERING	
GEGN468	ENGINEERING GEOLOGY AND GEOTECHNICS	4.0

#### Electives (Minor)

CEEN314	STRUCTURAL THEORY	3.0
CEEN405	NUMERICAL METHODS FOR ENGINEERS	3.0
CEEN415	FOUNDATION ENGINEERING	3.0
CEEN499	INDEPENDENT STUDY	1-6
CEEN520	EARTH RETAINING STRUCTURES / SUPPORT OF EXCAVATIONS	3.0
CEEN523	ANALYSIS AND DESIGN OF TUNNELS IN SOFT GROUND	3.0
GEOL308	INTRODUCTORY APPLIED STRUCTURAL GEOLOGY	3.0
or GEOL309	STRUCTURAL GEOLOGY AND TECTONICS	
or GEOL311	STRUCTURAL GEOLOGY FOR MINING ENGINEERS	
GEGN473	GEOLOGICAL ENGINEERING SITE INVESTIGATION	3.0
GEGN499	INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY	1-6
MNGN406	DESIGN AND SUPPORT OF UNDERGROUND EXCAVATIONS	3.0
MNGN407	ROCK FRAGMENTATION	3.0
MNGN408	UNDERGROUND DESIGN AND CONSTRUCTION	2.0
MNGN410	EXCAVATION PROJECT MANAGEMENT	2.0
MNGN418	ADVANCED ROCK MECHANICS	3.0
MNGN424	MINE VENTILATION	3.0
MNGN499	INDEPENDENT STUDY	1-6

#### Required Courses (Area of Special Interest - ASI)

CEEN312	SOIL MECHANICS	3.0
MNGN321	INTRODUCTION TO ROCK MECHANICS	3.0
MNGN404	TUNNELING	3.0

#### Electives (Area of Special Interest - ASI)

Students may choose one course from the required Minor courses or elective courses listed above.

## Department of Civil & Environmental Engineering

Marte Gutierrez, Professor

Michael Mooney, Professor

## Department of Geology & Geological Engineering

Jerry Higgins, Associate Professor

Wendy Zhou, Associate Professor

## Department of Mining Engineering

Hugh Miller, Associate Professor

Ray Henn, Adjunct Professor

Priscilla Nelson, Professor & Department Head

# Special Programs

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Please select from the list of links on the right for more information about the various special programs offered to undergraduate students at the Colorado School of Mines.

## **Division of Liberal Arts and International Studies (LAIS) Writing Center**

Located in room 133 Alderson 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. <http://inside.mines.edu/LAIS-Writing-Center->

## Skills Building Courses

The following courses are offered by various Administrative departments on campus to give students the opportunity to build valuable skills to assist with their academic and professional development.

The Freshman Seminar course, CSM101, is a required course and is part of the undergraduate degree requirements. All incoming Freshman will be registered for this course during their first semester at Mines. Incoming Transfer students may be eligible to receive transfer credit for this course to meet their degree requirements, based on previously completed coursework at the college level.

Transfer students who have successfully completed fewer than 30.0 transcribed semester hours at an institution of higher education after high school graduation will automatically be enrolled in CSM101.

CSM101	FRESHMAN SUCCESS SEMINAR	0.5
CSM151	SPATIAL VISUALIZATION AND MODELING FOR ENGINEERING AND APPLIED SCIENCE STUDENTS	1.0
CSM250	ENGINEERING YOUR CAREER PATH	1.0
CSM275	CASA BOUNCE BACK PROGRAM	1.0

For more information about CSM101 and CSM151, contact the Center for Academic Services and Advising (CASA) (<http://inside.mines.edu/CASAtHome>).

For more information about CSM250, contact the Career Center (<http://careers.mines.edu>).

## Study Abroad

2016-2017

Students wishing to pursue study abroad opportunities, either coursework, internships or research should contact the Office of International Programs (OIP), listed under the Services Section ([bulletin.mines.edu/services](http://bulletin.mines.edu/services)) 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 pre-approved, taken and successfully passed with a grade of "C" or better at a partner university 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. International University partners may have additional scholarship funding for study abroad or internship 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.

## 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 their course descriptions. Course descriptions can be found on the Undergraduate Programs and Departments page, under the Courses tab for each department.

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.

# Policies and Procedures

## 2016-2017

### 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 (<https://inside.mines.edu/POGO-Policies-Governance>). 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 Dean of Students located in the Student Center, Suite 172.

For emphasis, the following policies are included or identified in this section:

- **Student Honor Code**
- **Policy on Academic Integrity/Misconduct**
- **Policy Prohibiting Gender-Based Discrimination, Sexual Harassment and Sexual Violence**
- **Unlawful Discrimination Policy**
- **Alcohol and Other Drugs Education and Prevention Policy**
- **Electronic Communications (E-mail) Policy**
- **Student Complaint Process**
- **Access to Student Records**
- **Posthumous Degree Awards**
- **Equal Opportunity, Equal Access, and Affirmative Action**
  - **Title IX @ Mines** (<http://inside.mines.edu/POGO-Title-IX>)
  - **SpeakUP@Mines**

Please note: Any policy or procedure updates during the term will be reflected in the Mines Policy Library (<http://inside.mines.edu/POGO-Policies>) and those versions shall control.

### 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

For the most up-to-date version of this procedure and appeal request forms, please see the student section of the policy website (<https://inside.mines.edu/POGO-Policies-Governance>).

## Policy Prohibiting Gender-Based Discrimination, Sexual Harassment and Sexual Violence

### 1.0 BACKGROUND AND PURPOSE

The Board of Trustees of the Colorado School of Mines ("the School" or "Mines") promulgates this policy pursuant to the authority conferred by §23-41-104(1), C.R.S., Title IX of the Education Amendments of 1972, 20 U.S.C. §§ 1681 *et seq.*, and its implementing regulations, 34 C.F.R. Part 106; Title IV and VII of the Civil Rights Act of 1964 (42 U.S.C. § 2000c and 42 U.S.C. §§ 2000e) and relevant sections of the Violence Against Women Reauthorization Act of 2013 (42 U.S.C. §§ 14043e *et seq.*). This policy supersedes the Board of Trustees' Policy Prohibiting Sexual Harassment and shall govern if any other Mines policy conflicts with this policy's provisions. This policy does not preclude application or enforcement of other Mines policies. Nothing in this policy shall be construed to abridge academic freedom and inquiry, principles of free speech or Mines' educational purpose.

### 2.0 POLICY

Mines prohibits gender-based discrimination, sexual harassment or any form of sexual violence among the Mines campus community. Mines does not discriminate against any person because of gender, gender identity or gender expression. Mines will not tolerate any form of sexual harassment or sexual violence within the Mines campus community. Mines will not tolerate any form of retaliation against a community member for reporting complaints, or opposing gender-based discrimination, sexual harassment or sexual violence. Accordingly, the Board of Trustees adopts this policy prohibiting gender-based discrimination, sexual harassment and sexual violence.

In order to prevent incidents of gender-based discrimination, sexual harassment and sexual violence, Mines will: (1) develop, administer, maintain and update procedures to implement and resources to support this policy; (2) educate community members regarding policies and procedures related to prevention, reporting and investigation of gender-based discrimination, sexual harassment and sexual violence; (3) encourage community members to report actual and potential incidents of gender-based discrimination, sexual harassment and sexual violence; (4) take actions to prevent incidents of gender-based discrimination, sexual harassment and sexual violence from denying or limiting a community member's ability to participate in or benefit from Mines' educational and work programs; (5) make available timely services and resources for those who have been affected by gender-based discrimination, sexual

harassment and sexual violence; (6) take actions to remedy any harm from incidents of gender-based discrimination, sexual harassment and sexual violence; and (7) take actions to prevent the recurrence of gender-based discrimination, sexual harassment and sexual violence.

Mines' Unlawful Discrimination policy shall govern all other forms of harassment or discrimination. No complainant shall be permitted to file a complaint under the Policy Prohibiting Gender-Based Discrimination, Sexual Harassment and Sexual Violence and any other Mines' complaint or grievance policy or procedure when the complaint or grievance arises out of an identical sets of facts.

### 3.0 DEFINITIONS

**Gender-based discrimination** involves treating a Mines community member unfavorably because of that person's gender, gender identity or gender expression. All allegations involving gender-based discrimination will be governed by this policy and its implementing procedures.

**Sexual harassment** is a form of gender discrimination. Sexual harassment, without regard to the gender of individuals involved, consists 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 is used as the basis for employment or educational decisions; 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. All allegations involving sexual harassment will be governed by this policy and its implementing procedures.

**Sexual violence** includes rape, sexual assault, sexual battery, sexual abuse and sexual coercion. In some cases, domestic violence, dating violence and stalking may also be forms of sexual violence. All allegations involving sexual violence will be governed by this policy and its implementing procedures.

For a more detailed discussion of the terms defined above, please see the Gender-Based Harassment, Sexual Harassment and Sexual Violence Complaint, Investigation, Resolution and Adjudication Procedure for Complaints Involving Student Behavior and the Gender-Based Harassment, Sexual Harassment and Sexual Violence Complaint, Investigation, Resolution and Adjudication Procedure for Complaints Involving Employee or Third-Party Behavior.

### 4.0 PROHIBITION AGAINST RETALIATION

This policy prohibits retaliation against any individual for raising an allegations of gender-based discrimination, sexual harassment or sexual violence, for cooperating in an investigation or another proceeding related to such allegations, or for opposing gender-based discrimination, sexual harassment or sexual violence. Complaints or instances of retaliation shall be addressed as separate potential violations of this policy.

### 5.0 SANCTIONS FOR VIOLATIONS

A violation of this policy may result in the imposition of sanctions. Sanctions may include, but are not limited to, the following: mandatory attendance at gender-based discrimination, sexual harassment and/or sexual violence awareness and prevention seminars; mandatory attendance at other training programs; oral reprimand and warning; written reprimand and warning; student probation, suspension, or

expulsion; educational sanctions; restitution; suspension without pay; or termination of employment or appointment.

## 6.0 ENCOURAGEMENT OF REPORTING

Mines considers the health and safety of its community members to be of paramount importance. Therefore, Mines encourages community members to report all concerns regarding gender-based discrimination, sexual harassment and/or sexual violence in accordance with this policy and its procedures. There may be circumstances where community members are hesitant to report prohibited conduct because they fear it may result in other policy violations being discovered (such as drug use or underage alcohol consumption). Community members should always consider the health and safety of themselves and other Mines community members to be of primary concern and Mines shall review, if necessary, any other policy violations separately from allegations raised under this policy.

### Contact for Complaints about Student, Employee, or Third-Party Behavior,

**Karin Ranta-Curran** (krcurran@mines.edu), **Director Title IX & Equity, 303-273-2558.**

Additional contacts listed in the Title IX section below.

*For a complete policy statement and the most up-to-date procedures, definitions and resources as well as reporting forms, please refer to the Policy Library Student policies (<https://inside.mines.edu/POGO-Student>). 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. Amended by the Colorado School of Mines Board of Trustees August 29, 2014.*

## Unlawful Discrimination Policy and Complaint Procedure

### 1.0 BACKGROUND 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 Mines. This policy shall supersede any previously promulgated Mines policy that is in conflict herewith.

### 2.0 UNLAWFUL DISCRIMINATION POLICY

Attendance and employment at Mines 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, or any terms or conditions of employment shall be permitted. No discrimination in admission, application of academic standards, financial aid, scholastic awards, or any terms or conditions of employment shall be permitted. If a complaint of discrimination on the basis of gender arises, it shall be governed under Mines' Policy Prohibiting Gender-Based Discrimination, Sexual Harassment and Sexual Violence.

### 3.0 PERSONS WHO MAY FILE AN UNLAWFUL DISCRIMINATION COMPLAINT

An unlawful discrimination complaint may be filed by an individual described in one of the categories below:

A. Any member of the Mines campus community, including classified staff, exempt employees, and students as well as any applicant for employment or admission, who believes that he or she has been discriminated against by Mines, a branch of Mines, or another member of the Mines community on account of age, race, ethnicity, religion, national origin, disability, sexual orientation, or military veteran status;

B. Any person who believes that he or she has been threatened with or subjected to duress or retaliation by Mines, a branch of Mines, or a member of the Mines community as a result of (1) opposing any unlawful discriminatory practice; (2) filing a complaint hereunder; (3) representing a complainant hereunder; or (4) testifying, assisting, or participating in any manner in an investigation, proceeding, hearing, or lawsuit involving unlawful discrimination; or

C. The Associate Vice President for Human Resources or an attorney from the Office of Legal Services, if any of these individuals deem it to be in the best interest of Mines to do so.

### 4.0 CHOICE OF REMEDIES

No complainant shall be permitted to file an unlawful discrimination claim under the Mines Unlawful Discrimination Policy any other complaint or grievance policy or procedures when the complaint or grievance arises out of an identical set of facts. In such a situation, a complainant shall be entitled to file his or her claim under the policy or procedure of his or her choice.

*For a complete policy statement and the most up-to-date procedures, please see the policy website (<https://inside.mines.edu/POGO-Policies-Governance>). Promulgated by the Mines Board of Trustees on March 13, 1992. Amended by the Mines Board of Trustees on June 10, 1999; Amended by the Mines Board of Trustees on June 22, 2000; Amended by the Mines Board of Trustees, June 7, 2003; Amended by the Mines Board of Trustees August 14, 2007; Amended by the Mines Board of Trustees August 29, 2014.*

## Alcohol and Other Drugs Education and Prevention Policy

In compliance with the federal government's Drug Free Schools & Communities Act, there are community standards and potential consequences at the Colorado School of Mines pertaining to the illegal use of alcohol or drugs. The unlawful possession, use, or distribution of illicit drugs and the unlawful or unauthorized use of alcohol by employees and students at Mines will result in disciplinary action consistent with School policies, and local, state, and federal laws.

While Colorado's Constitution allows for specific legal use, possession, and growing of marijuana under certain circumstances, because of Mines' status as a federal contractor and grant recipient and because marijuana use is still prohibited under federal law, the use, possession, and growing of marijuana on campus is prohibited. Student use of alcohol and other drugs (including marijuana) that results in an impaired ability to perform academically, or behavior that violates the Code of Conduct constitutes a violation of this policy.

For more information, or for further policy details, please see the Alcohol and Other Drugs Education and Prevention Policy and the

Colorado Drug Law Summary in the Policy Library, student section (<http://inside.mines.edu/POGO-Student>). Also see the Residence Life Policies (<http://inside.mines.edu/%5Cresidencelife.mines.edu/RSL-Policies>) and the Annual Campus Security and Fire Safety Report (<http://publicsafety.mines.edu>) for more on programming and requirements.

## Electronic Communications (E-mail) 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.

*For a complete policy statement and associated procedures please see the policy website* (<https://inside.mines.edu/POGO-Policies-Governance>), information technology section. **The policy website shall be considered the official & controlling Mines' policy.** Nothing in the 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.

Questions about this policy may be directed to either of the following: Registrar's Office ([http://inside.mines.edu/Registrars\\_Office](http://inside.mines.edu/Registrars_Office)) @ 303-273-3200 or [registrar@mines.edu](mailto:registrar@mines.edu); or

Computing, Communications & Information Technologies (<http://ccit.mines.edu>) (CCIT) @ 303-273-3431 or complete a request form at the Mines Help Center (<http://helpdesk.mines.edu>).

## 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, sexual harassment, or sexual violence, there are specific procedures that will be followed (these are noted and linked in this section or contact the Director, Title IX & Equity, 303-273-2558. Additional contacts listed in the Title IX section below.) For all other concerns, 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:

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, academic honors, university email address, and photo including student ID picture. 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.

See also FERPA (<http://inside.mines.edu/FERPA>) at Mines in the Registrar's pages.

## 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 PhD 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 PhD, 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 of this Bulletin as well as the on the policy website (<https://inside.mines.edu/POGO-Policies-Governance>). Colorado School of Mines has instituted an affirmative action plan, which is available for perusal in numerous Mines offices including the Library, the Dean of Students' Office, and the Office of Human Resources.

## **Title IX @ Mines**

**Karin Ranta-Curran**, Title IX Coordinator and Director of Equity  
Guggenheim Hall, Room 210, 1500 Illinois Street, Golden, CO 80401  
303.384.2558 | [krcurran@mines.edu](mailto:krcurran@mines.edu)

### **Deputy Title IX Coordinators:**

Katie Schmalzel, Prevention Programs Manager  
Guggenheim Hall, Room 210, Golden, CO 80401  
303-384-3260 | [kschmalz@mines.edu](mailto:kschmalz@mines.edu)

Rebecca Flintoft, Assistant Vice President, Student Services & Administration  
Student Center, Suite 218, 1200 6th Street, Golden, CO 80401  
303.273.3050

Brent Waller, PhD, Director of Residence Life  
Campus Living Office, 1795 Elm St., Golden, CO 80401  
303-869-5433 (LIFE)

Jane Rosenthal, Director, Compliance & Policy Office  
Guggenheim Hall, Room 211, Golden, CO 80401  
303-384-2236 | [janerose@mines.edu](mailto:janerose@mines.edu)

Deb Wernli, Employment Manager  
Guggenheim Hall, Room 110, Golden, CO 80401  
303-273-3494 | [dwernli@mines.edu](mailto:dwernli@mines.edu)

## **SpeakUP@Mines**

Students and employees have an additional anonymous channel for reporting concerns through the Whistleblower Policy and the SpeakUP@Mines (<http://speakup.mines.edu>) program.

## **Consumer Information - Your Right to Know**

As a prospective or continuing student at Colorado School of Mines, you have a right to certain information that the university is required by law to provide. Much of that information is safety related or financial in nature, but other broad categories are included such as graduation rates, athletics, and the various costs associated with attending Mines.

Current federal regulations require that institutions of higher education disclose such information and make it readily available to current and prospective students. A new provision in the Higher Education Amendments of 1998 requires institutions to provide a list of the information to which students are entitled with instructions on how they may obtain it. A paper copy of all of the information can be found in the Compliance and Policy Office in Guggenheim Hall.

More information can be found on the Financial Aid website (<http://inside.mines.edu/UserFiles/File/studentLife/financialAid/Consumer%20Information.pdf>).

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JOSHUA HUTCHENS, 2007-B.S. Purdue, M.S. James Madison; Instructor and Co-Head Wrestling Coach

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