Colorado School of Mines

2011–2012 Undergraduate Bulletin

To Mines Students:
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Published by Colorado School of Mines, Golden, CO 80401

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Academic Affairs: Wendy Harrison, Associate Provost and Dean of Undergraduate Studies and Faculty

Contents

Academic Calendar

Fall Semester 2011

Confirmation deadline	Aug. 22, Monday
Faculty Conference	Aug. 22, Monday
Classes start (1)	Aug. 23, Tuesday
Graduate Students—last day to register without late fee	Aug. 26, Friday
Labor Day (Classes held)	Sept. 5, Monday
Last day to register, add or drop courses without a "W" (Census Day)	Sept. 7, Wednesday
Fall Break	Oct. 17 & 18, Monday & Tuesday
Midterm grades due	Oct. 17, Monday
Last day to withdraw from a course—Continuing students	Nov. 15, Tuesday
Priority Registration Spring Semester	Nov. 14-18, Monday–Friday
Non-class day prior to Thanksgiving Break	Nov. 23, Wednesday
Thanksgiving Break	Nov. 24 –Nov. 25, Thursday–Friday
Last day to withdraw from a course—New students in 1st or 2nd semester at CSM	Dec. 2, Friday
Last day to completely withdraw from CSM	Dec. 8, Thursday
Classes end	Dec. 8, Thursday
Dead Week	Dec. 5-Dec. 9, Monday-Friday
Dead Day	Dec. 9, Friday
Final exams	Dec. 10, 12-15 , Saturday, Monday–Thursday
Semester ends	Dec. 16, Friday
Midyear Degree Convocation	Dec. 16, Friday
Final grades due	Dec. 19, Monday
Winter Recess	Dec. 19 –Jan. 10, Saturday–Tuesday

Spring Semester 2012

Confirmation deadline	Jan. 10, Tuesday
Classes start (1)	Jan. 11, Wednesday
Grad Students—last day to register without late fee	Jan. 13, Friday
Last day to register, add or drop courses without a "W" (Census Day)	Jan. 26, Thursday
Non-class day - Presidents' Day	Feb. 20, Monday
Midterms grades due	March 5, Monday
Spring Break	March 12-16, Monday-Friday
Last day to withdraw from a course—Continuing students	April 10, Tuesday
E-Days	March 29 - March 31, Thursday–Saturday
Priority Registration, Summer and Fall Terms	April 9-13, Monday–Friday
Last day to withdraw from a course—New students in 1st or 2nd semester at CSM	April 27, Friday
Last day to completely withdraw from CSM	May 3, Thursday
Classes end	May 3, Thursday
Dead Week	April 30-May 4, Monday-Friday
Dead Day	May 4, Friday
Final exams	May 5, 7-10 Saturday, Monday–Thursday
Semester ends	May 11, Friday
Commencement	May 11, Friday
Final grades due	May 14, Monday

Summer Sessions 2012

Summer I - First Day of Class (1)	May 14, Monday
Summer I (Census Day)	May 18, Friday
Memorial Day (Holiday—No classes held)	May 28, Monday
Last day to withdraw from Summer I Term (all students)	June 8, Friday
Summer I ends	June 22, Friday
Summer I grades due	June 25, Monday

Summer II First Day of Class (1)	June 25, Monday
Independence Day (Holiday—No classes held)	July 4, Wednesday
Summer II Census Day	June 29, Friday
Last day to withdraw from Summer II Term (all students)	July 20, Friday
Summer II ends (2)	Aug. 3, Friday
Summer II grades due	Aug. 6, Monday

(1) Petition for changes in tuition classification due in the Registrar's office for this term.
(2) PHGN courses end two weeks later on Friday, August 17th.

Section 1 – Welcome

Mission and Goals

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

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

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

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

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

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

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

The Academic Environment

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

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

- All CSM graduates must have depth in an area of specialization, enhanced by hands-on experiential learning, and breadth in allied fields. They must have the knowledge and skills to be able to recognize, define and solve problems by applying sound scientific and engineering principles. These attributes uniquely distinguish our graduates to better function in increasingly competitive and diverse technical professional environments.
- Graduates must have the skills to communicate information, concepts and ideas effectively orally, in writing, and graphically. They must be skilled in the retrieval, interpretation and development of technical information by various means, including the use of computer-aided techniques.

- ◆Graduates should have the flexibility to adjust to the ever changing professional environment and appreciate diverse approaches to understanding and solving society's problems. They should have the creativity, resourcefulness, receptivity and breadth of interests to think critically about a wide range of cross-disciplinary issues. They should be prepared to assume leadership roles and possess the skills and attitudes which promote teamwork and cooperation and to continue their own growth through life-long learning.
- ◆Graduates should be capable of working effectively in an international environment, and be able to succeed in an increasingly interdependent world where borders between cultures and economies are becoming less distinct. They should appreciate the traditions and languages of other cultures, and value diversity in their own society.
- ◆Graduates should exhibit ethical behavior and integrity. They should also demonstrate perseverance and have pride in accomplishment. They should assume a responsibility to enhance their professions through service and leadership and should be responsible citizens who serve society, particularly through stewardship of the environment.

History of CSM

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

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

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

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

Unique Programs

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

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

While many of the programs at CSM are firmly grounded in tradition, they are all experiencing continual evolution and innovation. Recent successes in integrating aspects of the curriculum have spurred similar activity in other areas such as the geosciences. There, through the medium of computer visualization, geophysicists and geologists are in the process of creating a new emerging discipline. A similar development is occurring in geo-engineering through the integration of aspects of civil engineering, geology and mining. CSM has played a leadership role in this kind of innovation over the last decade. Many degree programs offer CSM undergraduate students the opportunity to begin work on a Graduate Certificate, Professional Master's Degree, or Master's Degree while completing the requirements for their Bachelor's Degree. These combined Bachelors-Masters programs have been created by CSM faculty in those situations where they have deemed it academically advantageous to treat BS and MS degree programs as a continuous and integrated process. These are accelerated programs that can be valuable in fields of engineering and applied science where advanced education in technology and/or management provides the opportunity to be on a fast track for advancement to leadership positions. These programs also can be valuable for students who want to get a head start on graduate education.

Location

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

Accreditation

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

Administration

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

Academic Integrity

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.

Student Honor Code

Colorado School of Mines students also feel strongly about academic integrity. The students independently wrote and approved an Honor Code promoting high academic standards and zero tolerance of academic misconduct.

Preamble: The students of Colorado School of Mines (Mines) have adopted the following Student Honor Code (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 Judicial Panel.

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 Violation of Student 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.

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:

1. The faculty member or thesis committee informs the student(s) of the allegations and charge of academic misconduct within 10 business days. This involves both verbal and written communication to the student(s). A conversation regarding the incident should take place between the faculty member/thesis committee and student. This conversation allows faculty members to get the student's perspective prior to making an official decision. It also allows the faculty member to educate the student on inappropriate behavior.
2. A) In the case of an allegation of academic misconduct associated with regular coursework, if after talking with the student, 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 - Permanent notation of Academic Misconduct on the student's transcript

B) 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" 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.

C) 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 10.11 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 indicted 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 Studies, the Dean of Graduate Studies or the Associate Dean of Students. The information is then provided to the faculty member concerned.

Appeal Process for Student Academic Misconduct

Students charged with academic misconduct must be afforded a fair opportunity for an appeal. For those alleged to have engaged in research misconduct, the appeal procedure is defined in the Faculty Handbook section 10.11. For all other charges of academic misconduct, upon notification of a finding of academic misconduct and the associated penalties, the student may appeal the decision of the faculty member for one of the following grounds for appeal only:

- The student believes his/her due process rights were violated as the student was not allowed to present relevant information.
- The student can provide evidence that academic misconduct did not occur and the faculty member abused his/her authority and/or made an arbitrary decision without fully considering the information presented.
- There is new information to consider that, if true, would be sufficient to alter the faculty member's decision. Such information must not have been known by the student appealing at the time of the original meeting with the faculty member.

To appeal the decision, the student must submit a written request in the form of a letter to the Vice President for Student Life. The letter of appeal should provide a thorough explanation of the following:

1. Under what grounds (see list above) is the appeal being requested?
2. How does the appeal request fit the selected grounds for appeal?
3. What specific aspect of the decision is being appealed?

The letter of appeal must be received by the Vice President for Student Life within 7 business days of the date of the written notice of a violation from the Associate Dean of Students. Once an appeal request is received, the Vice President for Student Life will forward it on to one of the Appeal Review Administrators. The Appeal Review Administrator will review the written request to determine if the acceptable grounds for an appeal are met and if the appeal is timely filed. After review of the request, the Appeal Review Administrator will take one of the following actions:

a. Deny the appeal. If the appeal is denied, the decision is final and considered binding upon all involved, from which no additional appeals are permitted.
b. Proceed with the appeal by notifying the student and submitting all the details and the evidence to the Student Appeals Committee for resolution.

If the appeal request is granted, the Student Appeals Committee will review the case within 15 days. Please see the Student Handbook for more information on the Student Ap-

peals Committee. The Student Appeals Committee may do any or all of the following during the review: interview with the faculty member; interview with the student(s); interview any appropriate witnesses; and/or review the student file including any homework, tests, quizzes or other assignments that were involved in the alleged misconduct. At the conclusion of the review, the Student Appeals Committee will make one of the following decisions:

a. Reverse the decision of the faculty member and withdraw the charge from the student's record.
b. Affirm the decision of the faculty member and uphold the sanction(s).
c. Forward the case to the Office of Academic Affairs for further consideration: the Student Appeals Committee believes that additional considerations should be made which could include increasing or decreasing the sanctions imposed or addressing additional issues that arose through the appeal process. Recommendations for appropriate sanctions should be made by the Student Appeals Committee to the Office of Academic Affairs. The additional consideration will be conducted by the Dean of Undergraduate Studies or Dean of Graduate Studies, depending on the academic standing of the student requesting the appeal. The Office of Academic Affairs staff member will make a final decision that will be communicated to the student within 10 business days.

The decision issued by the Student Appeals Committee or the Office of Academic Affairs (in matters that are forwarded for further consideration) is final and shall be considered binding upon all involved, from which no additional appeals are permitted.

Colorado School of Mines Non-Discrimination Statement

In compliance with federal law, including the provisions of Titles VI and VII of the Civil Rights Act of 1964, Title IX of the Education Amendment of 1972, Sections 503 and 504 of the Rehabilitation Act of 1973, the Americans with Disabilities Act (ADA) of 1990, the ADA Amendments Act of 2008, Executive Order 11246, the Uniformed Services Employment and Reemployment Rights Act, as amended, the Genetic Information Nondiscrimination Act of 2008, and Board of Trustees Policy 10.6, the Colorado School of Mines does not discriminate against individuals on the basis of age, sex, sexual orientation, gender identity, gender expression, race, religion, ethnicity, national origin, disability, military service, or genetic information in its administration of educational policies, programs, or activities; admissions policies; scholarship and loan programs; athletic or other school-administered programs; or employment.

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

The Employment-related EEO and discrimination contact is Mike Dougherty, Associate Vice President for Human Resources, Guggenheim Hall, Room 110, Golden, Colorado 80401 (Telephone: 303.273.3250). The ADA Coordinator and the Section 504 Coordinator for employment is Ann Hix, Benefits Manager, Human Resources, Guggenheim Hall, Room 110, Golden, Colorado 80401 (Telephone: 303.273.3250). The ADA Coordinator and the Section 504 Coordinator for students and academic educational programs is Ron Brummett, Director of Career Planning & Placement / Student Development Services, 1600 Maple Street, Suite 8, Golden, Colorado 80401 (Telephone: 303.273.3297). The Title IX Coordinator is Maureen Durkin, Director of Policy and Planning, Guggenheim Hall, Room 212A, Golden, Colorado 80401 (Telephone: 303.384.2236). The ADA Facilities Access Coordinator is Gary Bowersock, Director of Facilities Management, 1318 Maple Street, Golden, Colorado 80401 (Telephone: 303.273.3330).

Section 2- Student Life

Facilities

Student Center

The Ben H. Parker Student Center contains the offices for the Vice President of Student Life and Dean of Students, Associate Dean of Students, Housing, Student Activities and Greek Life, Student Government (ASCSM), Admissions and Financial Aid, Cashier, Student Development and Academic Services, Services for Students with Disabilities, International Student and Scholar Services, Career Services, Registrar, Blaster Card, Conferences Services, and student organizations. The Student Center also contains the student dining hall (known as the Slate Café), 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.

Services

Academic Advising

First-year students are advised and mentored through the First-Year Advising and Mentoring Program, CSM101. CSM101 Mentors and Academic Advisors establish immediate contact with first-year students in order to:

- facilitate the transition from high school to college;
- provide guidance with course selection & registration;
- assess and monitor academic progress; and
- provide referrals to appropriate campus resources.

Each first-year academic advisor, a member of the academic faculty, is assigned one section of CSM101 and advises approximately twenty-five students. Transfer students who have successfully completed fewer than 30 transcripted 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. The Admissions Office advises undecided transfer students, during their first year, who have successfully completed 30 or more semester hours.

Questions concerning work in a particular course should be discussed with the course instructor. The student's advisor can answer general academic advising questions. All students assigned a first-year academic advisor will be issued an alternative PIN for priority registration and must meet individually with their academic advisor for academic advising prior to receiving this PIN. Each first-year academic advisor serves as the academic advisor until the student officially declares an academic major with the Registrar's Office. At that point, the departmental advisor assumes the role of registration advisement and alternative PIN assignment.

Office for Student Development and Academic Services

The Student Development and Academic Services Office (SDAS), located in the Student Center, serves as the personal, academic and career counseling center for all students enrolled in four credit hours or more or any student that has paid the Student Services Fee. Through its various services, the center acts as a comprehensive resource for the personal growth and life skills development of our students. SDAS houses a library of over 200 books and other materials for checkout, and is home to CSM's Engineers Choosing Health Options (ECHO), promoting wise and healthy decision making regarding students' use of alcohol and other drugs. Please visit http://counseling.mines.edu for more information.

Counseling: Experienced, professional counselors offer assistance in a variety of areas. Personal counseling for stress management, relationship issues, wellness education and/or improved self image are a few of the areas often requested. Assertiveness, stress management, time management, gender issues, the MBTI, and career assessments are also popular interactive presentations. SDAS works closely with other student life departments to address other issues.

Academic Services: The staff often conducts workshops in areas of interest to college students, such as time management, learning skills, test taking, preparing for finals and college adjustment. One-on-one academic counseling with assessment of individual learning skills is also available. Please visit http://academicservices.mines.edu for more information about tutoring programs, academic counseling and CSM101.

Tutoring and Academic Excellence Workshops: Free walk-in tutoring is available to all CSM students for most freshmen and sophomore courses. Tutoring in some upper

division courses is available. Weekly academic excellence workshops in introductory calculus, chemistry, and physics are provided as well.

Disability Services: This office serves students with documented disabilities who are seeking academic accommodations or adjustments. Disability Services coordinates CSM's efforts to comply with the broad mandates of Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act Amendments Act of 2008 (ADAAA). Further information, application and documentation guidelines can be found on the Disability Services website http://disabilities.mines.edu.

International Student Services

International student advising and international student services are the responsibility of International Student and Scholar Services, located in the Student Center. The International Student and Scholar Services Office coordinates the Friendship Family Program. Orientation programs for new international students are held at the beginning of each semester. Visas and work permits are processed through the International Student Advisor at the International Student and Scholar Services Office.

Office of International Programs/Study Abroad

The Office of International Programs (OIP), a program in Academic Affairs located at 1706 Illinois Street, develops international opportunities for students and faculty at CSM, including study abroad programs. For information about the international activities of OIP, see p. 190.

Identification Cards (BLASTER CARD)

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

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

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

Student Health Center

The Student Health Center, located at 17th and Elm, provides primary health care to CSM students and their spouses. Students pay a Student Health Services fee each semester which entitles them to unlimited visits with a healthcare provider as well as certain prescriptions and over-the-counter medications. Spouses of enrolled students may also pay the fee and receive services except for dental services. The health center provides wellness education, immunizations, allergy shots, flu shots, nutrition counseling and information regarding a wide range of health concerns. Staff members are available to provide health-promotion events for students groups and residence hall programming.

The Student Health Center is open Monday through Friday 8 A.M.-12 P.M. and 1-4:45 P.M. It is staffed by Nurse Practitioners and RN's throughout the day. A physician is on campus several days per week from 3-4:45 pm during the academic year, and is on call when the Health Center is closed.

Dental services are provided to students at the Student Health Center. Services are provided by a dentist, dental hygienist, and dental assistant, and are available by appointment 3 days per week during the academic year and with limited hours during the summer. Services include x-rays, cleanings, fillings, and simple extractions. Referrals to local specialists are made if necessary.

To be eligible for care at the Health Center, students must be enrolled in four or more credit-hours and have paid the Health Services fee. Supervised by the Director of Student Services. Phone: (303) 273-3381; FAX: (303) 279-3155.

Mandatory Health Insurance

Mines requires that all degree-seeking students who are U. S. Citizens or permanent residents, and all international students regardless of degree-seeking status have health insurance that meets or exceeds Mines coverage requirements. Please see http://healthcenter.mines.edu/Insurance-Information for current information. Enrollment in the Student Health Benefit Plan is automatic, and each student's account will be charged the Student Health Benefit Plan premium unless a waiver is completed. Domestic students must complete an online enrollment/waiver prior to Census Date. International students must complete a paper waiver and submit it to the International Student and Scholar Services Office prior to Census Date each academic year.

Immunizations

Documentation confirming proof of immunity to measles, mumps, rubella (MMR's) is required of all students enrolled in four credit hours or more or any student that has paid the Student Health Services fee. A health history form will be sent to students after they are accepted for admission and have stated their intent to enroll. It must be returned to the Student Health Center prior to arriving on campus

Proof of immunity consists of an official Certificate of Immunization signed by a physician, nurse, or public health official which documents two doses of each (measles, mumps, and rubella). The Certificate must specify the type of vaccine and the dates (month, day, and year) of administration or written evidence of laboratory tests showing immunity to measles, mumps, and rubella. Failure to meet the immunization requirement will result in a hold on students' registration until this information is received by the Student Health Center.

The completed health history form is confidential and will be a student's medical record while at Mines. This record will be kept in the Student Health Center. The record will not be released unless the student signs a written release.

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 CSM 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 CSM graduates and to the mission of CSM. 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 Advice and Counseling

- Resources to help choose a major;
- Individual resume and cover letter critiques;
- Individual job search advice;
- Practice video-taped interviews.

Career Planning Services

- CSM101 First-Year Advising and Mentoring Program - focusing on exploring and connecting with an academic major at Mines;
- Online resources for exploring careers and employers at http://careers.mines.edu;
- "Career Digger" online - short bios describe what recent grads are doing on their jobs;
- "Career Manual" online - resume writing, resume and cover letter examples, and job search tips;
- Job Search Workshops - successful company research, interviewing, business etiquette, networking skills;
- Salary and overall outcomes information;
- Company contact information;
- Grad school information;
- Career resource library.

Job Resources

- Career Day (Fall and Spring);
- Online summer, part-time, and full-time entry-level job postings at http://diggernet.net;
- Virtual Career Fairs and special recruiting events;
- Cooperative Education Program - available to students who have completed three semesters at CSM (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;
- On-campus interviewing - industry and government representatives visit the campus to interview students and explain employment opportunities;
- General employment board;
- Resume referrals;
- Employer searching resource;
- Continued services up to 24 months after graduation.

Standards, Codes of Conduct

Students can access campus rules and regulations, including the student code of conduct, student honor code, alcohol policy, sexual misconduct policy, the unlawful discrimination policy and complaint procedure, public safety and park-

ing policies, and the distribution of literature and free speech policy, by visiting the Planning and Policy Analysis website at http://inside.mines.edu/Student_policies. We encourage all students to review the electronic document and expect that students know and understand the campus policies, rules and regulations as well as their rights as a student. Questions and comments regarding the above mentioned policies can be directed to the Associate Dean of Students located in the Student Center, Suite 172.

Student Publications

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

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

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

Veterans Services

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

Tutoring

Individual tutoring in most courses is available through the Office for Student Development and Academic Services. This office also sponsors group tutoring sessions and Academic Excellence Workshops which are open to all interested CSM students. For more information about services and eligibility requirements, contact the Student Development and Academic Services office.

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

The WISEM office in Academic Affairs is located in 300 Guggenheim Hall. The mission of WISEM is to enhance opportunities for women in science and engineering careers, to increase retention of women at CSM, and to promote equity and diversity in higher education. The office sponsors programs for women students and faculty and produces the Chevron Lecture Series. For further information, contact: Debra K. Lasich, Executive Director of Women in Science, Engineering and Mathematics, Colorado School of Mines, 1133 17th Street, Golden, CO 80401-1869, or call (303) 273-3097.

Minority Engineering Program

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

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

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

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

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

Society of Hispanic Professional Engineers (SHPE) is a non-profit organization that exists for the advancement of Hispanic engineering (sciences) students to become profes-

sional engineers and scientists, to increase the number of Hispanics entering into the field of engineering, and to develop and implement programs benefiting Hispanics seeking to become engineers and scientists. Anyone interested in joining may do so. SHPE is a national organization with student and professional chapters in nearly 100 cities across the country. The organization is divided into five regions representing 76 student chapters. The SHPE organization is governed by a National Board of Directors which includes representatives from all regions including two student representatives.

Activities

Student Activities Office

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

Student Government

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

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

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

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

Special Events

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

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

International Day is planned and conducted by the International Council. 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.

Living Groups

Residence Hall Association (RHA) is a student-run organization developed to coordinate and plan activities for students living in the Residence Halls. Its membership is represented by students from each hall floor. Officers are elected each fall for that academic year.

Social Fraternities and Sororities

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

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

Honor Societies

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

Special Interest Organizations

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

International Student Organizations

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

Professional Societies

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

Recreational Organizations

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

Outdoor Recreation Program

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

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

Student Honors

Awards are presented each year to members of the graduating class and others in recognition of students who have maintained a superior scholastic record, who have distinguished themselves in school activities, and who have done exceptional work in a particular subject.

Robert F. Aldredge Memorial Award. A cash award, presented in geophysics for the highest scholastic average in geophysics courses.

American Institute of Chemists Award. A one year membership, presented in chemistry and chemical engineering for demonstrated scholastic achievement, leadership, ability, and character.

Robert A. Baxter Award. A cash award, given for meritorious work in chemistry.

Charles N. Bell, 1906, Award. A Brunton transit is awarded for completing the course in mining to the student demonstrating the most progress in school work during each year.

The Blackwell Award for Excellence in Creative Expression. A plaque and cash award are presented by the Division of Liberal Arts and International Studies to a student who has excelled in the evocative representation of the human condition through the genres of poetry, fiction, creative non-fiction, music, or the artistic representation of academic inquiry. The award is funded through the generosity of J. Michael Blackwell, Class of 1959.

The Brunton Award in Geology. A Brunton transit is awarded in recognition of highest scholastic achievement and interest in and enthusiasm for the science of geology.

Hon. D. W. Brunton Award. A Brunton transit, provided for by Mr. Brunton, is awarded for meritorious work in mining.

The Leo Borasio Memorial Award. A plaque and cash award presented each year to the outstanding junior in the McBride Honors Program. Mr. Borasio was a 1950 graduate of the School of Mines.

Clark B. Carpenter Award. A cash award given to the graduating senior in mining or metallurgy who, in the opinion of the seniors in mining and metallurgy and the professors in charge of the respective departments, is the most deserving of this award.

Clark B. Carpenter Research Award. A cash award presented in honor of Professor Clark B. Carpenter to a student or students, undergraduate or graduate, selected by the Department of Metallurgical Engineering on the basis of scholastic ability and accomplishment. This award derives from an endowment by Leslie E. Wilson, E.M., 1927.

Mary and Charles Cavanaugh Memorial Award. A cash award given in metallurgy based on scholarship, professional activity, and participation in school activities.

Colorado Engineering Council Award. A silver medal presented for excellence in scholarship, high integrity, and general engineering ability.

Distinguished Military Graduate. Designated by the ROTC professor of military science for graduating seniors who possess outstanding qualities of leadership and high moral character, and who have exhibited a definite aptitude for and interest in military service.

Dwight D. "Ike" Eisenhower Award. Provided for by Mr. and Mrs. R. B. Ike Downing, $150 and a plaque is awarded to the outstanding ROTC cadet commissioned each year, based on demonstrated exemplary leadership within the Corps of Cadets and academic excellence in military science.

Prof. Everett Award. A cash award presented to an outstanding senior in mathematics through the generosity of Frank Ausanka, '42.

Cecil H. Green Award. A gold medal given to the graduating senior in geophysical engineering, who in the opinion of the Department of Geophysics, has the highest attainment in the combination of scholastic achievement, personality, and integrity.

The Neal J. Harr Memorial Outstanding Student Award. Provided by the Rocky Mountain Association of Geologists, the award and rock hammer suitably engraved, presented in geology for scholastic excellence in the study of geology with the aim of encouraging future endeavors in the earth sciences.

Harrison L. Hays, '31, Award. A cash award presented in chemical and petroleum-refining for demonstrating by scholarship, personality, and integrity of character, the general potentialities of a successful industrial career.

John C. Hollister Award. A cash award is presented to the most deserving student in Geophysics and is not based solely on academic performance.

Robert M. Hutchinson Award for Excellence in Geological Mapping. An engraved Brunton Compass given in recognition of this phase of Geological Engineering.

Henry W. Kaanta Award. A cash award and plaque is presented to a graduating senior majoring in extractive metallurgy or mineral processing for the outstanding paper written on a laboratory procedure or experimental process.

Maryanna Bell Kafadar Humanities Award. A plaque and cash award are presented by the Division of Liberal Arts and International Studies to a graduating senior for excellence in the study of the humanities and for contributions to the cultural life of the campus. The award is funded through the generosity of the late Ahmed D. Kafadar, Classes of 1942 and 1943, 1986 Distinguished Achievement Medal for significant achievements in the mineral industries, and 1987-88 Honorary Doctor of Engineering, in memory of his wife, Maryanna Bell Kafadar.

Alan Kissock, 1912, Award. A cash award is presented in metallurgy for best demonstrating the capability for creativity and the ability to express it in writing.

George C. Marshall Award. A certificate, an official biography of General Marshall and an expense paid trip to the National Security Conference sponsored by the Marshall Foundation, is presented to the most outstanding ROTC cadet who demonstrates those leadership and scholastic qualities which epitomized the career of General Marshall.

Metallurgical Engineering Faculty Award. An engraved desk set is presented from time to time by the faculty of the department to a graduating senior who, by participation in and contribution to campus life, and by academic achievement, has demonstrated those characteristics of a well-rounded graduate to which CSM aspires.

Evan Elliot Morse Memorial Award. A cash award is presented annually to a student in physics who, in the opinion of the Physics Department faculty, has shown exceptional competence in a research project.

Old Timers' Club Award. A suitable gift is presented to a graduating senior who, in the opinion of the Department of Mining Engineering, has shown high academic standing in coal mining engineering and potential in the coal industry.

The Frank Oppenheimer Memorial Science and Society Award. A plaque and cash award are presented jointly by the Division of Liberal Arts and International Studies and the Department of Physics to a freshman for excellence in writing in the core course "Nature and Human Values" for a written work which examines social, ethical, economic, and/or political issues.

Outstanding Graduating Senior Awards. A suitably engraved plaque is presented by each degree-granting department to its outstanding graduating senior.

H. Fleet Parsons Award. A cash award presented for outstanding service to the School through leadership in student government.

Maxwell C. Pellish, 1924, Academic Achievement Award. A suitably engraved plaque presented to the graduating senior with the highest cumulative grade point average who has had a minimum of 6 semesters at CSM.

The Thomas Philipose Outstanding Senior Award. A plaque and cash award, presented to a senior in the McBride Honors Program in Public Affairs for Engineers whose scholarship, character, and personality best exemplify the ideals of the program as determined by the Committee of tutors.

Physics Faculty Distinguished Graduate Award. Presented from time to time by the faculty of the department to graduating engineering physics seniors with exceptionally high academic achievement in physics.

George R. Pickett Memorial Award. A cash award presented to a graduating senior on the basis of demonstrated interests and accomplishments in the study of borehole geophysics.

President's Senior Scholar Athlete Award. A plaque presented to the graduating senior who has the highest academic average and who lettered in a sport in the senior year.

The Arthur B. Sacks Award for Excellence in Environmental Sustainability. A plaque and cash award are presented by the Division of Liberal Arts and International Studies to a graduating senior or graduating graduate student who has excelled in studying and raising awareness of environmental sustainability as informed by the Brundtland Commission's definition of sustainable development. The award is funded through the generosity of Dr. Arthur B. Sacks, Professor in the Division of Liberal Arts and International Studies and his wife, Normandy Roden Sacks.

Ryan Sayers Memorial Award. Presented to a graduating senior in Engineering Physics and/or Mathematical and Computer Sciences in recognition of outstanding academic achievement and performance of significant research as an undergraduate.

William D. Waltman, 1899, Award. Provided for by Mr. Waltman, a cash award and suitably engraved plaque is presented to the graduating senior whose conduct and scholarship have been most nearly perfect and who has most nearly approached the recognized characteristics of an American gentleman or lady during the recipient's entire collegiate career.

H.G. Washburn Award. A copy of De Re Metallica by Agricola is awarded in mining engineering for good scholastic record and active participation in athletics.

Charles Parker Wedgeforth Memorial Award. Presented to the most deserving and popular graduating senior.

Section 3 - Tuition, Fees, Financial Assistance, Housing

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

Undergraduate Tuition

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

Fees

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

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

Housing

NOTE: Room and board charges are established by the Board of Trustees (BOT) and are subject to change. Payment of room and board charges falls under the same guidelines as payment of tuition and fees. Rates below are in effect for the 2011-2012 Academic Year. Included is a "flexible" meal plan which guarantees students a designated number of meals per week or per semester and gives them between $100.00 and $300.00 to spend as they wish on additional meals or at any of the other campus dining locations. For more information, please contact the Student Life Office at (303) 273-3350.

Rates for 2011-2012 (per year)

Residence Halls (Students must choose a meal plan)

Morgan/Thomas/Bradford/Randall Halls

Double Room $4,638
Single Room $5,486

Weaver Towers

Double Room $4,938
Single Room $5,742
"E" Room, Single $6,232

Maple Hall

Double Room $5,334
Single Room $6,134

Residence Halls at Mines Park*

Double Occupancy Room $4,972
Single Occupancy Room $5,824

* *Includes Mines Park Parking Permit*

Residence Hall Association Fee $50 included in room rates.

Sigma Nu Fraternity $4,500

FIJI Fraternity $4,982

Alpha Phi Sorority $4,870

Pi Phi Sorority $4,870

Sigma Kappa Sorority $4,870

All CSM owned Fraternity and Sorority Houses—Summer $70/week

Resident Meal Plans

Marble . . . . . $4,250 (per year)
Unlimited meals + $100 Flex Dollars/semester
Quartz . . . . . $4,150 (per year)
14 meals/week + $200 Flex Dollars/semester
Granite . . . . . $3,900 (per year)
160 meals/semester + $250 Flex Dollars/semester
Topaz (Mines Park Residents Only)
. . . . . $3,500 (per year)
115 meals/semester + $300 Flex Dollars/semester

Summer Session Housing (Weekly Rate)

Double Room $75
Single Room $115

*Mines Park Apartment (per month)**

Family Housing

1 Bedroom $750/month
2 Bedroom $866/month

Apartment Housing

1 Bedroom $750
2 Bedroom $1,016
3 Bedroom $1,359

Single Student Housing at Jones Road

1 Bedroom $650/month

*Tenant pays gas and electric utilities. CSM provides free wireless and wired internet, basic expanded cable, water, sewer, public electric, and Mines Park parking permit. Tenant may pay $18.50/month per phone line (optional).

Residence Hall Application

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

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

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

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

Advance Deposits

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

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

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

Payments and Refunds

Payment Information

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

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

Financial Responsibility

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

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

Late Payment Penalties

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

Encumbrances

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

Refunds

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

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

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

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

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

State of Colorado Residency Qualifications

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

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

Resident Students

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

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

These requirements must be met by one of the following: (a) the father, mother, or guardian of the student if an unemancipated minor, or (b) the student if married or over 22, or (c) the emancipated minor.

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

Nonresident Students

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

The establishment of domicile for tuition purposes has two inseparable elements: (1) a permanent place of habitation in Colorado and (2) intent to remain in Colorado with no intent to be domiciled elsewhere. The twelve-month waiting period does not begin until both elements exist. Documentation of the following is part of the petitioning process to document physical presence: copies of rental arrangements, rent receipts, copy of warranty deed if petitioner owns the personal residence property and verification of dates of employment. Documentation of the following is part of the petitioning process to document intent: Colorado drivers license, motor vehicle registration (as governed by Colorado Statute), voter registration, payment of Colorado state income taxes, ownership of residential real estate property in the state (particularly if the petitioner resides in the home), any other factor peculiar to the individual which tends to establish the necessary intent to make Colorado one's permanent place of habitation.

Nonresident students wishing to obtain further information on the establishment of residency or to apply for resident status should contact the Registrar's Office. The "Petition for In-State Tuition Classification" is due in the Registrar's Office by the first day of classes of the term the student is requesting resident status.

College Opportunity Fund

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

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

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

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

For additional information please refer to:

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

Colorado Commission on Higher Education's website:
http://highered.colorado.gov/Finance/COF/default.html

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

Financial Aid and Scholarships

Undergraduate Student Financial Assistance

The role of the CSM Financial Assistance Program is to enable students to enroll and complete their educations, regardless of their financial circumstances. In fulfilling this role, the Office of Financial Aid administered over $33.8 million in total assistance in 2009-2010, including over $16 million in grants and scholarships. Additional information may be found at the CSM financial aid web site, 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 Stafford Student Loan.

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

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

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

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

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

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

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

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

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

In addition to scholarships through CSM, many students receive scholarships from their hometown civic, religious or other organizations. All students are urged to contact organizations with which they or their parents are affiliated to investigate such scholarships. The Financial Aid Office reserves the right, unless otherwise instructed by the student, to release the student's information to scholarship providers for the purpose of assisting students in obtaining scholarships.

Financial Aid Policies

General

CSM students requesting or receiving financial assistance sponsored by the U.S. Government, the State of Colorado, or the Colorado School of Mines are required to report to the CSM Financial Aid Office all financial assistance offered or received from all sources including CSM immediately upon receipt or notification of such assistance. For the purpose of this paragraph, "financial assistance" shall include, but not be limited to, grants, scholarships, fellowships, or loans funded by public or private sources, as well as all income not consid-

ered 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, necessary travel, and reasonable personal expenses.

Funds for the Federal Pell Grant, Federal Supplemental Educational Opportunity Grant, Federal College Work-Study Program, Federal Perkins Loan, Federal Stafford Loan, and Federal 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 as successfully passing a minimum of 12 credits each semester with a minimum 2.000 semester grade average. Students who register part-time must successfully complete all of the credits for which they register with a minimum 2.000 grade average. Satisfactory standing is determined after each semester, including summer. If students are deficient in either the credit hour or grade average measure, they will receive a one semester warning period during which they must return to satisfactory standing by passing at least 12 credits with a minimum 2.000 semester grade average.

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

Study Abroad

Students wishing to pursue study abroad opportunities should contact the Office of International Programs (OIP), listed under the Services section of this Bulletin, p.190. Colorado School of Mines encourages students to include an international study/work experience in their undergraduate education. CSM maintains student exchange programs with engineering universities in South America, Europe, Australia, Africa, and Asia. Courses successfully passed abroad can be substituted for their equivalent course at CSM. Overall GPA is not affected by courses taken abroad. A well-planned study abroad program will not delay graduation. In addition, study abroad can be arranged on an individual basis at universities throughout the world.

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

Withdrawals

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

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

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

Section 4 - Living Facilities

Residence Halls

Residence hall living is an integral part of the Colorado School of Mines experience, although no students are required to live on campus. The "Traditional" residence halls (Morgan, Thomas, Bradford and Randall halls) house about 380 students in mostly double rooms with a central restroom/shower facility on each floor. Weaver Towers has living space for 230 students in suites with single and double rooms, a common living area, and two single restroom/shower facilities. There are a limited number of single rooms available. Weaver Towers features seven or eight person suites with each suite containing both single and double bedrooms, a living/study room and two bathrooms. Maple Hall is our newest residence hall and opened August 2011. This 290-bed facility houses 2- and 4-person suites, with single and double bedrooms and a private bathroom in each suite. Five social lounges, nine study rooms, community kitchen and activity room, central living room with fireplace, music practice room, student storage and workshop space, laundry facilities, vending, mailroom, and desk assistant services are available to all residents of Maple Hall.

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

Dining Facilities

Colorado School of Mines operates a dining hall, known as the Slate Café, in the Ben H. Parker Student Center. Students who live in the residence halls are required to purchase a residential meal plan. Breakfast, lunch and dinner are served Monday through Friday, and brunch and dinner are served on Saturday and Sunday. Additional dining facilities, including a food court, convenience store, and Einstein Bros. Bagels serve students with meal plans and/or by cash/credit sales. Students not living in a residence hall may purchase any one of several meal plans which best meets their individual needs. No meals are served during breaks (Thanksgiving, Fall, Winter and Spring Break).

Mines Park Apartments*

The Mines Park apartment complex is located west of the 6th Avenue and 19th Street intersection on 55 acres owned by CSM. The complex houses upper class, graduate students, families, and some freshmen. Residents must be full-time students.

Units are complete with refrigerators, stoves, dishwashers, cable television, wired and wireless internet connections, and an optional campus phone line for an additional fee. There are two community centers which contain the laundry facilities, recreational and study space, and a convenience store.

2011-2012 rates are as follows:

Mines Park Family Housing

1 bedroom	$750/mo
2 bedroom	$866/mo

Mines Park Apartment Housing

1 bedroom	$750/mo
2 bedroom	$1,016/mo
3 bedroom	$1,359/mo

Single Student Housing at Jones Road

1 bedroom	$650/mo

*Tenant pays gas and electric utilities. A Mines Park parking permit is included.

CSM pays for wireless and wired internet, basic expanded cable, water, sewer, public electric, and provides a Mines Park parking permit. Tenant pays $18.50/month per phone line (optional).

For an application to any of the campus housing options, please contact the Housing Office at (303) 273-3350 or visit the Student Life office in the Ben Parker Student Center, Room 218.

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, contact the Student Activities office or the individual organization.

Private Rooms, Apartments

Many single students live in private homes in Golden. Colorado School of Mines participates in no contractual obligations between students and Golden citizens who rent rooms to them. Rents in rooming houses generally range from $350 to $450 per month. Housing is also available in the community of Golden, where apartment rentals range from $575 to $1,250 per month.

Section 5 - Undergraduate Information

Undergraduate Bulletin

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

Admission Requirements

Colorado School of Mines admits students who have demonstrated the ability to accomplish classroom and laboratory work and benefit from our programs. The decision to admit a student is based on his or her ability to earn a degree at CSM. Criteria considered in evaluating students include (1) pattern of course work in high school or college, (2) grades earned in those courses, (3) ACT or SAT test scores, (4) rank in class, and (5) other available test scores. No single criterion for admission is used; however, the most important factor is the academic record in high school or college.

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

Freshmen

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

1. An applicant must be a graduate of an accredited high school.
2. An applicant should rank in the upper one-third 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
   Geometry 1
   Advanced Mathematics (including Trigonometry) 1
   English 4
   History or Social Studies 3
   Academic Elective 2
   Laboratory Science 3
   Foreign Language 1

   One unit of laboratory science must be either chemistry or physics. The second and third units may be chemistry, physics, biology, zoology, botany, geology, etc. with laboratory. Both physics and chemistry are recommended for two of the three required units. General Science is not acceptable as a science unit, however it is acceptable as an academic elective unit.
4. The 2 units of academic electives (social studies, mathematics, English, science, or foreign language) must be acceptable to the applicant's high school to meet graduation requirements. For applicants submitting GED Equivalency Diplomas, these units may be completed by the GED test.
5. Applicants from the United States and Canada are required to submit the scores of either the Scholastic Aptitude Test (SAT) of the College Entrance Examination Board or the American College Test (ACT) battery. Applications for either the SAT or ACT may be obtained from the high school counselors, or by writing to Educational Testing Service, P.O. Box 592, Princeton, NJ 08541 for the SAT; or to the American College Testing Program, P.O. Box 168, Iowa City, IA 52243 for the ACT. You may also register online at www.collegeboard.com (SAT) and www.act.org (ACT).

Transfer Students

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

1. Students transferring from another college or university must have completed the same high school course requirements as entering freshmen. A transcript of the applicant's high school record is required. ACT or SAT test scores are not required if the student has completed a minimum of 30 credit hours of college credit.

2. Applicants must present official college transcripts from all colleges attended. Applicants should have an overall 2.75 (C+) grade point average or better. Students presenting a lower GPA will be given careful consideration and acted on individually.
3. An applicant who cannot re-enroll at the institution from which he or she wishes to transfer because of scholastic record or other reason will be evaluated on a case-by-case basis.
4. Completed or "in progress" college courses - which meet CSM graduation requirements - are eligible for transfer credit if the course is not remedial or vocational, and the grade earned is a "C" or better.

Former Students

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

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

Official transcripts for all coursework completed while away from Mines must be submitted to the Registrar's Office for review of transferability of the credit.

Exchange Students

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

International Students

For purposes of admission, international applicants are defined as all persons who are not citizens or permanent residents of the United States.

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

International applicants must submit a completed international application form; a $45 nonrefundable application 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

You must prove proficiency in the English language by achieving one of the following:

a. 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).

b An IELTS (International English Language Testing System) Score of 6.5, with no band below a 6.0.

c. A PTE A (Pearson Test of English) score of 70 or higher.

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

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

Advanced Credit for International Evaluation

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

1. Credit is granted based upon recommendation by recognized academic publications, primarily the World Education Series of American Association of Collegiate Registrars and Admissions Officers.
2. Validation by a comparable credit-granting department at Colorado School of Mines. Validation by one of the following two options will be at the discretion of the credit-granting department.

Option A: Course-by-course evaluation examination by comparable Colorado School of Mines academic department.

Option B: The advisor and/or academic dean's office makes a preliminary evaluation of the level a student has completed and begins the student at that level. Upon successful completion of that course, all related lower-level courses in that area, as determined by the department granting credit, would be validated and credit awarded.

Enrollment Requirements

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

Fraudulent Applications

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

Nondegree Students

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

Admission Procedures

All Applicants

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

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

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

High School Students

Applicants are encouraged to apply online at www.mines.edu. Questions can be directed to the Admissions Office via email: admit@mines.edu.; or via postal mail: Admissions Office, Colorado School of Mines, 1600 Maple Street, Golden, CO 80401. A student may apply for admission any time after completing the 11th grade. The application will be evaluated upon receipt of the completed application form, a high school transcript showing courses completed, courses remaining to be completed, ranking in class, other pertinent data, and SAT or ACT test scores. High school seniors are encouraged to apply in the fall term of senior year. Additionally, it is recommended that the ACT and/or SAT be taken during this term. In some cases, the grades or marks received in courses taken during the first half of the senior year may be required. Applicants who meet freshman admission requirements are admitted subject to completion of all entrance requirements and high school graduation.

Transfer Students

Guaranteed Transfer

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

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

Transfer by Review

Undergraduate students at another college or university who wish to transfer to CSM should apply online at www.mines.edu.

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

Advanced Placement and International Baccalaureate

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

In special cases, advanced placement may be granted for course work not completed under the College Entrance Examination Board Program. Students wishing such credit may demonstrate competence by writing the Advanced Placement Examination on the subject. Information can be secured from the College Entrance Examination Board, P.O. Box 592, Princeton, NJ 08541. More information on which subjects are accepted can be found on the web at www.mines.edu.

Course work completed for select subjects under the International Baccalaureate Program in high school may be ac-

cepted for college credit provided that the International Baccalaureate Program Exam grade is a 5, 6, or 7 on selected standard and higher level exams. In some cases, departmental approval is required before credit is granted. More information on which subjects are accepted can be found on the web at www.mines.edu.

Declaration of Option (Major)

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

Medical Record

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

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

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

Veterans

Colorado School of Mines is approved by the Colorado State Approving Agency for Veteran Benefits under chapters 30, 31, 32, 33, 35, 1606, and 1607. Undergraduates must register for and maintain 12 credit hours, and graduate students must register for and maintain 9 credit hours of graduate work in any semester to be certified as a full-time student for full-time benefits. Any hours taken under the full-time category will decrease the benefits to 3/4 time, 1/2 time, or tuition payment only.

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

Academic Regulations

Deficiencies

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

Prerequisites

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

Remediation

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

Transfer Credit

New Transfer Students

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

Continuing Students

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

Returning Students

Students who have matriculated at CSM, withdrawn, applied for readmission and wish to transfer in credit taken at an institution while they were absent from CSM, must obtain

approval, upon return, of the department head of the appropriate course, the department head of the student's option, and the Registrar.

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

Course Withdrawals, Additions and Drops

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

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

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

All adds/drops are initiated in the Registrar's Office. To withdraw from a course (with a "W") a student must obtain the appropriate form from the Registrar's office, have it initialed by the instructor and signed by the student's advisor to indicate acknowledgment of the student's action, and return it to the Registrar's Office by close of business on the last day that a withdrawal is authorized. Acknowledgment (by initials) by the division/department is required in only 2 cases: 1. when a course is added after the 11th day of the semester and 2. when the Registrar has approved, for extenuating circumstances, a withdrawal after the last date specified (a "late withdrawal"). Approval of a late withdrawal can be given by the Registrar acting on behalf of the Office of Academic Affairs in accordance with CSM's refund policy, and in compliance with federal regulations.

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

Independent Study

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

Off-Campus Study

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

Absenteeism

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

(1) Student is a varsity athlete and is representing the School in a varsity athletics activity.

(2) Student is representing the School in an authorized activity related to a club or academic endeavor (academic competitions, student professional society conferences, club sport competition, program-sponsored competitions, etc.)

(3) Student has a documented personal reason (illness, injury, jury duty, life-threatening illness or death in the immediate family, etc.).

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

Varsity Athletics Absences:

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

Authorized Activity Absences:

The Associate Dean of Students may authorize excused absences upon receipt of proper documentation of the school related activity. All excused absences for school-sponsored

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

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

Personal Reason Absences:

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

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

Unexcused Absences:

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

Withdrawal from School

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

Undergraduate Grading System

Grades

When a student registers in an undergraduate course (400-level and lower), one of the following grades will appear on his/her academic record, except if a student registered as NC fails to satisfy all conditions, no record of this registration in the course will be made. The assignment of the grade symbol is based on the level of performance, and represents the extent of the student's demonstrated mastery of the material listed in the course outline and achievement of the stated course objectives.

A	Excellent
B	Good
C	Satisfactory
D	Poor (lowest passing)
F	Failed
S	Satisfactory, C or better, used at mid-term
U	Unsatisfactory, below C, used at mid-term
WI	Involuntarily Withdrawn
W	Withdrew, No Penalty
T	Transfer Credit
PRG	In Progress
PRU	In Progress Unsatisfactory
INC	Incomplete
NC	Not for Credit
Z	Grade not yet submitted

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

The following is a notice of an upcoming change only: Undergraduate Grading System beginning Fall 2012

Grades

When a student registers in an undergraduate (400-level and lower) course, one of the following grades will appear on the academic record. Grades are based on the level of performance and represent the extent of the student's demonstrated mastery of the material listed in the course outline and achievement of the stated course objectives. These are CSM's grade symbols and their qualitative interpretations:

A	Excellent
A-	
B+	
B	Good
B-	
C+	

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

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

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

This is the end of the notice of the upcoming change to the grading system.

Incomplete Grade

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

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

NC Grade (Not for Credit or Audit)

A student may for special reasons, with the instructor's permission, register in a course on the basis of NC (Not for Credit). To have the grade NC appear on his/her transcript, the student must enroll at registration time as a NC student in the course and comply with all conditions stipulated by the course instructor, except that if a student registered as NC fails to satisfy all conditions, no record of this registration in the course will be made. The Registration Action Form is used to request that a course be recorded as an audit. This form is available in the Registrar's Office.

Grade Appeal Process

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

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

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

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

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

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

4. The Faculty Affairs Committee will request a response to the appeal from the instructor. On the basis of its review of the student's appeal, the instructor's response, and any other information deemed pertinent to the grade appeal, the Faculty Affairs Committee will determine whether the grade should be revised. The decision rendered will be either: 1) the original grading decision is upheld, or 2) sufficient evidence exists to indicate a grade has been assigned unfairly. In this latter case, the Faculty Affairs Committee will assign the student a new grade for the course. The Committee's decision is final. The Committee's written decision and supporting documentation will be delivered to the President of the Faculty Senate, the office of the EVPAA, the student, the instructor, and the instructor's Department Head/Division Director no later than 15 business days following the Senate's receipt of the grade appeal.

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

Quality Hours and Quality Points

For graduation a student must successfully complete a certain number of required semester hours and must maintain grades at a satisfactory level. The system for expressing the quality of a student's work is based on quality points and quality hours. The grade A represents four quality points, B three, C two, D one, F none. 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. The quality hours earned are the number of semester hours in which grades of A, B, C, D, or F are awarded. To compute a grade-point average, the number of cumulative quality hours is divided into the cumulative quality points earned. Grades of W, WI, INC, PRG, PRU, or NC are not counted in quality hours.

Transfer Credit

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

Semester Hours

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

Grade-Point Averages

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

Overall Grade-Point Average

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

The overall grade-point average includes all attempts at courses taken at Colorado School of Mines with the exception of courses which fall under the repeat policy in effect from Fall 2007 through Summer 2010.

If a course completed during the Fall 2007 term through Summer 2010 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 2010 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 2010.

The major grade point average includes every course completed in the major department or division at Colorado

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

Honor Roll and Dean's List

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

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

Graduation Awards

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

3.500 - 3.699 Cum Laude

3.700 - 3.899 Magna Cum Laude

3.900 - 4.000 Summa Cum Laude

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

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

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

Good Standing

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

Academic Probation and Suspension

Probation

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

1. may not register for more than 15 credit hours
2. may be required to withdraw from intercollegiate athletics
3. may not run for, or accept appointment to, any campus office or committee chairmanship. A student who is placed on probation while holding a position involving significant responsibility and commitment may be required to resign after consultation with the Associate Dean of Students or the President of Associated Students. A student will be removed from probation when the cumulative grade-point average is brought up to the minimum, as specified in the table below.

Suspension

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

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

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

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

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

missions Committee meetings are held prior to the beginning of each regular semester and at the end of the spring term.

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

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

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

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

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

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

Notification

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

Repeated Failure

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

Access to Student Records

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

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

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

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

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

Challenge of the Record. If the student wishes to challenge any part of the record, the Registrar or Dean of the Graduate School will be so notified in writing. The Registrar or Dean may then (l) remove and destroy the disputed document, or (2) inform the student that the document represents a necessary part of the record; and, if the student wishes to appeal, (3) convene a meeting of the student and the document originator (if reasonably available) in the presence of the Associate Vice President for Academic Affairs as mediator, whose decision will be final.

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

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

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

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

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

General Information

Academic Calendar

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

Electronic Communications (E-mail) Policy

BACKGROUND AND PURPOSE

Communication to students at the Colorado School of Mines (Mines) is an important element of the official business of the university. It is vital that Mines have an efficient and workable means of getting important and timely information to students. Examples of communications that require timely distribution include information from Fiscal Services, the Registrar's Office, or other offices on campus that need to deliver official and time-sensitive information to students. (Please note that emergency communications may occur in various forms based on the specific circumstances).

Electronic communication through e-mail and Trailhead Portal announcements provides a rapid, efficient, and effective form of communication. Reliance on electronic communication has become the accepted norm within the Mines community. Additionally, utilizing electronic communications is consistent with encouraging a more environmentally-conscious means of doing business and encouraging continued stewardship of scarce resources. Because of the wide-spread use and acceptance of electronic communication, Mines is adopting the following policy regarding electronic communications with students.

POLICY

It is the policy of the Colorado School of Mines that official university-related communications with students will be sent via Mines' internal e-mail system or via campus or targeted Trailhead announcements. All students will be assigned a Mines e-mail address and are expected to periodically check their Mines assigned e-mail as well as their Trailhead portal page. It is also expected that e-mail

sent to students will be read in a timely manner. Communications sent via e-mail to students will be considered to have been received and read by the intended recipients.

PROCEDURES

1. All students will be given an EKey, which is an activation code that offers access to electronic resources at Mines. With their EKey, students must activate their assigned Mines e-mail address.
2. Once their e-mail address is activated, students are expected to check their Mines e-mail inbox on a frequent and consistent basis and have the responsibility to recognize that certain communications from the university may be time-critical. As such, students also are responsible for responding in a timely manner to official communications from the university when a response is requested.
3. The policy does not prevent students from using a personal e-mail address for university-related communications and purposes. If a student chooses to use a personal e-mail address as his or her address of choice for receiving university-related communications, he or she must forward e-mail from the Mines assigned e-mail address to the personal e-mail address. However, if a student chooses to forward communications to a personal e-mail address, she or he must be aware that Mines personnel may not be able to assist in resolving technical difficulties with personal e-mail accounts. Furthermore, forwarding communications to a personal e-mail address does not absolve a student from the responsibilities associated with communication sent to his or her official Mines e-mail address. Please note: If a student changes his or her official Mines e-mail address to a personal address, it will be changed back to the Mines assigned e-mail address. Students have the option to forward their Mines e-mail to a personal address to avoid this problem. Should a student choose the forwarding option, he or she must ensure that SPAM filters will not block e-mail coming from the mines.edu address.
4. Nothing in these procedures should be construed as prohibiting university-related communications being sent via traditional means. Use of paper-based communication may be necessary under certain circumstances or may be more appropriate to certain circumstances. Examples of such communications could include, but not be limited to disciplinary notices, fiscal services communications, graduation information and so forth.

RESPONSIBLE PARTIES

Questions about this policy may be directed as follows:

Registrar's Office
Phone: 303-273-3200 or
E-mail: registrar@mines.edu

Computing, Communications & Information Technologies (CCIT)
Phone: 303-273-3431 or
Complete a request form at the
Mines Help Center (http://helpdesk.mines.edu/)

Classification of Students

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

Freshmen	0 to 29.9 semester credit hours
Sophomore	30 to 59.9 semester credit hours
Junior	60 to 89.9 semester credit hours
Senior	90 or more semester credit hours

Part-Time Degree Students

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

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

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

Seniors in Graduate Courses

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

1. The student gains admission to the Graduate School.
2. The student's graduate committee agrees that these credits are a reasonable part of his graduate program.
3. The student provides proof that the courses in question were not counted toward those required for the Bachelor's Degree.

4. Graduate courses applied to a graduate degree may not count toward eligibility for undergraduate financial aid. This may only be done if a student has been admitted to a Combined BS/MS degree program and has received the appropriate prior approvals.

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

Course Substitution

To substitute credit for one course in place of another course required as part of the approved curricula in the catalog, a student must receive the approval of the Registrar, the heads of departments of the two courses, the head of the student's option department. There will be a periodic review by the Office of the Executive Vice President for Academic Affairs. Forms for this purpose are available in the Registrar's Office.

Change of Bulletin

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

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

Students' Use of English

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

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

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

Summer Sessions

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

DEAD DAY

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

FINAL EXAMINATIONS POLICY

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

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

Academic activities that are explicitly disallowed by this policy include:

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

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

- The introduction of new materials
- Laboratory finals
- Required homework
- Required in-class assignments such as quizzes or worksheets (NO EXAMS)
    - o Quizzes are shorter exercises which take place on a fairly regular basis (e.g. 15-30 minutes in duration, 6-10 times a semester).
    - o Exams are major exercises which take place only a few times a semester (e.g. 50-120 minutes in duration, 2-4 times a semester).
- Major course assignments such as Final Presentations or Term Projects provided the assignment was assigned at

least 4 weeks in advance or was clearly indicated in the course syllabus (Presentations must not be scheduled in conflict with regularly scheduled courses in departments outside of the one scheduling the presentation.)

- Take home finals (provided they are not due prior to finals week
- Make-up exams for students who miss a scheduled exam in the prior week due to emergency, illness, athletic event, or other CSM sanctioned activity (provided this absence has been approved by the Associate Dean of Students)

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

Full-time Enrollment

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

Posthumous Degree Awards

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

Consideration for either of these degrees begins with a petition to the Faculty Senate from an academic department or degree granting unit. The petition should identify the degree sought. In the event that the degree-granting unit is seeking a conventional degree award, the petition should include evidence of the reasonable expectations that the student would have completed his or her degree requirements. For a Baccalaureate, such evidence could consist of, but is not limited to:

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

For a Graduate Degree:

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

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

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

Curriculum Changes

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

Undergraduate Degree Requirements

Bachelor of Science Degree

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

Bachelor of Science (Chemical Engineering)
Bachelor of Science (Chemical & Biochemical Engineering)
Bachelor of Science (Chemistry)
Bachelor of Science (Economics)
Bachelor of Science (Engineering)
Bachelor of Science (Engineering Physics)
Bachelor of Science (Geological Engineering)
Bachelor of Science (Geophysical Engineering)
Bachelor of Science (Mathematical and Computer Sciences)
Bachelor of Science (Metallurgical & Materials Engineering)
Bachelor of Science (Mining Engineering)
Bachelor of Science (Petroleum Engineering)

Graduation Requirements

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

1. A minimum cumulative grade-point average of 2.000 for all academic work completed in residence.
2. A minimum cumulative grade-point average of 2.000 for courses in the candidate's major.

3. A minimum of 30 hours credit in 300 and 400 series technical courses in residence, at least 15 of which are to be taken in the senior year.
4. A minimum of 19 hours in humanities and social sciences courses.
5. The recommendation of their degree-granting department/division to the faculty.
6. The certification by the Registrar that all required academic work is satisfactorily completed.
7. The recommendation of the faculty and approval of the Board of Trustees.

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

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

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

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

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

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

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

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

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

Undergraduate Programs

All programs are designed to fulfill the expectations of the *Profile of the Colorado School of Mines Graduate* in accordance with the mission and goals of the School, as introduced on page 5. To enable this, the curriculum is made up of a common core, twelve undergraduate degree granting programs, and a variety of support and special programs. Each degree granting program has an additional set of goals which focus on the technical and professional expectations of that program. The common core and the degree granting programs are coupled through course sequences in mathematics and the basic sciences, in specialty topics in science and/or engineering, in humanities and the social sciences, and in design. Further linkage is achieved through a core course sequence which addresses system interactions among phenomena in the natural world, the engineered world, and the human world.

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

Course Numbering

Numbering of Courses:

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

Course Numbering:

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

Overview: Core & Distributed Course Requirements

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

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

1) The Core Curriculum

Core requirements are applicable to all undergraduate students:

In Mathematics and the Basic Sciences, 12 semester hours in Calculus for Scientists and Engineers (MATH111, MATH112, MATH213), MATH225 Differential Equations (3) (2 semester hours in Differential Equations for Geological Engineering majors); Principles of Chemistry – CHGN121 (4); and Calculus-based Physics I – PHGN100 (4.5).

In Design, EPIC 151 Design I, Engineering Practices Introductory Course Sequence (EPICS) (3)

In Systems, SYGN200 Human Systems (3)

In Humanities and the Social Sciences, 7 semester hours: LAIS100 Nature and Human Values (4), EBGN201 Principles of Economics (3)

In Physical Education, Four separate semesters including PAGN101 and PAGN102 and two 200 level courses, totaling a minimum of 2 credit hours. Neither PAGN 101 nor PAGN 102 may be repeated for credit. See the Physical Education and Athletics section for specifics.

In Freshman Orientation and Success, 0.5 semester hours in CSM101.

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

1. The choice must not be in conflict with any *Graduation Requirements* (p. 35).
2. Free electives to satisfy degree requirements may not exceed three semester hours in activity courses such as band, chorus, studio art, physical education, and athletics courses combined.

2) Distributed Humanities and Social Science Requirement

DHSS Requirements are applicable to all undergraduate students:

9 credit hours (3 courses) required from the approved list; at least 3 of the 9 credits must be completed in a course at the 400-level. See the approved list in the Liberal Arts and International Studies section of this Bulletin.

3) Distributed Science Requirement

DS Requirements are applicable to all undergraduate students:

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

4) Distributed Engineering Requirement (see major program listing)

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

- Design II - EPIC251 - Required by all ABET accredited engineering degree programs.
- Thermodynamics - DCGN209, DCGN210, or EGGN371
- Statics - DCGN 241
- Introduction to Electrical Circuits, Electronics, and Power - EGGN381

PROGRAM	BELS101 (4)	SYGN101 (4)	PHGN200	CHGN122 (4)	CSCI101 (3)
CHEMISTRY	CHOICE	CHOICE	REQ	REQ	NA
CHEMICAL ENGINEERING	REQ	NA	REQ	REQ	NA
CHEMICAL & BIOCHEMICAL ENGINEERING	REQ	NA	REQ	REQ	NA
ECONOMICS	CHOICE	CHOICE	CHOICE	CHOICE	CHOICE
ENGINEERING-CIVIL	CHOICE	CHOICE	REQ	REQ	CHOICE
ENGINEERING-ELECTRICAL	CHOICE	CHOICE	REQ	CHOICE	CHOICE
ENGINEERING-ENVIRONMENTAL	CHOICE	CHOICE	REQ	REQ	NA
ENGINEERING-MECHANICAL	CHOICE	CHOICE	REQ	REQ	CHOICE
GEOLOGICAL ENGINEERING	NA	REQ	REQ	REQ	NA
GEOPHYSICAL ENGINEERING	CHOICE	REQ	REQ	CHOICE	NA
MATHEMATICAL & COMPUTER SCIENCES	CHOICE	CHOICE	REQ	CHOICE	REQ
METALLURGICAL & MATERIALS ENGINEERING	CHOICE	CHOICE	REQ	REQ	NA
MINING ENGINEERING	NA	REQ	REQ	REQ	NA
PETROLEUM ENGINEERING	NA	REQ	REQ	REQ	NA
ENGINEERING PHYSICS	CHOICE	CHOICE	REQ	REQ	NA

The Freshman Year

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

Fall Semester			
*subject code** and course number*	lec.	lab.	sem.hrs.
CHGN121 Principles of Chemistry I	3	3	4
MATH111 Calculus for Scientists & Engn'rs I	4		4
EBGN201* Principles of Economics	3		3
LAIS100* Nature and Human Values	4		4
CSM101 Freshman Success Seminar	0.5		0.5
PAGN101 Physical Education I		0.5	0.5
Total			16

Spring Semester	lec.	lab.	sem.hrs.
MATH112 Calculus for Scientists & Engn'rs II	4		4
EPIC151* Design I	2	3	3
PHGN100 Physics I	3.5	3	4.5
PAGN102 Physical Education II		2	0.5
Distributed Science Course*			4
Total			16

** For scheduling purposes, registration in combinations of SYGN101, BELS101, LAIS100, EBGN201, and EPIC151 will vary between the fall and spring semesters. Students admitted with acceptable advanced placement credits will be registered in accordance with their advanced placement status.*

*** Key to Subject Codes*

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

The Sophomore Year

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

Curriculum Changes

In accordance with the statement on Curriculum Changes on page 38, the Colorado School of Mines makes improvements in its curriculum from time to time. To confirm that they are progressing according to the requirements of the curriculum, students should consult their academic advisors on a regular basis and should carefully consult any Bulletin Addenda that may be published.

Core & Distributed Course Requirements - Course Descriptions

1) Core Curriculum

Mathematics and the Basic Sciences

Chemistry

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

Mathematics

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

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

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

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

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

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

MATH222. INTRODUCTION TO DIFFERENTIAL EQUATIONS FOR GEOLOGISTS & GEOLOGICAL ENGINEERS (II). An introduction to differential equations with a special emphasis on problems in the earth related fields. Topics include first and second order ordinary differential equations, Laplace Transforms, and applications relevant to the earth related fields. Prerequisites: MATH213 or MATH223 or MATH224. Student must also be a declared major in Geology and Geological Engineering. 2 hours lecture; 2 semester hours.

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

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

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

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

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

Physics

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

Design

Engineering Practices Introductory Course Sequence (EPICS)

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

EPIC155. EPICS I Graphics (I,II). Instruction and practice in mechanical sketching and computer-aided drafting methods. Specific lessons include perspective sketching, geometric construction, isometric and orthographic views, dimensions, and sections. Homework is assigned weekly. Each unit culminates in one in-class proficiency examination or extended written assignment, plus one capstone design portfolio. Prerequisites: permission of the EPICS Program Director. 1hour lecture, 1 hour laboratory, 1 semester hour.

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

Systems

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

Humanities and the Social Sciences

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

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

Physical Education

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

PAGN102. PHYSICAL EDUCATION (II) (Required) Sections in physical fitness and team sports, relating to personal health and wellness activities. Prerequisite: PAGN101 or consent of the Department Head.

See Physical Education and Athletics section toward the end of the Bulletin for available 200-level courses.

Freshman Orientation and Success

CSM101. FIRST-YEAR ADVISING AND MENTORING PROGRAM is a "college transition" course, taught in small groups. Emphasis is placed on fostering connectedness to CSM, developing an appreciation of the value of a Mines education, and learning the techniques and University resources that will allow freshmen to develop to their fullest potential at CSM. Course Objectives: Become an integrated member of the CSM community; explore, select and connect with an academic major; and develop as a person and a student. 9 meetings during semester; 0.5 semester hours.

2) Distributed Humanities and Social Science Requirement

See Liberal Arts and International Studies section for the list of approved courses and the associated course descriptions.

3) Distributed Science Requirement

BELS101 BIOLOGICAL AND ENVIRONMENTAL SYSTEMS (I,II) This course presents the basic principles and properties of biological and environmental systems. It considers the chemistry of life and the structure and function of cells and organisms. Concepts related to physiology, energetics, and genetics are introduced. The fundamentals of environmental science are presented and we consider how organisms interact with each other and with their environment and discuss the possibilities and problems of these interactions. Basic engineering principles of thermodynamics, kinetics, mass balance, transport phenomena and material science are presented and applied to biological systems. 4 semester hours

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

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

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

SYGN101. EARTH AND ENVIRONMENTAL SYSTEMS (I, II, S) Fundamental concepts concerning the nature, composition and evolution of the lithosphere, hydrosphere, atmosphere and biosphere of the earth integrating the basic sciences of chemistry, physics, biology and mathematics. Understanding of anthropological interactions with the natural systems, and related discussions on cycling of energy and mass, global warming, natural hazards, land use, mitigation of environmental problems such as toxic waste disposal, exploitation and conservation of energy, mineral and agricultural resources, proper use of water resources, biodiversity and construction. 3 hours lecture, 3 hours lab; 4 semester hours.

4) Distributed Engineering Requirement

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

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

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

EGGN371. THERMODYNAMICS I (I, II, S) A comprehensive treatment of thermodynamics from a mechanical engineering point of view. Thermodynamic properties of substances inclusive of phase diagrams, equations of state, internal energy, enthalpy, entropy, and ideal gases. Principles of conservation of mass and energy for steady-state and transient analyses. First and Second Law of thermodynamics, heat engines, and thermodynamic efficiencies. Application of fundamental principles with an emphasis on refrigeration and power cycles. Prerequisite: MATH213/223. 3 hours lecture; 3 semester hours.

EGGN381. INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER (I, II, S) This course provides an engineering science analysis of electrical circuits. DC and single-phase AC networks are presented. Transient analysis of RC, RL, and RLC circuits is studied as is the analysis of circuits in sinusoidal steady-state using phasor concepts. The following topics are included: DC and single-phase AC circuit analysis, current and charge relationships. Ohm's Law, resistors, inductors, capacitors, equivalent resistance and impedance, Kirchhoff's Laws, Thévenin and Norton equivalent circuits, superposition and source transformation, power and energy, maximum power transfer, first order transient response, algebra of complex numbers, phasor representation, time domain and frequency domain concepts, and ideal transformers. The course features PSPICE, a commercial circuit analysis software package. Prerequisite: PHGN200. 3 hours lecture; 3 semester hours.

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

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

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

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

EPIC262 – AUTOCAD (I,II): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. EPICS 262-AutoCAD incorporates semester-long instruction and practice in AutoCAD computer-aided drawing, with projects involving the use of AutoCAD in design solutions. Recent projects include remodeling plans for the Ford Building, a solar tree house education center, an environmentally sustainable house, and new structural designs for use in Haiti following the January 2010 earthquake in Haiti. Students in the Civil Engineering specialty in Engineering, the Environmental Engineering specialty in Engineering, or Mining Engineering, should consider registering for this course. Prerequisite: EPIC151. 3 semester hours.

EPIC263 – DRILLING ENGINEERING (S): Design EPICS II builds on the design process introduced in Design EPICS I, which focuses on open-ended problem solving in which students integrate teamwork and communication with the use of computer software as tools to solve engineering problems. Computer applications emphasize information acquisition and processing based on knowing what new information is necessary to solve a problem and where to find the information efficiently. This course implements the design process with drilling technology and automated drilling processes to solve multidisciplinary drilling project issues. Based on the project conditions set by the client, various alternatives and configurations are possible to meet the project objectives. Teams select and build a body of evidence to market their most desirable alternatives. Prerequisite: EPIC151. 3 semester hours.

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

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

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

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

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

Combined Undergraduate/Graduate Degree Programs

A. Overview

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

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

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

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

B. Admission Process

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

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

C. Requirements

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

Once admitted into a graduate program, undergraduate Combined Program students must maintain good standing in the Combined Program by maintaining a minimum semester GPA of 3.0 in all courses taken. Students not meeting this re-

quirement are deemed to be making unsatisfactory academic progress in the Combined Degree Program. Students for whom this is the case are subject to probation and, if occurring over two semesters, subject to discretionary dismissal from the graduate portion of their program as defined in the Unsatisfactory Academic Performance section of this Bulletin.

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

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

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

If an undergraduate Combined Degree Program student would like to enroll in a 500-level course and apply this course directly to his/her graduate degree, he/she must 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, 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.

Special Programs

Design --EPICS (Engineering Practices Introductory Course Sequence)

NATALIE C.T. VAN TYNE, Program Director and Teaching Associate Profesor

JOEL G. DUNCAN, Teaching Professor (also in Geology & Geological Engineering)

ROBERT D. KNECHT, Teaching Professor & CE Research Professor

MARTIN J. SPANN, Teaching Assistant Professor

Design EPICS is designed to prepare students for their upper-division courses and to develop some of the key skills of the professional engineer: the ability to solve complex, open-ended problems, the ability to work in teams, the ability to select a solution from competing alternatives, and the ability to communicate effectively. The first semester course, EPIC151, is required by all undergraduate options. The second semester course, EPIC251, is required by all undergraduate engineering options according to ABET requirements. EPIC251 is not required for majors in Chemistry, Mathematical and Computer Sciences, and Economics and Business

An award-winning program, Design EPICS replaces the traditional core courses in introductory computing skills, graphics, and technical communication. Whenever possible, instruction in these subjects is "hands-on" and experiential, with the instructor serving primarily as mentor rather than lecturer.

Problem-solving skills are developed through open-ended design problems organized as semester-long "projects", which the students solve in teams. Projects grow in content and complexity as the program applies a guided methodology to projects submitted by an external client. The projects require extensive library research and self-education in appropriate technical areas; they also require students to consider non-technical constraints (economic, ethical, political, societal, etc.) and incorporate them into their solutions.

Written and oral communications skills are studied and practiced as an integral part of the project work. Specific graphics and computing skills are integrated within projects wherever applicable.

Division of Liberal Arts and International Studies (LAIS) Writing Center

Located in room 309 Stratton Hall (phone: 303-273-3085), the LAIS Writing Center is a teaching facility providing all CSM students with an opportunity to enhance their writing proficiency. The LAIS Writing Center faculty are experienced technical and professional writing instructors. The Center assists writers with all their writing needs, from course assignments to scholarship applications, proposals, letters and resumes. This service is free to CSM students and includes one-to-one tutoring and online resources (at http://www.mines.edu/academic/lais/wc/).

Writing Across the Curriculum (WAC)

To support the institutional goal of developing professional communication skills, required writing and communication-intensive courses are designated in both the core and in the degree-granting programs. According to guidelines approved by the Undergraduate Council, degree-granting programs are to identify four courses, often two junior and two senior-level courses, as writing-intensive. The (generally four) writing-intensive courses within the various degree-granting programs are designated with (WI) in Section 5 of this Bulletin, Undergraduate Information, under Description of Courses.

In addition to disciplinary writing experience, students also obtain writing experience outside their disciplines as courses in LAIS are virtually all writing intensive. The Campus Writing Program, housed in the Division of Liberal Arts and International Studies (LAIS), supports the WAC program.

The Guy T. McBride, Jr. Honors Program in Public Affairs

As of 2009-10, the McBride Honors Program offers a 24-semester-hour program of seminars, courses, and off-campus activities that has the primary goal of providing a select number of students the opportunity to cross the boundaries of their technical expertise into the ethical, cultural, socio-political, and environmental dimensions of science and technology. Students will gain the knowledge, values, and skills to project, analyze and evaluate the moral, social and environmental implications of their future professional judgments and activities, not only for the particular organizations with which they will be involved, but also for the nation and the world. Themes, approaches and perspectives from the humanities and the social sciences are integrated with science and engineering perspectives to develop in students habits of thought necessary for a broad understanding of societal and cultural issues that enhance critical thinking, social responsibility and enlightened leadership. This Program leads to a certificate and a Minor in the McBride Honors Program in Public Affairs.

Bioengineering and Life Sciences (BELS)

Nine CSM departments and divisions have combined resources to offer a Minor Program and an Area of Special Interest (ASI) in Bioengineering and Life Sciences (BELS). The BELS minor and the ASI are flexible, requiring only one common core course (BELS 301, General Biology I). The rest of the courses can be chosen, in consultation with a BELS program advisor, from a broad list of electives, allowing students to concentrate their learning in areas such as Biomedical Engineering, Biomaterials, Environmental Biotechnology, Biophysics or Pre-Medical studies. Interested students should consult with the office of Dr. James F. Ely, Director of BELS Alderson Hall 331, 303-273-3885, jely@mines.edu.

The Energy Minor and ASI (EM)

The discovery, production, and use of energy in modern societies has profound and far-reaching economic, political, and environmental effects. As energy is one of CSM's core statutory missions, several CSM departments have come together to offer Minor and Area of Special Interest programs related to Energy. The 18-credit Energy Minor adds value to any CSM undergraduate degree program by not only addressing the scientific and technical aspects of energy production and use but its broader economic and social impacts as well. Students pursuing the Energy Minor may choose from three curricular tracks: Fossil Energy, Renewable Energy, or General. See page 161 for more details.

The Humanitarian Engineering Minor

Certificate Minor, Minor and Area of Special Interest

The Humanitarian Engineering and Humanitarian Studies Minors (HE & HS) are designed to prepare students to better understand the complexities of and develop a strong appreciation for society, culture, and environment in sustainable humanitarian engineering design projects. Humanitarian engineering projects are intended to provide fundamental needs (food, water, shelter, and clothing), or higher-level needs when these are specifically requested by the local people. The preparatory courses are offered through the Division of Liberal Arts and International Studies (LAIS) with additional technical electives offered by engineering departments across campus. Interested students are encouraged to investigate the many options previously listed and described in more detail below that range from a 12 credit hour area of special interest (ASI) to a 27-credit hour certificate minor in Humanitarian Engineering.

Space and Planetary Science and Engineering (SPSE)

The Space and Planetary Science and Engineering Program offers an Area of Special Interest for students interested in the science and exploration of space. This program brings together courses from five CSM departments and programs covering a diverse array of topics, including planetary science, astronomy, space exploration, and the engineering and design of instrumentation for space exploration. The curriculum can be chosen from a list of approved courses, in consultation with an SPSE program advisor. Interested students should contact Dr Jeff Andrews-Hanna, Director of SPSE (jcahanna@mines.edu).

Underground Construction and Tunneling Minor

Underground Construction and Tunneling is a growing discipline involving knowledge in the fields of mining engineering, geological engineering and civil engineering. The Departments/Divisions of Mining Engineering, Geology & Geological Engineering and Engineering (Civil Engineering Specialty) offer an interdisciplinary minor course of study that would allow students from these departments to take a suite of courses requiring a minimum of 18 credit hours. Only three credit hours from the student's degree granting department/division may be used toward the minor. The remainder would be part of a student's free elective courses. See page 186 for more details.

Minor Program/Area of Special Interest

Established Minor Programs/Areas of Special Interest (ASI) are offered by all of the undergraduate degree-granting departments as well as the Division of Environmental Science and Engineering, the Division of Liberal Arts and International Studies, and the Military Science Department.

A MINOR PROGRAM of study consists of a minimum of 18 credit hours of a logical sequence of courses. With the exception of four specific programs, only three of these hours may be taken in the student's degree-granting department and

no more than three of these hours may be at the 100- or 200-level. A Minor Program may not be completed in the same department as the major. See the specific program details for more information.

An AREA OF SPECIAL INTEREST consists of a minimum of 12 credit hours of a logical sequence of courses. Only three of these hours may be at the 100- or 200-level and no more than three of these hours may be specifically required for the degree program in which the student is graduating. With the approval of the department, an ASI may be completed within the same major department.

As a minimum, CSM requires that any course used to fulfill a minor/ASI requirement be completed with a passing grade. Some programs offering minors/ASIs may, however, impose higher minimum grades for inclusion of the course in the minor/ASI. In these cases, the program specified minimum course grades take precedence. For additional information on program-specific minimum course grade requirements, refer to the appropriate program section of this Bulletin.

As a minimum, to be awarded a minor/ASI, CSM requires students obtain a cumulative GPA of 2.0 or higher in all minor/ASI courses. All attempts at required minor/ASI courses are used in computing this minor/ASI GPA. Some programs offering minors/ASIs may, however, require a higher minimum cumulative GPA. In these cases, the program specified GPA takes precedence. For additional information on program specific GPA requirements, refer to the appropriate section of this Bulletin.

Students may not request more than half of the required courses for the minor or ASI be completed through transfer credit, including AP, IB and CLEP. Some minor/ASI programs, however, have been established in collaboration with other institutions through formal articulation agreements and these may allow transfer credit exceeding this limit. For additional information on program specific transfer credit limits, refer to the appropriate section of this Bulletin.

A Minor Program/Area of Special Interest declaration (which can be found in the Registrar's Office) should be submitted for approval prior to the student's completion of half of the hours proposed to constitute the program, or at the time of application for graduation - whichever comes first. Once the declaration form is submitted to the Registrar's Office, the student deciding not to complete the minor must officially drop the minor by notifying the Registrar's Office in writing. Should minor requirements not be complete at the time of graduation, the minor program will not be awarded. Minors are not added after the BS degree is posted. Completion of the minor will be recorded on the student's official transcript.

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

Study Abroad

Students wishing to pursue study abroad opportunities should contact the Office of International Programs (OIP), listed under the Services section of this Bulletin, p.174. Colorado School of Mines encourages students to include an international study/work experience in their undergraduate education. CSM maintains student exchange programs with engineering universities in South America, Europe, Australia, Africa, and Asia. Courses successfully passed abroad can be substituted for their equivalent course at CSM. Overall GPA is not affected by courses taken abroad. In addition, study abroad can be arranged on an individual basis at universities throughout the world.

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

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Chemical and Biological Engineering

DAVID W. M. MARR, Professor and Department Head
TRACY Q. GARDNER, Teaching Associate Professor and Assistant Department Head
ANTHONY M. DEAN, W.K.Coors Distinguished Professor
JOHN R. DORGAN, Professor
RONALD L. MILLER, Professor
J. DOUGLAS WAY, Professor
COLIN A. WOLDEN, Weaver Distinguished Professor
DAVID T. WU, Professor (also Chemistry)
SUMIT AGARWAL, Associate Professor
ANDREW M. HERRING, Associate Professor
CAROLYN A. KOH, Associate Professor
MATTHEW W. LIBERATORE, Associate Professor
C. MARK MAUPIN, Assistant Professor
KEITH B. NEEVES, Assistant Professor
AMADEU K. SUM, Assistant Professor
NING WU, Assistant Professor
HUGH KING, Senior Teaching Associate Professor
RACHEL MORRISH, Teaching Associate Professor
CYNTHIA NORRGRAN, Teaching Associate Professor
PAUL D. OGG, Teaching Associate Professor
JOHN M. PERSICHETTI, Teaching Associate Professor
JUDITH N. SCHOONMAKER, Teaching Associate Professor
ANGEL ABBUD-MADRID, Research Associate Professor
HANS HEINRICH-CARSTENSEN, Research Associate Professor
ROBERT M. BALDWIN, Professor Emeritus
ANNETTE L. BUNGE, Professor Emerita
JAMES F. ELY, University Professor Emeritus
JAMES H. GARY, Professor Emeritus
JOHN O. GOLDEN, Professor Emeritus
ARTHUR J. KIDNAY, Professor Emeritus
J. THOMAS MCKINNON, Professor Emeritus
E. DENDY SLOAN, JR., University Professor Emeritus
VICTOR F. YESAVAGE, Professor Emeritus

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. A student seeking the latter degree graduates as a fully-qualified Chemical Engineer with additional training in bioprocessing technologies that are of interest in renewable energy and other emerging fields.
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.

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, and oral and written technical communications skills are also stressed in this course.

Facilities for the study of chemical engineering or chemical and biochemical engineering at the Colorado School of Mines are among the best in the nation. Our modern in-house computer laboratory supports nearly 60 workstations for students to use in completing their assigned coursework. In addition, specialized undergraduate laboratory facilities exist for studying polymer properties, measuring reaction kinetics, characterizing transport phenomena, and for studying several typical chemical unit operations. Our honors undergraduate research program is open to highly qualified students and provides our undergraduates with the opportunity to carry out independent research or to join a graduate research team. This program has been highly successful and our undergraduate chemical engineering and chemical and biochemical engineering students have won several national competitions and awards based on research conducted while pursuing their baccalaureate degrees. We also have a cooperative (Co-Op) education program in which students can earn course credit while gaining work experience in industry.

Programs leading to the degree of Bachelor of Science in Chemical Engineering and to the degree of Bachelor of Science in Chemical and Biochemical Engineering are both accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology

(ABET), 111 Market Place, Suite 1050, Baltimore, MD 21202-4012, telephone (410) 347-7700.

Program Educational Objectives (Bachelor of Science in Chemical Engineering) and Bachelor of Science in Chemical and Biochemical Engineering)

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria, the Chemical and Biological Engineering Department at CSM has established 3 program educational objectives for all of its graduates and one additional objective specifically for its chemical and biochemical engineering graduates. Our graduates within 3 to 5 years of completing their degree will:

- be in graduate school or in the workforce utilizing their education in chemical engineering fundamentals including transport phenomena, reaction engineering, separations, process design and control, and associated mathematics and sciences
- be applying their knowledge of and skills in engineering fundamentals to analyze, synthesize, and evaluate systems and processes in conventional areas of chemical engineering such as energy conversion and chemical production and in contemporary and growing fields such as microelectronics and biotechnology
- have demonstrated both their commitment to continuing to develop personally and professionally and an appreciation for the ethical and social responsibilities of 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 in areas such as food science, pharmaceuticals, and renewable-energy technologies.

Combined Baccalaureate/Masters Degree Program

The Chemical and Biological Engineering Department offers the opportunity to begin work on a Master of Science (with or without thesis) degree while completing the requirements of the BS degree. These combined BS/MS degrees are designed to allow undergraduates engaged in research, or simply interested in furthering their studies beyond a BS degree, to apply their experience and interest to an advanced degree. Students may take graduate courses while completing their undergraduate degrees and count them towards their graduate degree. The requirements for the MS degree consist of the four core graduate courses (ChEN509, ChEN516, ChEN518, and ChEN568) and 18 additional credits. 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 on-line and require 3 letters of recommendation, a statement of purpose, and completion of the graduate record exam (GRE). For students who intend to begin the BS/MS program in Fall, applications are due by April 1st. The deadline is November 1st for students intending to enroll in the Spring semester. Students must have a GPA greater than 3.0 to be considered for the program. Interested students are encouraged to get more information from their advisor and/or the current faculty member in charge of Graduate Affairs.

Curriculum

The chemical engineering and chemical and biochemical engineering curricula are structured according to the goals outlined above. Accordingly, the programs of study are organized to include 3 semesters of science and general engineering fundamentals followed by 5 semesters of chemical/biochemical engineering fundamentals and applications. An optional 'track' system exists, which allows students majoring in chemical engineering to structure their electives credits into one of several specialty application areas. Courses may be categorized according to the following general system.

A. Chemical/Chemical and Biochemical Engineering Fundamentals

The following courses represent the basic knowledge component of the chemical engineering curriculum at CSM.

1. Mass and Energy Balances (ChEN201)
2. Fluid Mechanics (ChEN307)
3. Heat Transfer (ChEN308)
4. Chemical Engineering Thermodynamics (ChEN357)
5. Mass Transfer (ChEN375)
6. Transport Phenomena (ChEN430)

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:

1. Unit Operations Laboratory (ChEN312 and 313)
2. Reaction Engineering (ChEN418)
3. Process Dynamics and Control (ChEN403)
4. Chemical Engineering Design (ChEN402)
5. Bioprocess Engineering (ChEN460)
6. Chemical Engineering Technical Electives

C. Elective Tracks

Whereas Chemical and Biochemical Engineering majors have specific additional required courses to give them the biochemical engineering training they need, Chemical Engineering majors have technical electives credit requirements that may be fulfilled with several different courses. Students may elect to structure their electives into a formal Minor program of study (18 hours of coursework), an Area of Special Interest (12 hours) or a Specialty Track (9 hours). Minors and ASIs can be developed by the student in a variety of different

areas and programs as approved by the student's advisor and the heads of the relevant sponsoring academic programs. Some examples of Specialty Tracks for Chemical Engineering majors include:

Microelectronics
Bioengineering and Life Sciences
Polymers and Materials
Molecular Modeling
Environmental
Energy
Business and Economics

Details on recommended courses for Specialty Tracks can be obtained from the student's academic advisor. Alternatively, students may opt to take an assorted combination of approved courses on diverse topics to fulfill their technical electives credits.

Requirements (Chemical Engineering)

Freshman Year

Chemical Engineering students take the common core except they take Biological and Environmental Systems (BELS101) rather than Earth and Environmental Systems (SYGN101)

Sophomore Year Fall Semester	lec.	lab.	sem.hrs.
MATH213 Calculus for Scientists & Engn'rs III	4		4
PHGN200 Physics II	3.5	3	4.5
DCGN210 Introduction to Thermodynamics	3		3
CHGN221 Organic Chemistry I	3		3
CHGN223 Organic Chemistry Lab I		3	1
PAGN201 Physical Education III		2	0.5
Total			16

Sophomore Year Spring Semester	lec.	lab.	sem.hrs.
MATH225 Differential Equations	3		3
EBGN201 Principles of Economics	3		3
ChEN201 Mass and Energy Balances	3		3
ChEN202 Chemical Process Principles Lab		1	1
CHGN222 Organic Chemistry II	3		3
EPIC266* Chemical Processes Design II	2	3	3
PAGN202 Physical Education IV		2	0.5
Total			16.5

Junior Year Fall Semester	lec.	lab.	sem.hrs.
CHGN351 Physical Chemistry I	3	3	4
ChEN307 Fluid Mechanics	3		3
ChEN357 Chemical. Eng. Thermodynamics	3		3
SYGN200 Human Systems	3		3
Elective*	3		3
Total			16

Junior Year Spring Semester	lec.	lab.	sem.hrs.
ChEN358 Chemical. Eng. Thermodynamics Lab		3	1
ChEN375 Chemical Eng. Mass Transfer	3		3
ChEN308 Chemical Eng. Heat Transfer	3		3
LAIS/EBGN H&SS Elective I	3		3
Elective(s)**	3		3
Chemistry or Chemical Engineering Elective***	3		3
Total			17

Summer Session	lec.	lab.	sem.hrs.
ChEN312/313 Unit Operations Laboratory		6	6
Total			6

Senior Year Fall Semester	lec.	lab.	sem.hrs.
ChEN418 Reaction Engineering	3		3
ChEN430 Transport Phenomena	3		3
LAIS/EBGN H&SS Elective II	3		3
Electives**	6		6
Total			15

Senior Year Spring Semester	lec.	lab.	sem.hrs.
ChEN402 Chemical Engineering Design	3		3
ChEN403 Process Dynamics and Control	3		3
LAIS/EBGN H&SS Elective III	3		3
ChEN421 Engineering Economics	3		3
Elective**	3		3
Total			15

Degree total	134.5

* Certain other EPIC2xx courses can be substituted for EPIC266 with approval of the department head or assistant department head.

**Six of the electives credits must be ChEN courses, at least 3 of which must be at the 400 level.

***An additional 3 of the electives credits must be either ChGN or ChEN credits.

Requirements (Chemical and Biochemical Engineering)

Freshman Year

Chemical and Biochemical Engineering Students take the common core except they take Biological and Environmental Systems (BELS101) rather than Earth and Environmental Systems (SYGN101)

Sophomore Year Fall Semester	lec.	lab.	sem.hrs.
MATH213 Calculus for Scientists & Engn'rs III	4		4
PHGN200 Physics II	3.5	3	4.5
DCGN210 Introduction to Thermodynamics	3		3
CHGN221 Organic Chemistry I	3		3
CHGN223 Organic Chemistry Lab I		3	1
PAGN201 Physical Education III		2	0.5
Total			16

Sophomore Year Spring Semester	lec.	lab.	sem.hrs.
MATH225 Differential Equations	3		3
EBGN201 Principles of Economics	3		3
ChEN201 Mass and Energy Balances	3		3
ChEN202 Chemical Process Principles Lab		1	1
CHGN222 Organic Chemistry II	3		3
EPIC265 Biochemical Processes Design II	2	3	3
PAGN202 Physical Education IV		2	0.5
Total			16.5

Junior Year Fall Semester	lec.	lab.	sem.hrs.
CHGN351 Physical Chemistry I	3	3	4
ChEN307 Fluid Mechanics	3		3
ChEN357 Chemical. Eng. Thermodynamics	3		3
SYGN200 Human Systems	3		3
Elective	3		3
Total			16

Junior Year Spring Semester	lec.	lab.	sem.hrs.
CHGN428 Intro. Biochemistry	3		3
ChEN358 Chemical. Eng. Thermodynamics Lab		3	1
ChEN375 Chemical Eng. Mass Transfer	3		3
ChEN308 Chemical Eng. Heat Transfer	3		3
LAIS/EBGN H&SS Elective I	3		3
CHGN462 Microbiology	3		3
Total			16

Summer Session	lec.	lab.	sem.hrs.
ChEN312/313 Unit Operations Laboratory		6	6
Total			6

Senior Year Fall Semester	lec.	lab.	sem.hrs.
ChEN418 Reaction Engineering	3		3
ChEN430 Transport Phenomena	3		3
LAIS/EBGN H&SS Elective II	3		3
ChEN460 Bioprocess Engineering	3		3
ChEN461 Bioprocess Engineering Laboratory		3	1
Elective	3		3
Total			16

Senior Year Spring Semester	lec.	lab.	sem.hrs.
ChEN402 Chemical Engineering Design	3		3
ChEN403 Process Dynamics and Control	3		3
LAIS/EBGN H&SS Elective III	3		3
ChEN421 Engineering Economics	3		3
Elective	3		3
Total			15

Degree total 134.5

Description of Courses

Sophomore Year

ChEN200. COMPUTATIONAL METHODS IN CHEMICAL ENGINEERING Fundamentals of computer programming as applied to the solution of chemical engineering problems. Introduction to Visual Basic, computational methods and algorithm development. Prerequisites: MATH112 or consent of instructor. 3 hours lecture; 3 semester hours.

ChEN201. MATERIAL AND ENERGY BALANCES (II) Introduction to the principles of conservation of mass and energy. Applications to chemical processing systems. Relevant aspects of computer-aided process simulation. Corequisites: DCGN210 (or equivalent); ChEN202, MATH225 or consent of instructor. 3 hours lecture; 3 semester hours.

ChEN202. CHEMICAL PROCESS PRINCIPLES LABORATORY (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. Prerequisite: DCGN210 (or equivalent); Corequisites: ChEN201, MATH225 or consent of instructor. 3 hours laboratory; 1 credit hour.

ChEN250. INTRODUCTION TO CHEMICAL ENGINEERING ANALYSIS AND DESIGN 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 DCGN210 (or equivalent) or consent of instructor. 3 hours lecture; 3 semester hours.

ChEN272/MTGN272. PARTICULATE MATERIALS PROCESSING Summer session. Characterization and production of particles. Physical and interfacial phenomena associated with particulate processes. Applications to metal and ceramic power processing. Laboratory projects and plant visits. Prerequisites: DCGN210 (or equivalent) and PHGN200. 3 weeks; 3 semester hours.

Junior Year

ChEN307. FLUID MECHANICS (I) Theory and application of momentum transport and fluid flow in chemical engineering. Fundamentals of microscopic phenomena and application to macroscopic systems. Relevant aspects of computer-aided process simulation. Prerequisites: MATH225, grade of C or better in ChEN201. 3 hours lecture; 3 semester hours.

ChEN308. HEAT TRANSFER (II) Theory and applications of energy transport: conduction, convection and radiation. Fundamentals of microscopic phenomena and application to macroscopic systems. Relevant aspects of computer-aided process simulation. Prerequisites: MATH225, grade of C or better in ChEN307. 3 hours lecture; 3 semester hours.

ChEN311/MTGN311. STRUCTURE OF MATERIALS Principles of crystallography and crystal chemistry. Characterization of crystalline materials using X-ray diffraction techniques. Applications to include compound identification, lattice parameter measurement, orientation of single crystals and crystal structure determination. Laboratory experiments to supplement the lectures. Prerequisite: PHGN200.

ChEN312/313. UNIT OPERATIONS LABORATORY (S) (WI) Principles of mass, energy, and momentum transport as applied to laboratory-scale processing equipment. Written and oral communications skills. Aspects of group dynamics, teamwork, and critical thinking. Prerequisites: ChEN201, ChEN307, ChEN308, ChEN357, and ChEN375. 6 hours lab; 6 semester hours.

ChEN334/MTGN334. CHEMICAL PROCESSING OF MATERIALS 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. This general formalism provides for a transferable knowledge-base to other systems not specifically covered in the course. Prerequisite: ChEN357. 3 hours lecture; 3 semester hours.

ChEN340. COOPERATIVE EDUCATION Cooperative work/education experience involving employment of a chemical engineering nature in an internship spanning at least one academic semester. Prerequisites: consent of instructor and department head. 1 to 3 semester hours. Repeatable to a maximum of 6 hours.

ChEN350. HONORS UNDERGRADUATE RESEARCH Scholarly research of an independent nature. Prerequisites: junior standing, consent of instructor and department head. 1 to 3 semester hours.

ChEN351. HONORS UNDERGRADUATE RESEARCH Scholarly research of an independent nature. Prerequisites: junior standing, consent of instructor and department head. 1 to 3 semester hours.

ChEN357. CHEMICAL ENGINEERING THERMODYNAMICS (I) Fundamentals of thermodynamics for application to chemical engineering processes and systems. Phase and reaction equilibria. Relevant aspects of computer-aided process simulation. Integrated laboratory experiments. Prerequisites: DCGN210 (or equivalent), MATH225, grade of C or better in ChEN201. 3 hours lecture; 3 semester hours.

ChEN348/MTGN348. MICROSTRUCTURAL DEVELOPMENT (WI) Introduction to the relationships between microstructure and properties of materials, with emphasis on metals. Fundamentals of imperfections in crystalline materials, phase equilibria, recrystallization and grain growth, strengthening mechanisms, and phase transformations. Laboratory sessions devoted to experiments illustrating the fundamentals presented in the lectures. Prerequisites: MTGN311 and ChEN357. 3 hours lecture; 3 hours lab; 4 semester hours.

ChEN358. CHEMICAL ENGINEERING THERMODYNAMICS LABORATORY Laboratory measurement, calculation and analysis of physical properties, phase equilibria and reaction equilibria and their application to chemical engineering. Relevant aspects of computer-aided simulation. Prerequisites: DCGN210 (or equivalent), ChEN201, MATH225. 3 hours laboratory; 1 semester hour.

ChEN375. MASS TRANSFER (II) Fundamentals of stagewise and diffusional mass transport with applications to chemical engineering systems and processes. Relevant aspects of computer-aided process simulation. Prerequisite: grade of C or better in ChEN357. 3 hours lecture; 3 semester hours.

ChEN398. SPECIAL TOPICS IN CHEMICAL ENGINEERING Topical courses in chemical engineering of special interest. Prerequisite: consent of instructor. 1 to 6 semester hours. Repeatable for credit under different titles.

ChEN399. INDEPENDENT STUDY Individual research or special problem projects. Topics, content, and credit hours to be agreed upon by student and supervising faculty member. Prerequisite: consent of instructor and department head, submission of "Independent Study" form to CSM Registrar. 1 to 6 semester hours. Repeatable for credit.

Senior Year

ChEN402. CHEMICAL ENGINEERING DESIGN (II) (WI) Advanced computer-aided process simulation and process optimization. Prerequisites: ChEN307, ChEN308, ChEN357, and ChEN375. Corequisites: ChEN418 and ChEN421. 3 hours lecture; 3 semester hours.

ChEN403. PROCESS DYNAMICS AND CONTROL (II) Mathematical modeling and analysis of transient systems. Applications of control theory to response of dynamic chemical engineering systems and processes. Prerequisites: ChEN201, ChEN307, ChEN308, and ChEN375. 3 hours lecture; 3 semester hours.

ChEN408. NATURAL GAS PROCESSING (II) Application of chemical engineering principles to the processing of natural gas. Emphasis on using thermodynamics and mass transfer operations to analyze existing plants. Relevant aspects of computer-aided process simulation. Prerequisites: CHGN221, ChEN201, ChEN307, ChEN308, ChEN375, or consent of instructor. 3 hours lecture; 3 semester hours.

ChEN409. PETROLEUM PROCESSES (I) Application of chemical engineering principles to petroleum refining. Thermodynamics and reaction engineering of complex hydrocarbon systems. Relevant aspects of computer-aided process simulation for complex mixtures. Prerequisites: CHGN221, ChEN201, ChEN357, and ChEN375, or consent of instructor. 3 hours lecture; 3 semester hours.

ChEN415/CHGN430/MLGN530. POLYMER SCIENCE AND TECHNOLOGY 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. Prerequisites: CHGN221, MATH225, ChEN201, ChEN357, or consent of instructor. 3 hours lecture; 3 semester hours.

ChEN416. POLYMER ENGINEERING AND TECHNOLOGY 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. Prerequisites: ChEN201, ChEN307, and MATH225, or consent of instructor. 3 hours lecture; 3 semester hours.

ChEN418. REACTION ENGINEERING (I) (WI) Applications of the fundamentals of thermodynamics, physical chemistry, and organic chemistry to the engineering of reactive processes. Reactor design; acquisition and analysis of

rate data; heterogeneous catalysis. Relevant aspects of computer-aided process simulation. Prerequisites: ChEN201, ChEN307, ChEN308, ChEN357, MATH225, CHGN221 and CHGN351. 3 hours lecture; 3 semester hours.

ChEN420. MATHEMATICAL METHODS IN CHEMICAL ENGINEERING 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. Prerequisites: MATH225, DCGN210 (or equivalent), ChEN307, and ChEN357, or consent of instructor. 3 hours lecture; 3 semester hours.

ChEN421/EBGN321. ENGINEERING ECONOMICS Economic analysis of engineering processes and systems. Interest, annuity, present value, depreciation, cost accounting, investment accounting and financing of engineering enterprises along with taxation, market evaluation and break-even analysis. Prerequisite: consent of instructor. 3 hours lecture; 3 semester hours.

ChEN430. TRANSPORT PHENOMENA (I) Theory and chemical engineering applications of momentum, heat, and mass transfer. Set up and solution of problems involving equations of motion and energy. Prerequisites: ChEN307, ChEN308 ChEN357, ChEN375 and MATH225. 3 hours lecture; 3 semester hours.

ChEN435/PHGN435. INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY (II) Application of science and engineering principles to the design, fabrication, and testing of microelectronic devices. Emphasis on specific unit operations and the interrelation among processing steps. Prerequisites: Senior standing in PHGN, ChEN, MTGN, or EGGN, and consent of instructor. Due to lab space the enrollment is limited to 20 students. 1.5 hours lecture, 4 hours lab; 3 semester hours.

ChEN440. MOLECULAR PERSPECTIVES IN CHEMICAL ENGINEERING 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. Prerequisites: ChEN 201, ChEN307, ChEN308, ChEN357, ChEN375, CHGN351 and 353, CHGN221 and 222, and MATH225, or consent of instructor. 3 hours lecture; 3 semester hours.

ChEN450. HONORS UNDERGRADUATE RESEARCH Scholarly research of an independent nature. Prerequisites: senior standing, consent of instructor and department head. 1 to 3 semester hours.

ChEN451. HONORS UNDERGRADUATE RESEARCH Scholarly research of an independent nature. Prerequisites: senior standing, consent of instructor and department head. 1 to 3 semester hours.

ChEN460. BIOPROCESS ENGINEERING (I) The analysis and design of biochemical unit operations and processes used in conjunction with bioreactors are investigated in this course. Industrial enzyme technologies are developed and explored. A strong focus is on the basic processes for producing bioethanol and biodiesel. Biochemical systems for organic oxidation and fermentation and inorganic oxidation and reduction will be presented. Prerequisites: ChEN201, ChEN357, ChEN375, CHGN428, and CHGN462. 3 hours lecture; 3 semester hours.

ChEN461. BIOCHEMICAL ENGINEERING LABORATORY (I) The measurement, calculation and analysis of processes including separations and reaction equilibria and their application to biochemical engineering. Relevant aspects of computer-aided process simulation. Prerequisites: ChEN201, ChEN357, ChEN375, CHGN428 and CHGN462. Corequisite: ChEN460. 1 credit hour; 3 hours laboratory.

ChEN470/BELS470. INTRODUCTION TO MICROFLUIDICS (I) This course introduces the basic principles and applications of microfluidic systems. Concepts related to microscale fluid mechanics, transport, physics, and biology are presented. To gain familiarity with small-scale systems, students are provided with the opportunity to design, fabricate, and test a simple microfluidic device. Prerequisites: ChEN201, ChEN307 and DCGN210 (or equivalent) or permission of instructor. 3 semester hours.

ChEN480. NATURAL GAS HYDRATES The purpose of this class is to learn about clathrate hydrates, using two of E.D. Sloan's books, (1) Clathrate Hydrates of Natural Gases, Third Edition (2008) co-authored by C.A.Koh, and (2) Hydrate Engineering, (2000). Using a basis of these books, and accompanying programs, we have abundant resources to act as professionals who are always learning. 3 hours lecture; 3 semester hours.

ChEN497. SUMMER PROGRAMS

ChEN498. SPECIAL TOPICS IN CHEMICAL ENGINEERING Topical courses in chemical engineering of special interest. Prerequisite: consent of instructor; 1 to 6 semester hours. Repeatable for credit under different titles.

ChEN499. INDEPENDENT STUDY Individual research or special problem projects. Topics, content, and credit hours to be agreed upon by student and supervising faculty member. Prerequisite: consent of instructor and department head, submission of "Independent Study" form to CSM Registrar. 1 to 6 semester hours. Repeatable for credit.

Chemistry and Geochemistry

DANIEL M. KNAUSS, Professor and Department Head
MARK E. EBERHART, Professor
KENT J. VOORHEES, Professor
DAVID T. WU, Professor (also Chemical Engineering)
STEPHEN G. BOYES, Associate Professor
SCOTT W. COWLEY, Associate Professor
JAMES F. RANVILLE, Associate Professor
RYAN RICHARDS, Associate Professor
E. CRAIG SIMMONS, Associate Professor
BETTINA M. VOELKER, Associate Professor
KIM R. WILLIAMS, Associate Professor
MATTHEW C. POSEWITZ, Assistant Professor
YONGAN YANG, Assistant Professor
MARK SEGER, Teaching Associate Professor
ROBERT RACICOT, Teaching Associate Professor
ED A. DEMPSEY, Teaching Assistant Professor
YUAN YANG, Research Assistant Professor
RAMON E. BISQUE, Professor Emeritus
STEPHEN R. DANIEL, Professor Emeritus
DEAN W. DICKERHOOF, Professor Emeritus
KENNETH W. EDWARDS, Professor Emeritus
GEORGE H. KENNEDY, Professor Emeritus
RONALD W. KLUSMAN, Professor Emeritus
DONALD LANGMUIR, Professor Emeritus
GEORGE B. LUCAS, Professor Emeritus
DONALD L. MACALADY, Professor Emeritus
PATRICK MACCARTHY, Emeritus Professor
MICHAEL J. PAVELICH, Professor Emeritus
THOMAS R. WILDEMAN, Professor Emeritus
JOHN T. WILLIAMS, Professor Emeritus
ROBERT D. WITTERS, Professor Emeritus

Program Description

Chemistry is the field of science associated with atoms and molecules. It focuses on the behavior and properties of matter, the relationship of energy with the bond-forming and bond-breaking reactions 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 broken into more focused disciplines, including organic chemistry, inorganic chemistry, theoretical chemistry, computational chemistry, biochemistry, physical chemistry, materials chemistry, and analytical 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, computing, energy, agriculture, and biotechnology.

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 minerals, energy, materials, 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 students' individual career goals. Those aspiring to enter Ph.D. programs in chemistry are encouraged to include undergraduate research beyond the minimum required among their elective hours. Others interested in industrial chemistry choose area of special interest courses in chemical engineering or metallurgy, for example. 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.

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 (Schroedinger 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), spectroscopy (dipole selection rules, rotational spectra, term symbols, atomic and molecular electronic spectra, magnetic spectroscopy, Raman spectroscopy, multiphoton selection rules, lasers), statistical thermodynamics (ensembles, partition functions, Einstein crystals, Debye crystals), group theory, surface chemistry, X-ray crystallography, electron diffraction, dielectric constants, dipole moments, and elements of computational chemistry.

Laboratory and communication skills

- Analytical methods - gravimetry, titrimetry, sample dissolution, quantitative spectroscopy, GC, HPLC, GC/MS, potentiometry, NMR, AA, ICP-AES
- Synthesis techniques - batch reactor assembly, inert-atmosphere manipulations, vacuum line methods, high-temperature methods, high-pressure methods, distillation, recrystallization, extraction, sublimation, chromatographic purification, product identification
- Physical measurements - refractometry, viscometry, colligative properties, FTIR, NMR
- Information retrieval - Chemical Abstracts on-line 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

Degree Requirements (Chemistry Track)

The B.S. curricula in chemistry are outlined below.

Sophomore Year Fall Semester	lec.	lab.	sem.hrs.
MATH213 Calculus for Scientists & Engn'rs III	4		4
PHGN200 Physics II	2	4	4.5
DCGN209 Introduction to Thermodynamics	3		3
CHGN221 Organic Chemistry I	3		3
CHGN223 Organic Chemistry I Lab	3	1	1
PAGN201 Physical Education III	2		0.5
Total			16

Sophomore Year Spring Semester	lec.	lab.	sem.hrs.
SYGN200 Human Systems	3		3
EBGN201 Principles of Economics	3		3
CHGN222 Organic Chemistry II	3		3
CHGN224 Organic Chemistry II Lab	3	1	1
MATH225 Differential Equations	3		3
CHGN335 Instrumental Analysis	3		3
PAGN202 Physical Education IV		2	0.5
Total			16.5

Junior Year Fall Semester	lec.	lab.	sem.hrs.
CHGN336 Analytical Chemistry	3		3
CHGN337 Analytical Chemistry Laboratory		3	1
CHGN341 Descriptive Inorganic Chemistry	3		3
CHGN351 Physical Chemistry I	3	3	4
CHGN395 Introduction to Undergraduate Research		3	1
LAIS/EBGN H&SS GenEd Restricted Elective I	3		3
Free elective	3		3
Total			18

Junior Year Spring Semester	lec.	lab.	sem.hrs.
CHGN353 Physical Chemistry II	3	3	4
CHGN323 Qualitative Organic Analysis	1	3	2
CHGN428 Biochemistry I	3		3
Technical Elective	3		3
Technical Elective	3		3
Total			15

Junior-Senior Year Summer Session	lec.	lab.	sem.hrs.
CHGN490 Synthesis & Characterization		18	6
Total			6

Senior Year Fall Semester	lec.	lab.	sem.hrs.
CHGN495 Research		9	3
LAIS/EBGN H&SS GenEd Restricted Elective II	3		3
Technical elective	3		3
Technical elective	3		3
Free elective	3		3
Total			15

Senior Year Spring Semester	lec.	lab.	sem.hrs.
CHGN495 Undergraduate Research		6	2
LAIS/EBGN H&SS GenEd Restricted Elective III	3		3
CHGN401 Theoretical Inorganic Chem.	3		3
Technical elective	3		3
Free elective	3		3
Total			14

Degree Total	133.5

Technical Electives are courses in any technical field. Examples of possible electives that will be recommended to students are: SYGN202; SYGN203; ChEN201; PHGN300; EBGN305, EBGN306, EBGN310, EBGN311, EBGN312;,BELS301/ESGN301, BELS302/ESGN302; ESGN353; GEGN206; GEOL 311; MATH323; MATH332 MNGN210; MTGN311; PEGN102; PHGN419; CHGN430; CHGN462

Environmental Chemistry Track

Sophomore Year Fall Semester	lec.	lab.	sem.hrs.
MATH213 Calculus for Scientists & Engn'rs III	4		4
PHGN200 Physics II	2	4	4.5
DCGN209 Introduction to Thermodynamics	3		3
CHGN221 Organic Chemistry I	3		3
CHGN223 Organic Chemistry I Lab		3	1
PAGN201 Physical Education III		2	0.5
Total			16

Sophomore Year Spring Semester	lec.	lab.	sem.hrs.
SYGN200 Human Systems	3		3
EBGN201 Principles of Economics	3		3
CHGN222 Organic Chemistry II	3		3
CHGN224 Organic Chemistry II Lab	3	1	1
MATH225 Differential Equations	3		3
CHGN335 Instrumental Analysis	3		3
PAGN202 Physical Education IV	2		0.5
Total			16.5

Junior Year Fall Semester	lec.	lab.	sem.hrs.
CHGN336 Analytical Chemistry	3		3
CHGN337 Analytical Chemistry Laboratory	3	1	1
CHGN341 Descriptive Inorganic Chemistry	3		3
CHGN351 Physical Chemistry I	3	3	4
CHGN395 Introduction to Undergraduate Research	3	1	1
LAIS/EBGN H&SS GenEd Restricted Elective I	3		3
Environmental Elective	3		3
Total			18

Junior Year Spring Semester	lec.	lab.	sem.hrs.
CHGN353 Physical Chemistry II	3	3	4
CHGN323 Qualitative Organic Analysis	1	3	2
CHGN428 Biochemistry I	3		3
Environmental Elective	3		3
Technical Elective	3		3
Total			15

Junior-Senior Year Summer Session	lec.	lab.	sem.hrs.
CHGN490 Synthesis & Characterization		18	6
Total			6

Senior Year Fall Semester	lec.	lab.	sem.hrs.
CHGN495 Research		9	3
Environmental Elective	3		3
Environmental Elective	3		3
LAIS/EBGN H&SS GenEd Restricted Elective II	3		3
Free elective	3		3
Total			15

Senior Year Spring Semester	lec.	lab.	sem.hrs.
CHGN495 Undergraduate Research		6	2
CHGN410 Surface Chemistry	3		3
LAIS/EBGN H&SS GenEd Restricted Elective III	3		3
CHGN403 Environmental Chemistry	3		3
Free elective	3		3
Total			14

Degree Total	133.5

Biochemistry Track

Sophomore Year Fall Semester	lec.	lab.	sem.hrs.
MATH213 Calculus for Scientists & Engn'rs III	4		4
PHGN200 Physics II	2	4	4.5
DCGN209 Introduction to Thermodynamics	3		3
CHGN221 Organic Chemistry I	3		3
CHGN223 Organic Chemistry I Lab	3	1	1
PAGN201 Physical Education III	2		0.5
Total			16

Sophomore Year Spring Semester	lec.	lab.	sem.hrs.
SYGN200 Human Systems	3		3
EBGN201 Principles of Economics	3		3
CHGN222 Organic Chemistry II	3		3
CHGN224 Organic Chemistry II Lab		3	1
MATH225 Differential Equations	3		3
CHGN335 Instrumental Analysis	3		3
PAGN202 Physical Education IV	2		0.5
Total			16.5

Junior Year Fall Semester	lec.	lab.	sem.hrs.
BELS301 General Biology I	3		3
BELS311 General Biology I Lab	3	1	1
CHGN336 Analytical Chemistry	3		3
CHGN337 Analytical Chemistry Laboratory		3	1
CHGN341 Descriptive Inorganic Chemistry	3		3
CHGN351 Physical Chemistry I	3	4	4
CHGN395 Introduction to Undergraduate Research		3	1
Total			16

Junior Year Spring Semester	lec.	lab.	sem.hrs.
CHGN353 Physical Chemistry II	3	3	4
CHGN323 Qualitative Organic Analysis	1	3	2
CHGN428 Biochemistry I	3		3
BELS303 General Biology II	3		3
BELS313 General Biology II Lab	3	1	1
LAIS/EBGN H&SS GenEd Restricted Elective I	3		3
Total			16

Junior-Senior Year Summer Session	lec.	lab.	sem.hrs.
CHGN490 Synthesis & Characterization		18	6
Total			6

Senior Year Fall Semester	lec.	lab.	sem.hrs.
CHGN429 Biochemistry II	3		3
CHGN495 Undergraduate Research		9	3
LAIS/EBGN H&SS GenEd Restricted Elective II	3		3
Technical Elective	3		3
Free elective	3		3
Total			15

Senior Year Spring Semester	lec.	lab.	sem.hrs.
CHGN495 Undergraduate Research		6	2
LAIS/EBGN H&SS GenEd Restricted Elective III	3		3
CHGN401 Theoretical Inorganic Chem.	3		3
Free elective	3		3
Free elective	3		3
Total			14

Degree Total	132.5

Possible technical electives that will be recommended to students are: CHGN403, CHGN462, BELS 321, BELS402, BELS404

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 CHGC 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.

Description of Courses

CHGN111. INTRODUCTORY CHEMISTRY (S) Introductory college chemistry. Elementary atomic structure and the periodic chart, chemical bonding, chemical bonding, chemical reactions and stoichiometry of chemi cal 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 (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 (I, II, S) Continuation of CHGN121 concentrating on chemical kinetics, thermodynamics, electrochemistry, organic nomenclature, and chemical equilibrium (acid- base, solubility, complexation, and redox). Laboratory experiments emphasizing quantitative chemical measurements. Prerequisite: Grade of C or better in CHGN121. 3 hours lecture; 3 hours lab, 4 semester hours.

CHGN198. SPECIAL TOPICS IN CHEMISTRY (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.

CHGN199. INDEPENDENT STUDY (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.

CHGN221. ORGANIC CHEMISTRY I (I, S) Structure, properties, and reactions of the important classes of organic compounds, introduction to reaction mechanisms. Prerequisites: Grade of C or better in CHGN122. 3 hours lecture; 3 semester hours.

CHGN222. ORGANIC CHEMISTRY II (II, S) Continuation of CHGN221. Prerequisites: Grade of C or better in CHGN221. 3 hours lecture; 3 semester hours.

CHGN223. ORGANIC CHEMISTRY I LABORATORY (I,II) 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 (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 IN CHEMISTRY (I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CHGN299. INDEPENDENT STUDY (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 (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 (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 both CHGN122 and DCGN209 or DCGN210, MATH112. 3 hours lecture; 3 semester hours.

CHGN336. ANALYTICAL CHEMISTRY (I) Theory and techniques of gravimetry, titrimetry (acid-base, complexometric, redox, precipitation), electrochemical analysis, chemical separations; statistical evaluation of data. Prerequisite: Grade of C or better in both CHGN122 and DCGN209 or DCGN210. 3 hours lecture; 3 semester hours.

CHGN337. ANALYTICAL CHEMISTRY LABORATORY (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 (I, II, S) Supervised, full-time, chemistry-related employment for a continuous six-month period (or its equivalent) in which specific educational objectives are achieved. Prerequisite: Second semester sophomore status and a cumulative grade-point average of at least 2.00. 0 to 3 semester hours. Cooperative Education credit does not count toward graduation except under special conditions.

CHGN341. DESCRIPTIVE INORGANIC CHEMISTRY (I) The chemistry of the elements and periodic trends in reactivity discussed in relation to the preparation and use of inorganic chemicals in industry and the environment. Prerequisite: Grade of C or better in both CHGN222 and DCGN209. 3 hours lecture; 3 semester hours.

CHGN351. PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE I (I) A study of chemical systems from a molecular physical chemistry perspective. Includes an introduction to quantum mechanics, atoms and molecules, spectroscopy, bonding and symmetry, and an introduction to modern computational chemistry. Prerequisite: MATH225; PHGN200; Grade of C or better in both CHGN 122 and DCGN 209 or DCGN 210. 3 hours lecture; 3 hours laboratory; 4 semester hours.

CHGN353. PHYSICAL CHEMISTRY: A MOLECULAR PERSPECTIVE II (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 (I) (WI) Introduction to Undergraduate Research is designed to prepare students to pursue their senior research projects prior to enrollment in CHGN495 (Undergraduate Research). Students will attend lectures and research presentations, the student, in consultation with their research advisor, will select a research area, perform literature research, design a research project and prepare a research proposal. Prerequisites: Completion of the chemistry curriculum through the Spring semester of the sophomore year or permission of the department head. Credit: 1 semester hour.

CHGN398. SPECIAL TOPICS IN CHEMISTRY (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.

CHGN399. INDEPENDENT STUDY (I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

CHGN401. THEORETICAL INORGANIC CHEMISTRY (II) Periodic properties of the elements. Bonding in ionic and metallic crystals. Acid-base theories. Inorganic stereochemistry. Nonaqueous solvents. Coordination chemistry and ligand field theory. Prerequisite: CHGN341 or consent of instructor. 3 hours lecture; 3 semester hours.

CHGN402. BONDING THEORY AND SYMMETRY (II) Introduction to valence bond and molecular orbital theories, symmetry; introduction to group theory; applications of

group theory and symmetry concepts to molecular orbital and ligand field theories. Prerequisite: CHGN341 or consent of instructor. 3 hours lecture; 3 semester hours.

CHGN403/ESGN403. INTRODUCTION TO ENVIRONMENTAL CHEMISTRY (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: SYGN101, DCGN209, CHGN222. 3 hours lecture; 3 semester hours.

CHGN410/MLGN510. SURFACE CHEMISTRY (II) Introduction to colloid systems, capillarity, surface tension and contact angle, adsorption from solution, micelles and microemulsions, the solid/gas interface, surface analytical techniques, van der Waal forces, electrical properties and colloid stability, some specific colloid systems (clays, foams and emulsions). Students enrolled for graduate credit in MLGN510 must complete a special project. Prerequisite: DCGN209 or consent of instructor. 3 hours lecture; 3 semester hours.

CHGN422. POLYMER CHEMISTRY LABORATORY (I) Prerequisites: CHGN221, CHGN223. 3 hours lab; 1 semester hour.

CHGN428. BIOCHEMISTRY I (II) Introductory study of the major molecules of biochemistry-amino acids, proteins, enzymes, nucleic acids, lipids, and saccharides- their structure, chemistry, biological function, and biosynthesis. Stresses bioenergetics and the cell as a biological unit of organization. Discussion of classical genetics, molecular genetics, and protein synthesis. Prerequisite: CHGN222 or permission of instructor. 3 hours lecture; 3 semester hours.

CHGN429. BIOCHEMISTRY II (I) A continuation of CHGN428. Topics include: nucleotide synthesis; DNA repair, replication and recombination; transcription, translation and regulation; proteomics; lipid and amino acid synthesis; protein target and degradation; membranes; receptors and signal transduction. Prerequisites: CHGN428 or permission of instructor. 3 hours lecture; 3 semester hours.

CHGN430/CHEN415/MLGN530. INTRODUCTION TO POLYMER SCIENCE (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 or permission of instructor. 3 hour lecture, 3 semester hours.

CHGN462/CHGC562/ESGN580. MICROBIOLOGY AND THE ENVIRONMENT (II) This course will cover the basic fundamentals of microbiology, such as structure and function of procaryotic versus eucaryotic cells; viruses; classification of micro-organisms; microbial metabolism, energetics, genetics, growth and diversity, microbial interactions with plants, animals, and other microbes. Additional topics covered will include various aspects of environmental microbiology such as global biogeochemical cycles, bioleaching, bioremediation, and wastewater treatment. Prerequisite: Consent of instructor 3 hours lecture, 3 semester hours.

CHGN475. COMPUTATIONAL CHEMISTRY (II) This class provides a survey of techniques of computational chemistry, including quantum mechanics (both Hartree-Fock and density functional approaches) and molecular dynamics. Emphasis is given to the integration of these techniques with experimental programs of molecular design and development. Prerequisites: CHGN351, CHGN401. 3 hours lecture; 3 semester hours.

CHGN490. SYNTHESIS AND CHARACTERIZATION (WI) Advanced methods of organic and inorganic synthesis; high-temperature, high-pressure, inert-atmosphere, vacuum-line, and electrolytic methods. Prerequisites: CHGN323, CHGN341. 6-week summer session; 6 semester hours.

CHGN495. UNDERGRADUATE RESEARCH (I, II, S) (WI) Individual research project under direction of a member of the Departmental faculty. Prerequisites: selection of a research topic and advisor, preparation and approval of a research proposal, completion of chemistry curriculum through the junior year or permission of the department head. Variable credit; 1 to 5 credit hours. Repeatable for credit.

CHGN496. SUMMER PROGRAMS

CHGN497. INTERNSHIP (I, II, S) Individual internship experience with an industrial, academic, or governmental host supervised by a Departmental faculty member. Prerequisites: Completion of chemistry curriculum through the junior year or permission of the department head. Variable credit; 1 to 6 credit hours.

CHGN498. SPECIAL TOPICS IN CHEMISTRY (I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CHGN499. INDEPENDENT STUDY (I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Economics and Business

RODERICK G. EGGERT, Professor and Division Director
JOHN T. CUDDINGTON, William J. Coulter Professor
CAROL A. DAHL, Professor
GRAHAM A. DAVIS, Professor
MICHAEL R. WALLS, Professor
EDWARD J. BALISTRERI, Associate Professor
MICHAEL B. HEELEY, Associate Professor
ALEXANDRA M. NEWMAN, Associate Professor
DANIEL KAFFINE, Assistant Professor
STEFFEN REBENNACK, Assistant Professor
JOY M. GODESIABOIS, Teaching Associate Professor
SCOTT HOUSER, Teaching Associate Professor
JOHN M. STERMOLE, Teaching Associate Professor
ANN DOZORETZ, Teaching Assistant Professor
FRANKLIN J. STERMOLE, Professor Emeritus
JOHN E. TILTON, University Emeritus Professor
ROBERT E. D. WOOLSEY, Professor Emeritus

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 CSM 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:

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

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

Sophomore Year Fall Semester	lec.	lab.	sem.hrs.
EBGN201 Principles of Economics	3		3
Distributed Science III			3-4.5
MATH213 Calc. for Scientists & Engineers III	4		4
PAGN201 Physical Education III	2		0.5
Free Elective	3		3
Total			15

Sophomore Year Spring Semester	lec.	lab.	sem.hrs.
EBGN301 Intermediate Microeconomics	3		3
MATH323 Probability and Statistics	3		3
MATH225 Differential Equations	3		3
SYGN200 Human Systems	3		3
PAGN202 Physical Education IV	2		0.5
Free Electives	3		3
Total			15.5

Junior Year Fall Semester	lec.	lab.	sem.hrs.
EBGN302 Intermediate Macroeconomics	3		3
EBGN325 Operations Research Methods	3		3
EBGN Elective I*	3		3
EBGN Elective II*	3		3
MATH332 Linear Algebra or MATH348 Advanced Engineering Math	3		3
LAIS/EBGN H&SS GenEd Restricted Elective I	3		3
Total			18

Junior Year Spring Semester	lec.	lab.	sem.hrs.
EBGN303 Econometrics	3		3
EBGN321 Engineering Economics	3		3
EBGN409 Math Econ.** or			
EBGN Elective III*	3		3
LAIS/EBGN H&SS GenEd Restricted Elective II	3		3
Free Elective	3		3
Total			15

Summer Session	lec.	lab.	sem.hrs.
EBGN403 Field Session	3		3
Total			3

Senior Year Fall Semester	lec.	lab.	sem.hrs.
EBGN404 Adv. Micro Topics	3		3
EBGN405 Adv. Macro Topics	3		3
EBGN455 Linear. Prog'** or EBGN Elective III	3		3
LAIS/EBGN H&SS GenEd Restricted Elective III	3		3
Free Elective	3		3
Total			15

Senior Year Spring Semester	lec.	lab.	sem.hrs.
EBGN Elective IV*	3		3
EBGN Elective V*	3		3
EBGN Elective VI*	3		3
Free Electives	6		6
Total			15

Degree Total	129.5

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

**Students must take either EBGN409 or EBGN455.

Minor Program in Economics and Business

The minor in Economics requires that students complete 6 economics courses, for a total of 18 credit hours. Minors are required to take Principles of Economics (EBGN201) and either Intermediate Microeconomics (EBGN301) or Intermediate Macroeconomics (EBGN302). Students must complete 4 additional courses from the lists below. Students may choose courses from either the economics focus or the business focus list (or both). Regardless of their course selection, the minor remains "Economics and Business." Economics courses taken as part of the Humanities and Social Sciences electives can be counted toward the minor.

Area of Special Interest in Economics and Business

The area of special interest in Economics and Business requires that students complete Principles of Economics (EBGN201) and 3 other courses in economics and business chosen from the lists below, for a total of 12 credit hours. Economics courses taken as part of the Humanities and Social Sciences electives can be counted toward the area of special interest.

Economics Focus

EBGN301 Intermediate Microeconomics
EBGN302 Intermediate Macroeconomics
EBGN303 Econometrics
EBGN310 Environmental and Resource Economics
EBGN315 Business Strategy
EBGN320 Economics and Technology
EBGN330 Energy Economics
EBGN340 Energy and Environmental Policy
EBGN342 Economic Development
EBGN398 Special Topics
EBGN404 Advanced Micro Topics
EBGN405 Advanced Macro Topics
EBGN409 Mathematical Economics
EBGN437 Regional Economics
EBGN441 International Economics
EBGN443 Public Economics
EBGN470 Environmental Economics
EBGN495 Economic Forecasting
EBGN498 Special Topics

Business Focus

EBGN304 Personal Finance
EBGN305 Financial Accounting
EBGN306 Managerial Accounting
EBGN314 Principles of Management
EBGN321 Engineering Economics
EBGN325 Operations Research
EBGN345 Corporate Finance
EBGN398 Special Topics
EBGN452 Nonlinear Programming
EBGN455 Linear Programming
EBGN456 Network Models
EBGN457 Integer Programming
EBGN459 Supply Chain Management
EBGN461 Stochastic Models in Management Science
EBGN474 Inventing, Patenting and Licensing
EBGN498 Special Topics

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
CSCI406 Algorithms
MATH406 Algorithms

CSCI404 Artificial Intelligence
EBGN452 Nonlinear Programming
EBGN455 Linear Programming
EBGN456 Network Models
EBGN457 Integer Programming
EGGN307 Introduction to Feedback Control
MATH332 Linear Algebra
EGGN417 Modern Control Design
EGGN502 Interdisciplinary Modeling and Simulation

Stochastic Modeling (minimum of one)
EBGN459 Supply Chain Management
EBGN461 Stochastic Modeling in Management Science
EBGN528 Industrial Systems Simulation
EBGN560 Decision Analysis
MATH424 Introduction to Applied Statistics
MATH438 Stochastic Models
MNGN438 Geostatistics
PEGN438 Geostatistics
MTGN450 Statistical Process Control and Design of Experiments

Survey Course (Maximum of one)
EBGN325 Operations Research
EGGN498 Engineering Design Optimization
MNGN433 Mine Systems Analysis

Description of Courses

Freshman Year
EBGN198. SPECIAL TOPICS IN ECONOMICS AND BUSINESS (I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EBGN199. INDEPENDENT STUDY (I, II) Individual research or special problem projects supervised by a faculty member. 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.

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

EBGN298. SPECIAL TOPICS IN ECONOMICS AND BUSINESS (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 permission. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EBGN299. INDEPENDENT STUDY (I, II) Individual research or special problem projects supervised by a faculty member. 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.

Junior Year
EBGN301. INTERMEDIATE MICROECONOMICS-(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-(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 (II) (WI) Introduction to econometrics, including ordinary least-squares and single-equation models; two-stage least-squares and multiple-equation models; specification error, serial correlation, heteroskedasticity, and other problems; distributive-lag models and other extensions, hypothesis testing and forecasting applications. Prerequisites: EBGN201 and MATH323. 3 hours lecture; 3 semester hours.

EBGN304. PERSONAL FINANCE (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 (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. 3 hours lecture; 3 semester hours.

EBGN306. MANAGERIAL ACCOUNTING (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: EBGN305. 3 hours lecture; 3 semester hours.

EBGN310. ENVIRONMENTAL AND RESOURCE ECONOMICS (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 (II) Introduction of underlying principles, fundamentals, and knowledge required of the manager in a complex, modern organization. 3 hours lecture; 3 semester hours.

EBGN315. BUSINESS STRATEGY (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 (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/CHEN421. ENGINEERING ECONOMICS (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. 3 hours lecture; 3 semester hours.

EBGN325. OPERATIONS RESEARCH (I) This survey course introduces fundamental operations research techniques in the optimization areas of linear programming, network models (i.e., maximum flow, shortest part, 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, MATH112. 3 hours lecture; 3 semester hours.

EBGN330. ENERGY ECONOMICS (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 (I) 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. Prerequisite: EBGN201. 3 hours lecture; 3 semester hours.

EBGN342. ECONOMIC DEVELOPMENT (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 (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: EBGN305. 3 hours lecture; 3 semester hours.

EBGN398. SPECIAL TOPICS IN ECONOMICS AND BUSINESS (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 permission. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EBGN399. INDEPENDENT STUDY (I, II) Individual research or special problem projects supervised by a faculty

member. 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.

Senior Year

EBGN403. FIELD SESSION (S) (WI) An applied course for students majoring in economics. The field session may consist of either participation in a computer simulation or an independent research project under the supervision of a faculty member. In the computer simulation, students work as part of the senior executive team of a company and are responsible for developing and executing a strategy for their company with on-going decisions on everything from new product development, to marketing, to finance and accounting. Prerequisites: EBGN301, EBGN302, EBGN303; or permission of the instructor. 3 semester hours.

EBGN404. ADVANCED TOPICS IN MICROECONOMICS-(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-(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, EBGN302 and EBGN303. 3 hours lecture; 3 semester hours.

EBGN409. MATHEMATICAL ECONOMICS (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; MATH332 or MATH348; or permission of the instructor. 3 hours lecture; 3 semester hours.

EBGN437 REGIONAL ECONOMICS (I) (WI) Analysis of the spatial dimension of economies and economic decisions. Interregional capital and labor mobility. Location decisions of firms and households. Agglomeration economies. Models of regional economic growth. Measuring and forecasting economic impact and regional growth. Local and regional economic development policy. Urban and regional spatial structure. Emphasis on application of tools and techniques of regional analysis. Prerequisite: EBGN301. 3 hours lecture; 3 semester hours.

EBGN441. INTERNATIONAL ECONOMICS (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 (I) (WI) This course covers public-sector economics, including the fundamental institutions and relationships between the government and private decision makers. It covers the fundamental general-equilibrium welfare theorems and their interaction with government policy instruments that affect efficiency and distribution. Normative topics include an intensive study of the causes and consequences of, and policy prescriptions for, market failure due to public goods, or other problems associated with externalities and income distribution. Positive analysis focuses on policy formation in the context of political-economy and public choice theories. Prerequisite: EBGN301. 3 hours lecture; 3 semester hours.

EBGN452. NONLINEAR PROGRAMMING (II) As an advanced course in optimization, this course will address both unconstrained and constrained nonlinear model formulation and corresponding algorithms, e.g., gradient search and Newton's method, Lagrange multiplier methods and reduced gradient algorithms. Applications of state-of-the-art hardware and software will emphasize solving real-world problems in areas such as mining, energy, transportation and the military. Prerequisite: EBGN455 or permission of instructor. 3 hours lecture; 3 semester hours.

EBGN455. LINEAR PROGRAMMING (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 or permission of instructor. 3 hours lecture; 3 semester hours.

EBGN456 NETWORK MODELS (II) Network models are linear programming problems that possess special mathemat-

ical structures. This course examines a variety of network models, specifically, spanning tree problems, shortest path problems, maximum flow problems, minimum cost flow problems, and transportation and assignment problems. For each class of problem, we present applications in areas such as manufacturing, finance, energy, mining, transportation and logistics, and the military. We also discuss an algorithm or two applicable to each problem class. As time permits, we explore combinatorial problems that can be depicted on graphs, e.g., the traveling salesman problem and the Chinese postman problem, and discuss the tractability issues associated with these problems in contrast to "pure" network models. Prerequisites: MATH111; EBGN325 or EBGN455; or permission of the instructor.

EBGN457. INTEGER PROGRAMMING (II) As an advanced course in optimization, this course will address computational performance of linear and linear-integer optimization problems, and, using state-of-the-art hardware and software, will introduce solution techniques for "difficult" optimization problems. We will discuss such methodologies applied to the monolith, e.g., branch-and-bound and its variations, cutting planes, strong formulations, as well as decomposition and reformulation techniques, e.g., Lagrangian relaxation, Benders decomposition, column generation. Additional special topics may be introduced as time permits. Prerequisite: EBGN455 or permission of instructor. 3 hours lecture; 3 semester hours.

EBGN459. SUPPLY CHAIN MANAGEMENT (II) As a quantitative managerial course, the course will explore how firms can better organize their operations so that they more effectively align their supply with the demand for their products and services. Supply Chain Management (SCM) is concerned with the efficient integration of suppliers, factories, warehouses and retail-stores (or other forms of distribution channels) so that products are provided to customers in the right quantity and at the right time. Topics include managing economies of scale for functional products, managing market-mediation costs for innovative products, make-to order versus make-to-stock systems, quick response strategies, risk pooling strategies, supply-chain contracts and revenue management. Additional "special topics" will also be introduced, such as reverse logistics issues in the supply-chain or contemporary operational and financial hedging strategies. Prerequisite: permission of the instructor. 3 hours lecture; 3 semester hours.

EBGN461. STOCHASTIC MODELS IN MANAGEMENT SCIENCE (II) As a quantitative managerial course, the course is an introduction to the use of probability models for analyzing risks and economic decisions and doing performance analysis for dynamic systems. The difficulties of making decisions under uncertainty are familiar to everyone. We will learn models that help us quantitatively analyze uncertainty and how to use related software packages for managerial decision-making and to do optimization under uncertainty. Illustrative examples will be drawn from many fields including marketing, finance, production, logistics and distribution, energy and mining. The main focus of the course is to see methodologies that help to quantify the dynamic relationships of sequences of "random" events that evolve over time. Prerequisite: permission of the instructor. 3 hours lecture; 3 semester hours.

EBGN470 ENVIRONMENTAL ECONOMICS (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 non-market values. Prerequisite: EBGN301. 3 hours lecture; 3 semester hours.

EBGN474 INVENTING, PATENTING & LICENSING (S) (WI) This course provides an introduction to the legal framework of inventing and patenting and addresses practical issues facing inventors. The course examines patent law, inventing and patenting in the corporate environment, patent infringement and litigation, licensing, and the economic impact of patents. Methods and resources for market evaluation, searching prior art, documentation and disclosure of invention, and preparing patent applications are presented. Prerequisite: Permission of instructor. 3 hours lecture; 3 semester hours.

EBGN495. ECONOMIC FORECASTING (II) An introduction to the methods employed in business and econometric forecasting. Topics include time series modeling, Box-Jenkins models, vector autoregression, cointegration, exponential smoothing and seasonal adjustments. Covers data collection methods, graphing, model building, model interpretation, and presentation of results. Topics include demand and sales forecasting, the use of anticipations data, leading indicators and scenario analysis, business cycle forecasting, GNP, stock market prices and commodity market prices. Includes discussion of links between economic forecasting and government policy. Prerequisites: EBGN301, EBGN302, EBGN303. 3 hours lecture; 3 semester hours.

EBGN497. SUMMER PROGRAMS

EBGN498. SPECIAL TOPICS IN ECONOMICS AND BUSINESS (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 permission. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

EBGN499. INDEPENDENT STUDY (I, II) Individual research or special problem projects supervised by a faculty member. 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.

Engineering

KEVIN L. MOORE, Gerard August Dobelman Distinguished Professor and Interim Division Director
MARTE S. GUTIERREZ, James R. Paden Chair Distinguished Professor
ROBERT J. KEE, George R. Brown Distinguished Professor
D. VAUGHAN GRIFFITHS, Professor
ROBERT H. KING, Professor
NING LU, Professor
NIGEL T. MIDDLETON, Senior Vice President for Strategic Enterprises, Professor
MICHAEL MOONEY, Professor
GRAHAM G. W. MUSTOE, Professor
PANKAJ K. (PK) SEN, Professor
JOEL M. BACH, Associate Professor
JOHN R. BERGER, Associate Professor
CRISTIAN V. CIOBANU, Associate Professor
WILLIAM A. HOFF, Associate Professor
PANOS D. KIOUSIS, Associate Professor
MARCELO GODOY SIMOES, Associate Professor
JOHN P. H. STEELE, Associate Professor
TYRONE VINCENT, Associate Professor
RAY RUICHONG ZHANG, Associate Professor
GREGORY BOGIN, Assistant Professor
ROBERT J. BRAUN, Assistant Professor
KATHRYN JOHNSON, Clare Boothe Luce Assistant Professor
SALMAN MOHAGHEGHI, Assistant Professor
ANTHONY J. PETRELLA, Assistant Professor
JASON PORTER, Assistant Professor
NEAL SULLIVAN, Assistant Professor
ANNE SILVERMAN, Assistant Professor
CAMERON TURNER, Assistant Professor
MICHAEL WAKIN, Assistant Professor
JUDITH WANG, Assistant Professor
RAVEL F. AMMERMAN, Teaching Professor
JOSEPH P. CROCKER, Teaching Professor
RICHARD PASSAMANECK, Teaching Professor
VIBHUTI DAVE, Teaching Associate Professor
JEFFREY SCHOWALTER, Teaching Associate Professor
EDWARD RIEDEL, Teaching Associate Professor
CANDACE S. SULZBACH, Teaching Associate Professor
ALEXANDRA WAYLLACE, Teaching Associate Professor
JINSONG HUANG, Research Associate Professor
HUAYANG ZHU, Research Associate Professor
CHRISTOPHER B. DRYER, Research Assistant Professor
JOAN P. GOSINK, Emerita Professor
MICHAEL B. McGRATH, Emeritus Professor
DAVID MUNOZ, Emeritus Associate Professor
KARL R. NELSON, Emeritus Associate Professor
GABRIEL M. NEUNZERT, Emeritus Associate Professor
CATHERINE K. SKOKAN, Emerita Associate Professor

Note: Faculty for the environmental engineering specialty are listed in the Environmental Science and Engineering section of this Bulletin.

Program Description

The Division of Engineering offers a design-oriented, interdisciplinary, accredited non-traditional undergraduate program in engineering with specialization in civil, electrical, environmental or mechanical engineering. The program emphasizes fundamental engineering principles and requires in-depth understanding within one of the four specialty areas that are offered. Graduates are in a position to take advantage of a broad variety of professional opportunities, and are well-prepared for an engineering career in a world of rapid technological change.

The program leading to the degree Bachelor of Science in Engineering is accredited by the Accreditation Board for Engineering and Technology (ABET), 111 Market Place, Suite 1050, Baltimore, MD 21202-4012, telephone (410) 347-7700.

Program Educational Objectives (Bachelor of Science in Engineering)

The Engineering program contributes to the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria. In addition, the Engineering Program at CSM has established the following program educational objectives:

- Graduates will understand the design and analysis of engineering systems and the interdisciplinary nature of engineering.
- Graduates will incorporate an appreciation for issues involving earth, energy, materials and the environment in their professional practice.
- Graduates will incorporate non-technical considerations (e.g., aesthetic, social, ethical, economic, etc.) in their professional practice.
- Graduates will contribute to the needs of society through engineering and professional practice, research, or service.

Curriculum

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

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

In the final two years, students complete an advanced core that includes electric circuits, engineering mechanics, advanced mathematics, thermodynamics, economics, engineering design, and additional studies in liberal arts and

international topics. Students must choose a specialty in civil, electrical, environmental or mechanical engineering and each specialty includes a set of unique upper-division course requirements. Free electives (9 credits), at the student's discretion, can be used to either satisfy a student's personal interest in a topic or they can be used as coursework as part of an "area of special interest" of at least 12 semester hours or a minor of at least 18 semester hours in another department or division.

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

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

The **Civil Engineering Specialty** builds on the multi-disciplinary engineering principles of the core curriculum to focus in Geotechnical and Structural Engineering. Civil Specialty students are also asked to choose three civil elective courses from a list that includes offerings from other civil-oriented departments at CSM such as Geological Engineering and Mining Engineering. These electives give students the opportunity for further specialization in other areas of Civil Engineering. Civil Specialty students interested in a more research-oriented component to their undergraduate curriculum are encouraged to take on an Independent Study project with one of the Civil Engineering Faculty. These projects can offer a useful experience that is relevant to future graduate work.

The **Electrical Engineering Specialty** builds on the engineering principles of the core curriculum to provide exposure to the fundamentals of electrical engineering. The program includes core electrical engineering coursework in circuit analysis, signal processing, electronics, electromagnetic fields and waves, digital systems, machines and power systems, and control systems. Students also take specialized electives in the areas of microprocessor-based systems design, digital signal processing, control systems, and power systems.

The **Environmental Engineering Specialty** introduces students to the fundamentals of environmental engineering including the scientific and regulatory basis of public health and environmental protection. Topics covered include environmental science and regulatory processes, water and wastewater engineering, solid and hazardous waste management, and contaminated site remediation.

The **Mechanical Engineering Specialty** complements the core curriculum with courses that provide depth in material mechanics and the thermal sciences with emphases in computational methods and engineering design. Topics such as computational engineering, machine design, control theory, fluid mechanics, and heat transfer are an important part of the mechanical engineering program. The Mechanical Engineering program has close ties to the metallurgical and materials engineering, physics, chemical engineering and biological life sciences communities on campus, and undergraduates are encouraged to get involved in one of the large number of research programs conducted by the Mechanical Engineering faculty. Many students go on to graduate school.

Students in each of the four specialties will spend considerable time in laboratories. The division is well equipped with basic laboratory equipment, as well as PC-based instrumentation systems, and the program makes extensive use of computer-based analysis techniques.

The Division of Engineering is housed in George R. Brown Hall. Emphasis on hands-on education is reflected in the division's teaching and research laboratories.

All students are encouraged to take the Fundamental of Engineering examination before graduation.

Degree Requirements in Engineering

Civil Specialty

Sophomore Year Fall Semester	lec.	lab.	sem.hrs.
DCGN241 Statics	3		3
EBGN201 Principles of Economics	3		3
MATH213 Calc. for Scientists & Engineers III	4		4
PHGN200 Physics II	3	3	4.5
CSCI260** Fortran Programming	2/3		2
PAGN2XX Physical Education		2	0.5
Total			17

Sophomore Year Spring Semester	lec.	lab.	sem.hrs.
DCGN381 Circuits, Electronics & Power	3		3
SYGN200 Human Systems	3		3
EGGN250 Multidisciplinary EG Lab I		4.5	1.5
EGGN320 Mechanics of Materials	3		3
EGGN351 Fluid Mechanics	3		3
EPIC25X Design II	3	1	3
PAGN2XX Physical Education		2	0.5
Total			17

Sophomore/Junior Summer Session	lec.	lab.	sem.hrs.
EGGN234 Field Session - Civil			3
Total			3

Junior Year Fall Semester	lec.	lab.	sem.hrs.
MATH225 Differential Equations	3		3
EGGN342 Structural Theory	3		3
EGGN361 Soil Mechanics	3		3
EGGN363 Soil Mechanics Laboratory		3	1
EGGN413 Computer Aided Engineering	3		3
LAIS/EBGN H&SS GenEd Restricted Elective I	3		3
Total			16

Junior Year Spring Semester	lec.	lab.	sem.hrs.
MATH348 Adv. Engineering Mathematics	3		3
EGGN464 Foundation Engineering	3		3
DCGN210 Introduction to Thermodynamics	3		3
EGGN444/445 Design of Steel or Concrete Structures	3		3
Civil Specialty Elective	3		3
Free Elective	3		3
Total			18

Senior Year Fall Semester	lec.	lab.	sem.hrs.
MATH323 Probability and Statistics	3		3
LAIS/EBGN H&SS GenEd Restricted Elective II	3		3
EGGN315 Dynamics	3		3
EGGN350 Multidisciplinary EG Lab II		4.5	1.5
EGGN491 Senior Design I	2	3	3
Civil Specialty Elective	3		3
Total			16.5

Senior Year Spring Semester	lec.	lab.	sem.hrs.
LAIS/EBGN H&SS GenEd Restricted Elective III	3		3
EGGN492 Senior Design II	1	6	3
Civil Specialty Elective	3		3
Free Elective	3		3
Free Elective	3		3
Free Elective	3		3
Total			18

Degree Total 138.50

Electrical Specialty

Sophomore Year Fall Semester	lec.	lab.	sem.hrs.
DCGN241 Statics	3		3
SYGN200 Human Systems	3		3
MATH213 Calc. for Scientists & Engineers III	4		4
PHGN200 Physics II	3	3	4.5
CSCI261 Programming Concepts	3		3
PAGN2XX Physical Education	2		0.5
Total			18

Sophomore Year Spring Semester	lec.	lab.	sem.hrs.
MATH225 Differential Equations	3		3
PAGN2XX Physical Education	2		0.5
EBGN201 Principles of Economics	3		3
EGGN320 Mechanics of Materials	3		3
DCGN381 Circuits, Electronics & Power	3		3
EGGN250 Multidisciplinary EG Lab I		4.5	1.5
EPIC25X Design II	3	1	3
Total			17

Junior Year Fall Semester	lec.	lab.	sem.hrs.
MATH323 Probability & Statistics	3		3
MATH348 Adv. Engineering Mathematics	3		3
EGGN371 Engineering Thermodynamics	3		3
EGGN382 Engineering Circuit Analysis	3		3
EGGN388 Information Systems Science	3		3
EGGN384 Digital Logic	3	3	4
Total			19

Junior Year Spring Semester	lec.	lab.	sem.hrs.
LAIS/EBGN H&SS GenEd Restricted Elective I	3		3
EGGN351 Fluid Mechanics	3		3
EGGN385 Electronic Devices & Circuits	3	3	4
EGGN386 Fund. of Eng. Electromagnetics	3		3
EGGN389 Fund. of Electric Machinery	3	3	4
Total			17

Junior/Senior Summer Session	lec.	lab.	sem.hrs.
EGGN334 Field session - Electrical	3		3
Total			3

Senior Year Fall Semester	lec.	lab.	sem.hrs.
LAIS/EBGN H&SS GenEd Restricted Elective II	3		3
EGGN450 Multidisciplinary EG Lab III		3	1
EGGN491 Senior Design I	2	3	3
EGGN307 Feedback Control Systems	3		3
Electrical Specialty Elective	3		3
Electrical Specialty Elective	3		3
Total			16

Senior Year Spring Semester	lec.	lab.	sem.hrs.
LAIS/EBGN H&SS GenEd Restricted Elective III	3		3
EGGN492 Senior Design II	1	6	3
Electrical Specialty Elective	3		3
Free Electives	3		3
Free Electives	3		3
Free Electives	3		3
Total			18

Degree Total 141

Environmental Specialty

Sophomore Year Fall Semester	lec.	lab.	sem.hrs.
DCGN241 Statics	3		3
SYGN200 Human Systems	3		3
MATH213 Calc. for Scientists & Engineers III	4		4
PHGN200 Physics II	3	3	4.5
CSCI260*** Fortran Programming	2/3		2
PAGN2XX Physical Education	2		0.5
Total			17

Sophomore Year Spring Semester	lec.	lab.	sem.hrs.
MATH225 Differential Equations	3		3
PAGN2XX Physical Education	2		0.5
EGGN320 Mechanics of Materials	3		3
DCGN381 Circuits, Electronics & Power	3		3
EGGN250 Multidisciplinary EG Lab I		4.5	1.5
EPIC25X Design II	3	1	3
EBGN201 Principles of Economics	3		3
Total			17

Junior Year Fall Semester	lec.	lab.	sem.hrs.
LAIS/EBGN H&SS GenEd Restricted Elective I	3		3
MATH348 Adv. Engineering Mathematics	3		3
EGGN315 Dynamics	3		3
EGGN351 Fluid Mechanics	3		3
EGGN353 Environmental Sci. & Eng. I	3		3
Free Elective	3		3
Total			18

Junior Year Spring Semester	lec.	lab.	sem.hrs.
MATH323 Probability & Statistics	3		3
EGGN350 Multidisciplinary EG Lab II		4.5	1.5
EGGN354 Environmental Sci. & Eng. II	3		3
EGGN371 Engineering Thermodynamics	3		3
Environmental Specialty Elective	3		3
Free Elective	3		3
Total			16.5

Junior/Senior Summer Session	lec.	lab.	sem.hrs.
EGGN335 Field Session - Environmental		3	3
Total			3

Senior Year Fall Semester	lec.	lab.	sem.hrs.
LAIS/EBGN H&SS GenEd Restricted Elective II	3		3
EGGN491 Senior Design I	2	3	3
EGGN413 Computer Aided Engineering	3		3
Environmental Specialty Elective	3		3
Environmental Specialty Elective	3		3
Total			15

Senior Year Spring Semester	lec.	lab.	sem.hrs.
LAIS/EBGN H&SS GenEd Restricted Elective III	3		3
EGGN492 Senior Design II	1	6	3
Environmental Specialty Elective	3		3
Environmental Specialty Elective	3		3
Free Elective	3		3
Free Elective	3		3
Total			18

Degree Total			137.5

Mechanical Specialty

Sophomore Year Fall Semester	lec.	lab.	sem.hrs.
DCGN241 Statics	3		3
SYGN200 Human Systems	3		3
MATH213 Calc. for Scientists & Engineers III	4		4
PHGN200 Physics II	3	3	4.5
CSCI261 Programming Concepts	3		3
PAGN2XX Physical Education	2		0.5
Total			18

Sophomore Year Spring Semester	lec.	lab.	sem.hrs.
MATH225 Differential Equations	3		3
PAGN2XX Physical Education	2		0.5
MTGN202 Engineered Material Systems	3		3
EGGN320 Mechanics of Materials	3		3
DCGN381 Circuits, Electronics & Power	3		3
EGGN250 Multidisciplinary EG Lab I		4.5	1.5
EPIC25X Design II	3	1	3
Total			17

Sophomore/Junior Summer Session	lec.	lab.	sem.hrs.
EGGN235 Field Session - Mechanical			3
Total			3

Junior Year Fall Semester	lec.	lab.	sem.hrs.
MATH323 Probability & Statistics	3		3
MATH348 Adv. Engineering Mathematics	3		3
LAIS/EBGN H&SS GenEd Restricted Elective I	3		3
EGGN315 Dynamics	3		3
EGGN371 Engineering Thermodynamics	3		3
EGGN388 Information Systems Science	3		3
Total			18

Junior Year Spring Semester	lec.	lab.	sem.hrs.
EBGN201 Principles of Economics	3		3
EGGN351 Fluid Mechanics	3		3
EGGN350 Multidisciplinary EG Lab II		4.5	1.5
EGGN307 Feedback Control Systems	3		3
EGGN413 Computer Aided Engineering	3		3
Mechanical Specialty Elective	3		3
Total			16.5

Senior Year Fall Semester	lec.	lab.	sem.hrs.
EGGN450 Multidisciplinary EG Lab III	3		1
EGGN491 Senior Design I	2	3	3
LAIS/EBGN H&SS GenEd Restricted Elective II	3		3
EGGN471 Heat Transfer	3		3
EGGN411 Machine Design	3	3	4
Free Elective	3		3
Total			17

Senior Year Spring Semester	lec.	lab.	sem.hrs.
LAIS/EBGN H&SS GenEd Restricted Elective III	3		3
EGGN492 Senior Design II	1	6	3
Mechanical Specialty Elective	3		3
Mechanical Specialty Elective	3		3
Free Elective	3		3
Free Elective	3		3
Total			18

Degree Total			140.5

**Civil Engineering students may take either the 2-credit CSCI260 Fortran Programming, the 3-credit EGGN205 Programming Concepts and Engineering Analysis, or the 3-credit CSCI261 Programming Concepts.

***Environmental Engineering students may take either the 2-credit CSCI260 Fortran Programming or the 3-credit CSCI261 Programming Concepts.

Engineering Specialty Electives

Civil Specialty

Civil Specialty students are required to take three Civil Elective courses from the following list. The electives have been grouped by themes for convenience only. When choosing their three courses, students can elect for breadth across themes or depth within a theme.

Students must take at least two courses marked (A).

Environmental

EGGN353 (A)Fundamentals of Environmental Science and Engineering I
EGGN354 (A)Fundamentals of Environmental Science and Engineering II
EGGN451 (A)Hydraulic Problems
EGGN453 (A)Wastewater Engineering
EGGN454 (A)Water Supply Engineering
EGGN455 (A)Solid and Hazardous Waste Engineering
EGGN456 (A)Scientific Basis of Environmental Regulations
EGGN457 (A)Site Remediation Engineering

General

EGGN307 (A)Feedback control systems
EBGN321 (A)Engineering Economics
EGGN460 (A)Numerical Methods for Engineers
EGGN433 (A)Surveying II

EGGN490 (B) Sustainable Engineering Design
EBGN553 (B)Project Management
EGGN399/499 (B)Independent Study (Civil)

Geotechnical
EGGN465 (A)Unsaturated Soil Mechanics
EGGN448 (A)Advanced Soil Mechanics
EGGN534 (A)Soil Behavior
EGGN531 (A)Soil dynamics and foundation vibrations
MNGN321 (A)Introduction to Rock Mechanics
MNGN404 (B)Tunneling
MNGN405 (B)Rock Mechanics in Mining
MNGN406 (B)Design and Support of Underground Excavations
GEGN466 (B)Groundwater Engineering
GEGN468 (B)Engineering Geology and Geotechnics
GEGN473 (B)Site investigation

Mechanics
EGGN422 (A)Advanced Mechanics of Materials
EGGN442 (A)Finite Element Methods For Engineers
EGGN473 (A)Fluid Mechanics II
EGGN478 (A)Engineering Vibrations

Structural
EGGN441 (A)Advanced Structural Analysis
EGGN444/445 (A)Steel Design or Concete Design*
EGGN447/547 (A) Timber and Masonry Design
EGGN549 (A) Advanced Steel Design
EGGN556 (A) Advanced Design of Reinforced Concrete

*To count as elective credit, the companion course must be taken as part of the Civil Specialty degree requirements (see page 72).

Graduate courses in EG and elsewhere may occasionally be approved as civil electives on an ad hoc basis. In order for a course that is not listed here to be considered, the student should submit a written request in advance to their faculty advisor enclosing a copy of the course syllabus.

Electrical Specialty

Electrical specialty students are required to take three courses from the following list of electrical technical electives:*

EGGN325 Introduction to Biomedical Engineering
EGGN400 Introduction to Robotics
EGGN417 Modern Control Design
EGGN430 Biomedical Instrumentation
EGGN460 Numerical Methods for Engineers
EGGN481 Digital Signal Processing
EGGN482 Microcomputer Architecture and Interfacing
EGGN483 Analog and Digital Communications Systems
EGGN484 Power Systems Analysis
EGGN485 Introduction to High Power Electronics
EGGN486 Practical Design of Small Renewable Energy Systems
EGGN487 Analysis and Design of Advanced Energy Systems
CSCI341 Computer Organization
CSCI/MATH440 Parallel Computing for Scientists and Engineers
MATH334 Introduction to Probability
MATH335 Introduction to Mathematical Statistics
MATH455 Partial Differential Equations
PHGN300 Modern Physics
PHGN320 Modern Physics II
PHGN412 Mathematical Physics
PHGN435 Interdisciplinary Microelectronics Processing Laboratory
PHGN440 Solid State Physics
PHGN441 Solid State Physics Applications and Phenomena
PHGN462 Electromagnetic Waves and Optical Physics

*Additional courses are advisor and Division Director approved special topics with a number EGGN398/498 and all graduate courses taught in the Electrical Engineering specialty area. Students should consult their faculty advisor for guidance.

Environmental Specialty

All students pursuing the Environmental Specialty are required to take EGGN/ESGN353 and EGGN/ESGN354. These courses are prerequisites for many 400 level Environmental Specialty courses. In addition students are required to take five courses from the following list:

ESGN401 Fundamentals of Ecology
ESGN440 Environmental Pollution: Sources, Characteristics, Transport and Fate
EGGN451 Hydraulic Problems
EGGN/ESGN453 Wastewater Engineering
EGGN/ESGN454 Water Supply Engineering
EGGN/ESGN456 Scientific Basis of Environmental Regulations
EGGN/ESGN457 Site Remediation Engineering
ESGN460 Onsite Water Reclamation and Reuse
ESGN462 Solid Waste Minimization and Recycling
ESGN463 Pollution Prevention Fundamentals and Practice
GEGN466 Groundwater Engineering

Students completing the Engineering degree with an environmental specialty may not also complete a minor or ASI in Environmental Science.

Students should consult their faculty advisor for guidance on course substitutions.

Mechanical Specialty

The list of approved Mechanical Engineering electives appears below. Students are required to take three of these courses and at least one must be from List A. In addition to these courses, any graduate course taught by a member of the Mechanical Engineering faculty will also be counted as a Mechanical Elective. Students are welcome to petition to have a course approved, and the petition form is provided on the Mechanical Engineering web site. Courses are occasionally added to this list with the most updated version maintained on the Mechanical Engineering web site.

List A
EGGN403 Thermodynamics II
EGGN422 Advanced Mechanics of Materials
EGGN473 Fluid Mechanics II
EGGN478 Engineering Vibrations

List B
EGGN325 Intro. to Biomedical Engineering
EGGN389 Fundamentals of Electric Machinery
EGGN400 Introduction to Robotics
EGGN417 Modern Control Design
EGGN425 Musculoskeletal Biomechanics

EGGN430 Biomedical Instrumentation
EGGN442 Finite Element Methods for Engineering
EGGN444 Design of Steel Structures
EGGN460 Numerical Methods for Engineers
EBGN321 Engineering Economics
ESGN527 Watersheds System Analysis
MTGN/EGGN390 Materials and Manufacturing Processes
MTGN445 Mechanical Properties of Materials
MTGN450 Statistical Control of Materials Processes
MTGN464 Forging and Forming
MTGN475/477 Metallurgy of Welding/Lab
MLGN/MTGN570 Introduction to Biocompatibility of Materials
MNGN444 Explosives Engineering II
PEGN311 Drilling Engineering Principles
PEGN361 Completion Engineering (II)
PEGN419 Well log analysis and formation evaluation
PEGN515 Reservoir Engineering Principles
PHGN300 Modern Physics
PHGN350 Intermediate Mechanics
PHGN435 Microelectronics Processing Laboratory
PHGN440 Solid State Physics

Division of Engineering Areas of Special Interest and Minor Programs

General Requirements

A **Minor Program** of study consists of a minimum of 18 credit hours of a logical sequence of courses. With the exception of the McBride Honors minor, only three of these hours may be taken in the student's degree-granting department and no more than three of these hours may be at the 100- or 200- level. A Minor Program may not be completed in the same department as the major.

An **Area of Special Interest** (ASI) consists of a minimum of 12 credit hours of a logical sequence of courses. Only three of these hours may be taken at the 100- or 200-level and no more than three of these hours may be specifically required for the degree program in which the student is graduating. An ASI may be completed within the same major department.

A **Minor Program / Area of Special Interest** declaration (available in the Registrar's Office) should be submitted for approval prior to the student's completion of half of the hours proposed to constitute the program. Approvals are required from the Director of the Engineering Division, the student's advisor, and the Department Head or Division Director in the department or division in which the student is enrolled.

Programs in the Engineering Division

The Engineering Division offers minor and ASI programs to meet two sets of audiences: (1) students that are not pursuing an engineering degree and (2) students that are pursuing an engineering degree in another department. For the first audience, a minor or ASI is available in General Engineering. This program offers the foundational coursework in engineering which is compatible with many of the topics in the Fundamentals of Engineering examination. For the second audience, there is a program in engineering specialties. This program recognizes that many non-engineering-division majors will have completed the fundamental engineering courses that are prerequisites to upper division engineering courses. Since these students complete the fundamental coursework as a part of their degree, they can pursue a minor or ASI in the four engineering specialties (civil, electrical, environmental, mechanical).

The requirements for a minor do not allow engineering division students to acquire a minor as a part of the Engineering Specialties program (for instance, a student that is an Engineering-civil-specialty student cannot get a minor in Engineering-mechanical). However, the ASI program in Engineering Specialties is available to all Engineering Division students with the note that an ASI in the students declared major area is not allowed (for instance, Engineering-mechanical-specialty students cannot acquire an ASI in Engineering-mechanical).

Students wishing to enroll in either program must satisfy all prerequisite requirements for each course in a chosen sequence. Students in the sciences or mathematics will therefore be better positioned to satisfy prerequisite requirements in the General Engineering program, while students in engineering disciplines will be better positioned to meet the prerequisite requirements for courses in the Engineering Specialties.

Students majoring in Engineering with an Environmental Specialty may not also complete a minor or ASI in Environmental Science and Engineering.

The courses listed below, constituting each program and the specialty variations, are offered as guidelines for selecting a logical sequence. In cases where students have unique backgrounds or interests, these sequences may be adapted accordingly through consultation with faculty in the Engineering Division.

General Engineering Program

A twelve (ASI) or eighteen hour (minor) sequence must be selected from:

DCGN241 Statics	3 sem hrs.
EGGN320 Mechanics of Materials	3 sem hrs.
EGGN351 Fluid Mechanics	3 sem hrs.
EGGN371 Thermodynamics	3 sem hrs.
DCGN381 Electrical Circuits, Electronics and Power	3 sem hrs.
EGGN315 Dynamics	3 sem hrs.
EBGN421 Engineering Economics	3 sem hrs.

Note: Multidisciplinary Engineering Laboratories I, II and III (EGGN 250, 350 and 450, respectively) may be taken as laboratory supplements to DCGN 381, EGGN351 and EGGN320.

Engineering Specialties Program

Civil

A twelve (ASI) or eighteen hour (minor) sequence must be selected from:

EGGN342 Structural Theory	3 sem hrs.
EGGN353 Fundamentals of Environmental Science and Engineering I	3 sem hrs.
EGGN354 Fundamentals of Environmental Science and Engineering II	3 sem hrs.
EGGN361 Soil Mechanics	3 sem hrs.
EGGN363 Soil Mechanics Laboratory	1 sem hrs.
EGGN422 Advanced Mechanics of Materials	3 sem hrs.
EGGN441 Advanced Structural Theory	3 sem hrs.
EGGN442 Finite Element Methods for Engineers	3 sem hrs.
EGGN433 Surveying II	3 sem hrs.
EGGN444 Design of Steel Structures	3 sem hrs.
EGGN445 Design of Reinforced Concrete Structures	3 sem hrs.
EGGN448 Advanced Soil Mechanics	3 sem hrs.
EGGN451 Hydraulic Problems	3 sem hrs.
EGGN453 Wastewater Engineering	3 sem hrs.
EGGN454 Water Supply Engineering	3 sem hrs.
EGGN460 Numerical Methods for Engineers	3 sem hrs.
EGGN464 Foundations	3 sem hrs.
EGGN465 Unsaturated Soil Mechanics	3 sem hrs.
EGGN478 Engineering Vibrations	3 sem hrs.
EGGN498 Advanced Soil Mechanics	3 sem hrs.
EGGN499 Dynamics of Structures and Soils	3 sem hrs.
GEGN467 Groundwater Engineering	4 sem hrs.
GEGN468 Engineering Geology and Geotechnics	3 sem hrs.
MNGN321 Introduction to Rock Mechanics	3 sem hrs.

Electrical

A twelve (ASI) or eighteen hour (minor) sequence must be selected from a basic electrical program comprising:*

DCGN381 Circuits, Electronics and Power	3 sem hrs.
EGGN382 Engineering Circuit Analysis	3 sem hrs.

Additional courses are to be selected from:

EGGN307 Introduction to Feedback Control Systems	3 sem hrs.
EGGN334 Engineering Field Session, Electrical Specialty	3 sem hrs.
EGGN384 Digital Logic	4 sem hrs.
EGGN385 Electronic Devices and Circuits	4 sem hrs.
EGGN386 Fund. of Engineering Electromagnetics	3 sem hrs.
EGGN388 Information Systems Science	3 sem hrs.
EGGN389 Fundamentals of Electric Machinery	4 sem hrs.
EGGN417 Modern Control Design	3 sem hrs.
EGGN430 Biomedical Instrumentation	3 sem hrs.
EGGN481 Digital Signal Processing	3 sem hrs.
EGGN482 Microcomputer Architecture and Interfacing	4 sem hrs.
EGGN483 Analog & Digital Communication Systems	4 sem hrs.
EGGN484 Power Systems Analysis	3 sem hrs.
EGGN485 Introduction to High Power Electronics	3 sem hrs.

*Additional courses are approved special topics with a number EGGN398/498 and all graduate courses taught in the Electrical Engineering specialty area. Students should consult their faculty advisor for guidance

Environmental Science and Engineering Minor and ASI

See the Catalog section that describes Environmental Science and Engineering

Mechanical

A twelve (ASI) or eighteen hour (minor) sequence must be selected from:

EGGN307 Introduction to Feedback Control Systems	3 sem hrs.
EGGN351 Fluid Mechanics	3 sem hrs.
EGGN403 Thermodynamics II	3 sem hrs.
EGGN400 Introduction to Robotics	3 sem hrs.
EGGN411 Machine Design	3 sem hrs.
EGGN413 Computer Aided Engineering	3 sem hrs.
EGGN422 Advanced Mechanics of Materials	3 sem hrs.
EGGN471 Heat Transfer	3 sem hrs.
EGGN473 Fluid Mechanics II	3 sem hrs.

Combined Engineering Baccalaureate and Engineering Systems Masters Degrees

The Division of Engineering offers a five year combined program in which students have the opportunity to obtain specific engineering skills supplemented with graduate coursework in Engineering. Upon completion of the program, students receive two degrees, the Bachelor of Science in Engineering and the Master of Science in Engineering.

Students must apply to enter this program by the beginning of their Senior year and must have a minimum GPA of 3.0. To complete the undergraduate portion of the program, students must successfully finish the classes indicated in any of the four specialty programs (civil, electrical, environmental or mechanical engineering). At the beginning of the Senior year, a *pro forma* graduate school application is submitted and as long as the undergraduate portion of the program is successfully completed, the student is admitted to the Engineering graduate program.

Students are required to take an additional thirty credit hours for the M.S. degree. Up to nine of the 30 credit hours beyond the undergraduate degree requirements can be 4XX level courses. The remainder of the courses will be at the graduate level (5XX and above). Students will need to choose a program specialty (Civil, Electrical, Mechanical, and Systems). The Engineering Division Graduate Bulletin provides details for each of these programs and includes specific instructions regarding required and elective courses for each. Students may switch from the combined program which includes a non-thesis Master of Science degree to a M.S. degree with a thesis option; however, if students change degree programs they must satisfy all degree requirements for the M.S. with thesis degree.

Interested students can obtain additional information from the Division of Engineering.

Combined Engineering Physics or Chemistry Baccalaureate and Engineering Systems Masters Degrees

The Division of Engineering in collaboration with the Departments of Physics and Chemistry offers five-year programs in which students have the opportunity to obtain specific engineering skills to complement their physics or chemistry background. Physics or chemistry students in this program fill in their technical and free electives over their standard four year Engineering Physics or Chemistry B.S. program with a reduced set of engineering classes. These classes come in one of two specialties within the division: Electrical engineering and Mechanical engineering. At the end of the fourth year, the student is awarded an Engineering Physics B.S. or Chemistry B.S., as appropriate. Students in this program are automatically entered into the Engineering Masters degree program. Course schedules for these five-year programs can be obtained in the Engineering, Physics and Chemistry Departmental Offices.

Students must apply to enter this program by the beginning of their Senior year and must have a minimum GPA of 3.0. To complete the undergraduate portion of the program, students must successfully finish the classes indicated by the "typical" class sequence for the appropriate track. At the beginning of the Senior year, a *pro forma* graduate school application is submitted and as long as the undergraduate portion of the program is successfully completed, the student is admitted to the Engineering graduate program.

Interested students can obtain additional information and detailed curricula from the Division of Engineering or the Physics Department.

Description of Courses

Freshman Year

EGGN198. SPECIAL TOPICS IN ENGINEERING (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.

EGGN199. INDEPENDENT STUDY (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.

Sophomore Year

EGGN205. PROGRAMMING CONCEPTS AND ENGINEERING ANALYSIS (I,II) This course provides an introduction to techniques of scientific computation that are utilized for engineering analysis, with the software package MATLAB as the primary computational platform. The course focuses on methods data analysis and programming, along with numerical solutions to algebraic and differential equations. Engineering applications are used as examples throughout the course. Prerequisite: MATH112 or MATH113 or MATH122 or consent of instructor. 3 hours lecture, 3 semester hours.

EGGN234. ENGINEERING FIELD SESSION, CIVIL SPECIALTY (S) The theory and practice of modern surveying. Lectures and hands-on field work teaches horizontal, vertical, and angular measurements and computations using traditional and modern equipment. Subdivision of land and applications to civil engineering practice, GPS and astronomic observations. Prerequisite: EPIC251. Three weeks (6 day weeks) in summer field session; 3 semester hours.

EGGN235. ENGINEERING FIELD SESSION, MECHANICAL SPECIALTY (S) This course provides the student with hands-on experience in the use of modern engineering tools as part of the design process including modeling, fabrication, and testing of components and systems. Student use engineering, mathematics and computers to conceptualize, model, create, test, and evaluate components and systems of their creation. Teamwork is emphasized by having students work in teams. Prerequisites: PHGN200/201, CSCI260/261 and EPIC251. Three weeks in summer field session; 3 semester hours.

EGGN250. MULTIDISCIPLINARY ENGINEERING LABORATORY I (I, II) (WI) Laboratory experiments integrating instrumentation, circuits and power with computer data acquisitions and sensors. Sensor data is used to transition between science and engineering science. Engineering Science issues like stress, strains, thermal conductivity, pressure and flow are investigated using fundamentals of equilibrium, continuity, and conservation. Prerequisite: DCGN381 or concurrent enrollment. 4.5 hours lab; 1.5 semester hour.

EGGN298. SPECIAL TOPICS IN ENGINEERING (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.

Junior Year

EGGN307. INTRODUCTION TO FEEDBACK CONTROL SYSTEMS (I, II) System modeling through an energy flow approach is presented, with examples from linear electrical, mechanical, fluid and/or thermal systems. Analysis of system response in both the time domain and frequency domain is discussed in detail. Feedback control design techniques, including PID, are analyzed using both analytical and computational methods. Prerequisites: (DCGN381 or PHGN215) and MATH225. 3 hours lecture; 3 semester hours.

EGGN315. DYNAMICS (I, II, S) Absolute and relative motions. Kinetics, work-energy, impulse-momentum, vibrations. Prerequisite: DCGN241 and MATH225. 3 hours lecture; 3 semester hours.

EGGN320. MECHANICS OF MATERIALS (I, II, S) Fundamentals of stresses and strains, material properties. Stresses and deformations due to axial, torsion, bending, transverse and combined loadings. State-of-stress at a point; stress transformations and Mohr's circle for stress; beam deflections, thin-wall pressure vessels, columns and buckling. Prerequisite: DCGN241 or MNGN317. 3 hours lecture; 3 semester hours.

EGGN325/BELS325. INTRODUCTION TO BIOMEDICAL ENGINEERING (I) The application of engineering principles and techniques to the human body presents many unique challenges. The discipline of Biomedical Engineering has evolved over the past 50 years to address these challenges. Biomedical Engineering is a diverse, seemingly all-encompassing field that includes such areas as biomechanics, biomaterials, bioinstrumentation, medical imaging, rehabilitation. This course is intended to provide an introduction to, and overview of, Biomedical Engineering. At the end of the semester, students should have a working knowledge of the special considerations necessary to apply various engineering principles to the human body. Prerequisites: None.3 hours lecture; 3 semester hours.

EGGN334. ENGINEERING FIELD SESSION, ELECTRICAL SPECIALTY (S) Experience in the engineering design process involving analysis, design, and simulation. Students use engineering, mathematics and computers to model, analyze, design and evaluate system performance. Teamwork emphasized. Prerequisites: EGGN382, EGGN388, and two of the following: EGGN384, EGGN385, EGGN389, and EPIC251. Three weeks in summer session; 3 semester hours.

EGGN335. ENGINEERING FIELD SESSION, ENVIRONMENTAL SPECIALTY (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: EGGN353, EPIC251, MATH323. Three weeks in summer session;
3 semester hours.

EGGN340. COOPERATIVE EDUCATION (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 Engineering Division Faculty Co-op Advisor prior to enrolling to clarify the educational objectives for their individual Co-op program. Prerequisite: 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 EGGN340, Cooperative Education, may be used as free elective credit hours or a civil specialty elective if, in the judgment of the Co-op Advisor, 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 or civil 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 Engineering Division Faculty Co-op Advisor.

EGGN342. STRUCTURAL THEORY (I, II) Analysis of determinate and indeterminate structures for both forces and deflections. Influence lines, work and energy methods, moment distribution, matrix operations, computer methods. Prerequisite: EGGN320. 3 hours lecture; 3 semester hours.

EGGN350. MULTIDISCIPLINARY ENGINEERING LABORATORY II (I, II) (WI) Laboratory experiments integrating electrical circuits, fluid mechanics, stress analysis, and other engineering fundamentals using computer data acquisition and transducers. Fluid mechanics issues like compressible and incompressible fluid flow (mass and volumetric), pressure losses, pump characteristics, pipe networks, turbulent and laminar flow, cavitation, drag, and others are covered. Experimental stress analysis issues like compression and tensile testing, strain gage installation, Young's Modulus, stress vs. strain diagrams, and others are covered. Experimental stress analysis and fluid mechanics are integrated in experiments which merge fluid power of the testing machine with applied stress and displacement of material specimen. Prerequisite: EGGN250. Prerequisite or concurrent enrollment:

EGGN351. FLUID MECHANICS (I, II, S) Fluid properties, fluid statics, control-volume analysis, Bernoulli equation, differential analysis and Navier-Stokes equations, dimensional analysis, internal flow, external flow, open-channel flow, turbomachinery. Prerequisite: DCGN241 or MNGN317. 3 hours lecture; 3 semester hours.EGGN351, EGGN320. 4.5 hours lab; 1.5 semester hour.

EGGN353/ESGN353. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I (I, II) Topics covered include: history of water related environmental law and regulation, major sources and concerns of water pollution, water quality parameters and their measurement, material and energy balances, water chemistry concepts, microbial concepts, aquatic toxicology and risk assessment. Prerequisite: CHGN122, PHGN100 and MATH213, or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN354/ESGN354. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II (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 organi-

zations in environmental management (relative to air, solid and hazardous waste). Prerequisite: CHGN122, PHGN100 and MATH213, or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN361. SOIL MECHANICS (I, II) An introductory course covering the engineering properties of soil, soil phase relationships and classification. Principle of effective stress. Seepage through soils and flow nets. Soil compressibility, consolidation, and settlement prediction. Shear strength of soils. Prerequisite: EGGN320. 3 hours lecture; 3 semester hours.

EGGN363. SOIL MECHANICS LABORATORY (I, II) Introduction to laboratory testing methods in soil mechanics. Classification, permeability, compressibility, shear strength. Prerequisite: EGGN361 or concurrent enrollment. 3 hours lab; 1 semester hour.

EGGN371. THERMODYNAMICS I (I, II, S) A comprehensive treatment of thermodynamics from a mechanical engineering point of view. Thermodynamic properties of substances inclusive of phase diagrams, equations of state, internal energy, enthalpy, entropy, and ideal gases. Principles of conservation of mass and energy for steady-state and transient analyses. First and Second Law of thermodynamics, heat engines, and thermodynamic efficiencies. Application of fundamental principles with an emphasis on refrigeration and power cycles. Prerequisite: MATH213/223. 3 hours lecture; 3 semester hours.

EGGN381. INTRODUCTION TO ELECTRICAL CIRCUITS (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. Prerequisite: PHGN200. 3 lecture hours, 3 semester hours.

EGGN382. ENGINEERING CIRCUIT ANALYSIS (I, II) This course provides for the continuation of basic circuit analysis techniques developed in EGGN381, by providing the theoretical and mathematical fundamentals to understand and analyze complex electric circuits. The key topics covered include: (i) Steady-state analysis of single-phase and three-phase AC power circuits, (ii) Laplace transform techniques, (iii) transfer functions, (iv) frequency response, (v) Bode diagrams, (vi) Fourier series expansions, and (vii) two-port networks. The course features PSPICE, a commercial circuit analysis software package. Prerequisites: EGGN381 or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN384. DIGITAL LOGIC (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: DCGN381 or PHGN215. 3 hours lecture; 3 hours lab; 4 semester hours.

EGGN385. ELECTRONIC DEVICES AND CIRCUITS (I, II) Semiconductor materials and characteristics, junction diode operation, bipolar junction transistors, field effect transistors, biasing techniques, four layer devices, amplifier and power supply design, laboratory study of semiconductor circuit characteristics. Prerequisite: EGGN 382 or PHGN215. 3 hours lecture; 3 hours lab; 4 semester hours.

EGGN386. FUNDAMENTALS OF ENGINEERING ELECTROMAGNETICS (II) This course provides an introduction to electromagnetic theory as applied to electrical engineering problems in wireless communications, transmission lines, and high-frequency circuit design. The theory and applications are based on Maxwell's equations, which describe the electric and magnetic force-fields, the interplay between them, and how they transport energy. Matlab and PSPICE will be used in homework assignments, to perform simulations of electromagnetic interference, electromagnetic energy propagation along transmission lines on printed circuit boards, and antenna radiation patterns. Prerequisites: EGGN382, MATH348 and/or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN388. INFORMATION SYSTEMS SCIENCE (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. Prerequisite: (DCGN381 or PHGN215) and MATH225. 3 hours lecture; 3 semester hours.

EGGN389. FUNDAMENTALS OF ELECTRIC MACHINERY I (I, II) This course provides an engineering science analysis of electrical machines. The following topics are included: DC, single-phase and three-phase AC circuit analysis, magnetic circuit concepts and materials, transformer analysis and operation, steady-state and dynamic analysis of rotating machines, synchronous and poly-phase induction motors, and laboratory study of external characteristics of machines and transformers. Prerequisite: EGGN382 or PHGN215. 3 hours lecture; 3 hours lab; 4 semester hours.

EGGN390/MTGN390. MATERIALS AND MANUFACTURING PROCESSES This course focuses on available engineering materials and the manufacturing processes used in

their conversion into a product or structure as critical considerations in design. Properties, characteristics, typical selection criteria, and applications are reviewed for ferrous and nonferrous metals, plastics and composites. The nature, features, and economics of basic shaping operations are addressed with regard to their limitations and applications and the types of processing equipment available. Related technology such as measurement and inspection procedures, numerical control systems and automated operations are introduced throughout the course. Prerequisite: EGGN320, MTGN202. 3 hours lecture; 3 semester hours. Taught on demand.

EGGN398. SPECIAL TOPICS IN ENGINEERING (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.

EGGN399. INDEPENDENT STUDY (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 under different topic/experience.

Senior Year

EGGN400. INTRODUCTION TO ROBOTICS (I, II) Overview and introduction to the science and engineering of intelligent mobile robotics and robotic manipulators. Covers guidance and force sensing, perception of the environment around a mobile vehicle, reasoning about the environment to identify obstacles and guidance path features and adaptively controlling and monitoring the vehicle health. A lesser emphasis is placed on robot manipulator kinematics, dynamics, and force and tactile sensing. Surveys manipulator and intelligent mobile robotics research and development. Introduces principles and concepts of guidance, position, and force sensing; vision data processing; basic path and trajectory planning algorithms; and force and position control. Prerequisite: CSCI261 and DCGN381. 2 hours lecture; 1 hour lab; 3 semester hours.

EGGN403. THERMODYNAMICS II (I) This course includes the study of thermodynamic relations, Clapeyron equation, mixtures and solutions, Gibbs function, combustion processes, first and second law applied to reacting systems, third law of thermodynamics, real combustion processes, equilibrium of multicomponent systems, simultaneous chemical reactions of real combustion processes, ionization, overview of the major characteristics of spark-ignition and compression-ignition engines, define parameters used to describe engine operation, develop the necessary thermodynamic and combustion theory required for a quantitative analysis of engine behavior, develop an integrated treatment of the various methods of analyzing idealized models of internal combustion engine cycles, and finally summarize how operating characteristics of spark-ignition and compression-ignition engine depend on the major engine design and operating variables. Prerequisite: EGGN351, EGGN371. 3 hours lecture; 3 semester hours.

EGGN408. INTRODUCTION TO SPACE EXPLORATION (I) Overview of extraterrestrial applications of science and engineering by covering all facets of human and robotic space exploration, including its history, current status, and future opportunities in the aerospace and planetary science fields. Subtopics include: the space environment, space transportation systems, destinations (Low-Earth orbit, Moon, Mars, asteroids, other planets), current research, missions, and projects, the international and commercial perspectives, and discussion of potential career opportunities. This seminarstyle class is taught by CSM faculty, engineers and scientists from space agencies and research organizations, aerospace industry experts, and visionaries and entrepreneurs of the private space commerce sector. Prerequisites: None; 1 hour lecture; 1 semester hour.

EGGN410 - MECHANICAL DESIGN USING GD&T (II) The mechanical design process can be broadly grouped into three phases: requirements and concept, design and analysis, details and drawing package. In this class students will learn concepts and techniques for the details and drawing package phase of the design process. The details of a design are critical to the success of a design project. The details include selection and implementation of a variety of mechanical components such as fasteners (threaded, keys, retaining rings), bearing and bushings. Fits and tolerances will also be covered. Statistical tolerance analysis will be used to verify that an assembly will fit together and to optimize the design. Mechanical drawings have become sophisticated communication tools that are used throughout the processes of design, manufacturing, and inspection. Mechanical drawings are interpreted either by the ANSI or ISO standard which includes Geometric Dimensioning and Tolerancing (GD&T). In this course the student will learn to create mechanical drawings that communicate all of the necessary information to manufacture the part, inspect the part, and allow the parts to be assembled successfully. Prerequisite: EGGN235. 3 hours lecture, 3 semester hours.

EGGN411. MACHINE DESIGN (I, II) This course is an introduction to the principles of mechanical design. Methods for determining static, fatigue and surface failure are presented. Analysis and selection of machine components such as shafts, keys, couplings, bearings, gears, springs, power screws, and fasteners is covered. Prerequisites: EPIC251; EGGN315 or PHGN350;, EGGN 320; and EGGN413. 3 hours lecture, 3 hours lab; 4 semester hours.

EGGN413. COMPUTER AIDED ENGINEERING (I, II) This course introduces the student to the concept of computer-aided engineering. The major objective is to provide

the student with the necessary background to use the computer as a tool for engineering analysis and design. The Finite Element Analysis (FEA) method and associated computational engineering software have become significant tools in engineering analysis and design. This course is directed to learning the concepts of FEA and its application to civil and mechanical engineering analysis and design. Note that critical evaluation of the results of a FEA using classical methods (from statics and mechanics of materials) and engineering judgment is employed throughout the course. Prerequisite: EGGN320. 3 hours lecture; 3 semester hours.

EGGN417. MODERN CONTROL DESIGN (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. Computer-based methods for control system design are presented. Prerequisite: EGGN307. 3 lecture hours, 3 semester hours.

EGGN422. ADVANCED MECHANICS OF MATERIALS (I, II) General theories of stress and strain; stress and strain transformations, principal stresses and strains, octahedral shear stresses, Hooke's law for isotropic material, and failure criteria. Introduction to elasticity and to energy methods. Torsion of noncircular and thin-walled members. Unsymmetrical bending and shear-center, curved beams, and beams on elastic foundations. Introduction to plate theory. Thick-walled cylinders and contact stresses. Prerequisite: EGGN320. 3 hours lecture; 3 semester hours.

EGGN425/BELS425. MUSCULOSKELETAL BIOMECHANICS (II) This course is intended to provide engineering students with an introduction to musculoskeletal biomechanics. At the end of the semester, students should have a working knowledge of the special considerations necessary to apply engineering principles 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: DCGN241, EGGN320, EGGN325/BELS325, or instructor permission. 3 hours lecture; 3 semester hours.

EGGN427/BELS427. PROSTHETIC AND IMPLANT ENGINEERING Prosthetics and implants for the musculoskeletal and other systems of the human body are becoming increasingly sophisticated. From simple joint replacements to myoelectric limb replacements and functional electrical stimulation, the engineering opportunities continue to expand. This course builds on musculoskeletal biomechanics and other BELS courses to provide engineering students with an introduction to prosthetics and implants for the musculoskeletal system. At the end of the semester, students should have a working knowledge of the challenges and special considerations necessary to apply engineering principles to augmentation or replacement in the musculoskeletal system. Prerequisites: EGGN/BELS325 or EGGN/BELS525. 3 hours lecture; 3 semester hours. Fall even years.

EGGN428/BELS428 - COMPUTATIONAL BIOMECHANICS Computational Biomechanics provides an introduction to the application of computer simulation to solve some fundamental problems in biomechanics and bioengineering. Musculoskeletal mechanics, medical image reconstruction, hard and soft tissue modeling, joint mechanics, and inter-subject variability will be considered. An emphasis will be placed on understanding the limitations of the computer model as a predictive tool and the need for rigorous verification and validation of computational techniques. Clinical application of biomechanical modeling tools is highlighted and impact on patient quality of life is demonstrated. Prerequisites: EGGN413, EGGN325. 3 hours lecture, 3 semester hours. Fall odd years.

EGGN430/BELS430. BIOMEDICAL INSTRUMENTATION The acquisition, processing, and interpretation of biological signals present many unique challenges to the Biomedical Engineer. This course is intended to provide students with an introduction to, and appreciation for, many of these challenges. At the end of the semester, students should have a working knowledge of the special considerations necessary to gathering and analyzing biological signal data. EGGN250, DCGN381, EGGN325/BELS325, or instructor permission. 3 hours lecture; 3 semester hours. Fall odd years.

EGGN431. SOIL DYNAMICS (II) Soil Dynamics combines engineering vibrations with soil mechanics, analysis, and design. Students will learn to apply basic principles of dynamics towards the analysis and design of civil infrastructure systems when specific issues as raised by the inclusion of soil materials must be considered. Prerequisites: EGGN320, EGGN361, and MATH225. 3 hours lecture; 3 semester hours.

EGGN433. SURVEYING II (I) Engineering projects with local control using levels, theodolites and total stations, including surveying applications of civil engineering work in the "field". Also includes engineering astronomy and computer generated designs; basic road design including centerline staking, horizontal and vertical curves, slope staking and earthwork volume calculations. Use of commercial software for final plan/profile and earthwork involved for the road project data collected in the field. Conceptual and mathematical knowledge of applying GPS data to engineering projects. Some discussion of the principles and equations of projections (Mercator, Lambert, UTM, State Plane, etc.) and their relationship to the databases of coordinates based on (North American Datum) NAD '27, NAD '83 and (High Accuracy Reference Network) HARN. Prerequisite: EGGN234. 2 hours lecture; 8-9 field work days; 3 semester hours.

EGGN435. HIGHWAY AND TRAFFIC ENGINEERING The emphasis of this class is on the multi-disciplinary nature of highway and traffic engineering and its application to the planning and design of transportation facilities. In the course of the class the students will examine design problems that will involve: geometric design, surveying, traffic operations, hydrology, hydraulics, elements of bridge design, statistics, highway safety, transportation planning, engineering ethics, soil mechanics, pavement design, economics, environmental science. 3 credit hours. Taught on demand.

EGGN441. ADVANCED STRUCTURAL ANALYSIS (II) Introduction to advanced structural analysis concepts. Non-prismatic structures. Arches, Suspension and cable-stayed bridges. Structural optimization. Computer Methods. Structures with nonlinear materials. Internal force redistribution for statically indeterminate structures. Graduate credit requires additional homework and projects. Prerequisite: EGGN342. 3 hour lectures; 3 semester hours.

EGGN442. FINITE ELEMENT METHODS FOR ENGINEERS (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: EGGN320. 3 hours lecture; 3 semester hours.

EGGN444. DESIGN OF STEEL STRUCTURES (I, II) To learn application and use the American Institute of Steel Construction (AISC) Steel Construction Manual. Course develops an understanding of the underlying theory for the design specifications. Students learn basic steel structural member design principles to select the shape and size of a structural member. The design and analysis of tension members, compression members, flexural members, and members under combined loading is included, in addition to basic bolted and welded connection design. Prerequisite: EGGN342. 3 hours lecture; 3 semester hours.

EGGN445. DESIGN OF REINFORCED CONCRETE STRUCTURES (I, II) This course provides an introduction to the materials and principles involved in the design of reinforced concrete. It will allow students to develop an understanding of the fundamental behavior of reinforced concrete under compressive, tensile, bending, and shear loadings, and gain a working knowledge of strength design theory and its application to the design of reinforced concrete beams, columns, slabs, and footings. Prerequisite: EGGN342. 3 hours lecture; 3 semester hours.

EGGN447. TIMBER AND MASONRY DESIGN The course develops the theory and design methods required for the use of timber and masonry as structural materials. The design of walls, beams, columns, beam-columns, shear walls, and structural systems are covered for each material. Gravity, wind, snow, and seismic loads are calculated and utilized for design. Prerequisite: EGGN320 or equivalent. 3 hours lecture: 3 semester hours. Spring semester, odd years.

EGGN448 ADVANCED SOIL MECHANICS Advanced soil mechanics theories and concepts as applied to analysis and design in geotechnical engineering. Topics covered will include seepage, consolidation, shear strength and probabilistic methods. The course will have an emphasis on numerical solution techniques to geotechnical problems by finite elements and finite differences. Prerequisite: EGGN361. 3 hour lectures; 3 semester hours. Fall even years.

EGGN450. MULTIDISCIPLINARY ENGINEERING LABORATORY III (I, II) Laboratory experiments integrating electrical circuits, fluid mechanics, stress analysis, and other engineering fundamentals using computer data acquisition and transducers. Students will design experiments to gather data for solving engineering problems. Examples are recommending design improvements to a refrigerator, diagnosing and predicting failures in refrigerators, computer control of a hydraulic fluid power circuit in a fatigue test, analysis of structural failures in an off-road vehicle and redesign, diagnosis and prediction of failures in a motor/generator system. Prerequisites: EGGN320, EGGN351, either EGGN350 or EGGN382; Corequisite: EGGN307. 3 hours lab; 1 semester hour.

EGGN453/ESGN453. WASTEWATER ENGINEERING (I) The goal of this course is to familiarize students with the fundamental phenomena involved in wastewater treatment processes (theory) and the engineering approaches used in designing such processes (design). This course will focus on the physical, chemical and biological processes applied to liquid wastes of municipal origin. Treatment objectives will be discussed as the driving force for wastewater treatment. Prerequisite: EGGN/ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN454/ESGN454. WATER SUPPLY ENGINEERING (I) Water supply availability and quality. Theory and design of conventional potable water treatment unit processes. Design of distribution systems. Also includes regulatory analysis under the Safe Drinking Water Act (SDWA). Prerequisite: EGGN/ESGN353, or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN455/ESGN455. SOLID AND HAZARDOUS WASTE ENGINEERING (I) This course provides an introduction and overview of the engineering aspects of solid and hazardous waste management. The focus is on control technologies for solid wastes from common municipal and industrial sources and the end-of-pipe waste streams and process residuals that are generated in some key industries. Prerequisite: EGGN/ESGN354. 3 hours lecture; 3 semester hours.

EGGN456/ESGN456. SCIENTIFIC BASIS OF ENVIRONMENTAL REGULATIONS (II) A critical examination of the experiments, calculations and assumptions underpinning numerical and narrative standards contained in federal and state environmental regulations. Top-down investigations of the historical development of selected regulatory guidelines and permitting procedures. Student directed design of improved regulations. Prerequisite: EGGN/ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN457/ESGN457. SITE REMEDIATION ENGINEERING (II) This course describes the engineering principles and practices associated with the characterization and remediation of contaminated sites. Methods for site characterization and risk assessment will be highlighted while the emphasis will be on remedial action screening processes and technology principles and conceptual design. Common isolation and containment and in situ and ex situ treatment technology will be covered. Computerized decision-support tools will be used and case studies will be presented. Prerequisite: EGGN/ESGN354 or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN460. NUMERICAL METHODS FOR ENGINEERS(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 261, MATH225, EGGN320. 3 hours lecture; 3 semester hours.

EGGN464. FOUNDATIONS (I, II) Techniques of subsoil investigation, types of foundations and foundation problems, selection of basis for design of foundation types. Open-ended problem solving and decision making. Prerequisite: EGGN361. 3 hours lecture; 3 semester hours.

EGGN465. UNSATURATED SOIL MECHANICS The focus of this course is on soil mechanics for unsaturated soils. It provides an introduction to thermodynamic potentials in partially saturated soils, chemical potentials of adsorbed water in partially saturated soils, phase properties and relations, stress state variables, measurements of soil water suction, unsaturated flow laws, measurement of unsaturated permeability, volume change theory, effective stress principle, and measurement of volume changes in partially saturated soils. The course is designed for seniors and graduate students in various branches of engineering and geology that are concerned with unsaturated soil's hydrologic and mechanics behavior. Prerequisites: EGGN461 or consent of instructor. 3 hours lecture; 3 semester hours. Taught on demand.

EGGN469. FUEL CELL SCIENCE AND TECHNOLOGY (I) Investigate fundamentals of fuel-cell operation and electrochemistry from a chemical-thermodynamics and materials-science perspective. Review types of fuel cells, fuel-processing requirements and approaches, and fuel-cell system integration. Examine current topics in fuel-cell science and technology. Fabricate and test operational fuel cells in the Colorado Fuel Cell Center. Prerequisites: EGGN371 or ChEN357 or MTGN351, or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN471. HEAT TRANSFER (I, II) Engineering approach to conduction, convection, and radiation, including steady-state conduction, nonsteady-state conduction, internal heat generation conduction in one, two, and three dimensions, and combined conduction and convection. Free and forced convection including laminar and turbulent flow, internal and external flow. Radiation of black and grey surfaces, shape factors and electrical equivalence. Prerequisite: MATH225; EGGN351; EGGN371 or PHGN 341. 3 hours lecture; 3 semester hours.

EGGN473. FLUID MECHANICS II (II) Review of elementary fluid mechanics and engineering, two-dimensional external flows, boundary layers, flow separation; Compressible flow, isentropic flow, normal and oblique shocks, Prandtl-Meyer expansion fans, Fanno and Rayleigh flow; Introduction to flow instabilities (e.g., Kelvin-Helmholtz instability, Raleigh Benard convection). Prerequisite: EGGN351 or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN478. ENGINEERING VIBRATIONS (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'Alambert's principle, Lagrange's equations and Hamilton's principle. Analysis of natural frequencies and mode shapes. Role of damping in machines and structures. Analysis and effects of resonance. Use of the modal superposition method and the transient Duhamel integral method. Prerequisite: EGGN315. 3 hours lecture; 3 semester hours.

EGGN481. DIGITAL SIGNAL PROCESSING (I) This course introduces the mathematical and engineering aspects of digital signal processing (DSP). An emphasis is placed on the various possible representations for discrete-time signals and systems (in the time, z-, and frequency domains) and how those representations can facilitate the identification of signal properties, the design of digital filters, and the sampling of continuous-time signals. Advanced topics include sigma-delta conversion techniques, multi-rate signal processing, and spectral analysis. The course will be useful to all

students who are concerned with information bearing signals and signal processing in a wide variety of application settings, including sensing, instrumentation, control, communications, signal interpretation and diagnostics, and imaging. Prerequisite: EGGN388 or consent of instructor. 3 hours lecture, 3 semester hours.

EGGN482. MICROCOMPUTER ARCHITECTURE AND INTERFACING (I) Microprocessor and microcontroller architecture focusing on hardware structures and elementary machine and assembly language programming skills essential for use of microprocessors in data acquisition, control, and instrumentation systems. Analog and digital signal conditioning, communication, and processing. A/D and D/A converters for microprocessors. RS232 and other communication standards. Laboratory study and evaluation of microcomputer system; design and implementation of interfacing projects. Prerequisite: EGGN384 or consent of instructor. 3 hours lecture; 3 hours lab; 4 semester hours.

EGGN483. ANALOG & DIGITAL COMMUNICATION SYSTEMS (II) Signal classification; Fourier transform; filtering; sampling; signal representation; modulation; demodulation; applications to broadcast, data transmission, and instrumentation. Prerequisite: EGGN388 or consent of instructor. 3 hours lecture; 3 hours lab; 4 semester hours.

EGGN484. POWER SYSTEMS ANALYSIS (I) 3-phase power systems, per-unit calculations, modeling and equivalent circuits of major components, voltage drop, fault calculations, symmetrical components and unsymmetrical faults, system grounding, power-flow, selection of major equipment, design of electric power distribution systems. Prerequisite: EGGN389. 3 hours lecture; 3 semester hours.

EGGN485. INTRODUCTION TO HIGH POWER ELECTRONICS (II) Power electronics are used in a broad range of applications from control of power flow on major transmission lines to control of motor speeds in industrial facilities and electric vehicles, to computer power supplies. This course introduces the basic principles of analysis and design of circuits utilizing power electronics, including AC/DC, AC/AC, DC/DC, and DC/AC conversions in their many configurations. Prerequisites: EGGN385, EGGN389. 3 hours lecture; 3 semester hours.

EGGN486. PRACTICAL DESIGN OF SMALL RENEWABLE ENERGY SYSTEMS This course provides the fundamentals to understand and analyze renewable energy powered electric circuits. It covers practical topics related to the design of alternative energy based systems. It is assumed the students will have some basic and broad knowledge of the principles of electrical machines, thermodynamics, electronics, and fundamentals of electric power systems. One of the main objectives of this course is to focus on the interdisciplinary aspects of integration of the alternative sources of energy, including hydropower, wind power, photovoltaic, and energy storage for those systems. Power electronic systems will be discussed and how those electronic systems can be used for stand-alone and grid-connected electrical energy applications. Prerequisite: EGGN382 or consent of instructor. 3 hours lecture; 3 semester hours. Taught on demand.

EGGN487. ANALYSIS AND DESIGN OF ADVANCED ENERGY SYSTEMS (II) The course investigates the design, operation and analysis of complex interconnected electric power grids, the basis of our electric power infrastructure. Evaluating the system operation, planning for the future expansion under deregulation and restructuring, ensuring system reliability, maintaining security, and developing systems that are safe to operate has become increasingly more difficult. Because of the complexity of the problems encountered, analysis and design procedures rely on the use of sophisticated power system simulation computer programs. The course features some commonly used commercial software packages. Prerequisites: EGGN 484 or consent of instructor. 2 hours lecture, 3 hours laboratory; 3 semester hours.

EGGN490 SUSTAINABLE ENGINEERING DESIGN (I) This course is a comprehensive introduction into concept of sustainability and sustainable development from an engineering point of view. It involves the integration of engineering and statistical analysis through a Life Cycle Assessment tool, allowing a quantitative, broad-based consideration any process or product design and their respective impacts on environment, human health and the resource base. The requirements for considering social implications are also discussed. Prerequisites: Senior or graduate standing, or consent of instructor.; 3 hours lecture, 3 semester hours.

EGGN491. SENIOR DESIGN I (I, II) (WI) This course is the first of a two-semester capstone course sequence giving the student experience in the engineering design process. Realistic open-ended design problems are addressed for real world clients at the conceptual, engineering analysis, and the synthesis stages and include economic and ethical considerations necessary to arrive at a final design. Students are assigned to interdisciplinary teams and exposed to processes in the areas of design methodology, project management, communications, and work place issues. Strong emphasis is placed on this being a process course versus a project course. This is a writing-across-the-curriculum course where students' written and oral communication skills are strengthened. The design projects are chosen to develop student creativity, use of design methodology and application of prior course work paralleled by individual study and research. Prerequisite: Field session appropriate to the student's specialty and EPIC251. For Mechanical Specialty students, concurrent enrollment or completion of EGGN 411. For Civil Specialty students, concurrent enrollment or completion of any one of EGGN444, EGGN445, EGGN447, or EGGN464. 1-2 hour lecture; 6 hours lab; 3 semester hours.

EGGN492. SENIOR DESIGN II (I, II) (WI) This course is the second of a two-semester sequence to give the student experience in the engineering design process. Design integrity and performance are to be demonstrated by building a prototype or model, or producing a complete drawing and specification package, and performing pre-planned experimental tests, wherever feasible, to verify design compliance with client requirements. Prerequisite: EGGN491. 1 hour lecture; 6 hours lab; 3 semester hours.

EGGN493. ENGINEERING DESIGN OPTIMIZATION The application of gradient, stochastic and heuristic optimization algorithms to linear and nonlinear optimization problems in constrained and unconstrained design spaces. Students will consider problems with continuous, integer and mixed-integer variables, problems with single or multiple objectives and the task modeling design spaces and constraints. Design optimization methods are becoming of increasing importance in engineering design and offer the potential to reduce design cycle times while improving design quality by leveraging simulation and historical design data. Prerequisites: MATH213 and MATH225 (Required), CSCI260 or CSCI261 or other experience with computer programming languages (Suggested). 3 hours lecture; 3 semester hours. Spring even years.

EGGN497. SUMMER PROGRAMS

EGGN498. SPECIAL TOPICS IN ENGINEERING (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.

EGGN499. INDEPENDENT STUDY (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 under different topic/experience.

Environmental Science and Engineering

JOHN E. McCRAY, Professor and Division Director
JÖRG DREWES, Professor
TISSA ILLANGASEKARE, Professor and AMAX Distinguished Chair
ROBERT L. SIEGRIST, Professor
RONALD R.H. COHEN, Associate Professor
LINDA A. FIGUEROA, Associate Professor
JUNKO MUNAKATA MARR, Associate Professor
JOHN R. SPEAR. Associate Professor
TZAHI Y. CATH, Assistant Professor
CHRISTOPHER P. HIGGINS, Assistant Professor
JONATHAN O. SHARP, Assistant Professor
PEI XU, Research Associate Professor
TOSHIHIRO SAKAKI, Research Assistant Professor
KATHRYN LOWE, Senior Research Associate
PAUL B. QUENEAU, Adjunct Professor
PATRICK RYAN, Adjunct Professor
DANIEL T. TEITELBAUM, Adjunct Professor
BRUCE D. HONEYMAN, Emeritus Professor

Program Description

The Environmental Science and Engineering (ESE) Division offers specialty and minor programs in Environmental Science and Engineering. ESE provides an undergraduate curriculum leading to a Minor (18 hours) or an Area of Special Interest (ASI) (12 hours).

Environmental Engineering Specialty in the Engineering Division

The Environmental Engineering Specialty introduces students to the fundamentals of environmental engineering including the scientific and regulatory basis of public health and environmental protection. Topics covered include environmental science and regulatory processes, water and wastewater engineering, solid and hazardous waste management, and contaminated site remediation.

See entries in this Bulletin under Engineering (pg. 48) and the degree program leading to the BS in Engineering with a Specialty in Environmental Engineering. This undergraduate Specialty is supported by the Environmental Science and Engineering Division.

Environmental Science and Engineering Minor and ASI

General Requirements:

A **Minor Program** of study consists of a minimum of 18 credit hours of a logical sequence of courses. With the exception of the McBride Honors minor, only three of these hours may be taken in the student's degree-granting department and no more than three of these hours may be at the 100- or 200- level. A Minor Program may not be completed in the same department as the major.

An **Area of Special Interest** (ASI) consists of a minimum of 12 credit hours of a logical sequence of courses. Only three of these hours may be taken at the 100- or 200-level and no more than three of these hours may be specifically required for the degree program in which the student is graduating. An ASI may be completed within the same major department.

A **Minor Program / Area of Special Interest** declaration (available in the Registrar's Office) should be submitted for approval prior to the student's completion of half of the hours proposed to constitute the program. Approvals are required from the Director of the Environmental Science and Engineering Division, the student's advisor, and the Department Head or Division Director in the department or division in which the student is enrolled.

Students majoring in Engineering with an Environmental Specialty may not also complete a minor or ASI in Environmental Science and Engineering.

All students pursuing the ESE Minor or ASI are required to take ESGN/EGGN353 and ESGN/EGGN354.

Additional courses for the ASI or Minor sequence must be selected from:

ESGN401 Fundamentals of Ecology
ESGN440A Environmental Pollution: Sources, Characteristics, Transport and Fate
ESGN/EGGN453 Wastewater Engineering
ESGN/EGGN454 Water Supply Engineering
ESGN/EGGN456 Scientific Basis of Environmental Regulations
ESGN/EGGN457 Site Remediation Engineering
ESGN460 Onsite Water Reclamation and Reuse
ESGN462 Solid Waste Minimization and Recycling
ESGN463 Pollution Prevention: Fundamentals and Practice
ESGN490 Environmental Law

Combined Degree Program Option

CSM Undergraduate students have the opportunity to begin work on a M.S. degree in Environmental Science and Engineering while completing their Bachelor's degree. The CSM Combined Degree Program provides the vehicle for students to use undergraduate coursework as part of their Graduate Degree curriculum. For more information please see the ESE Division website: http://ese.mines.edu/ufield.html.

Description of Courses

Undergraduate Courses

ESGN198. SPECIAL TOPICS IN ENVIRONMENTAL SCIENCE AND ENGINEERING (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.

ESGN199. INDEPENDENT STUDY (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 under different titles.

ESGN203/SYGN203. NATURAL AND ENGINEERED ENVIRONMENTAL SYSTEMS Introduction to natural and engineered environmental systems analysis. Environmental decision making, sustainable development, pollution sources, effects and prevention, and environmental life cycle assessment. The basic concepts of material balances, energy balances, chemical equilibrium and kinetics and structure and function of biological systems will be used to analyze environmental systems. Case studies in sustainable development, industrial ecology, pollution prevention and life cycle assessment with be covered. The goal of this course is to develop problem-solving skills associated with the analysis of environmental systems. Prerequisites: CHGN122 or concurrent; MATH112 or concurrent; PHGN 100; SYGN101. 3 semester hours.

ESGN298. SPECIAL TOPICS IN ENVIRONMENTAL SCIENCE AND ENGINEERING (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.

ESGN299. INDEPENDENT STUDY (I, II) Individual research or special problem projects supervised by faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: Independent Study form must be complete and submitted to the Registrar. Variable credit: 1-6. Repeatable for credit under different titles.

ESGN353/EGGN353. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I (I, II) Topics covered include history of water related environmental law and regulation, major sources and concerns of water pollution, water quality parameters and their measurement, material and energy balances, water chemistry concepts, microbial concepts, aquatic toxicology and risk assessment. Prerequisite: : CHGN122, PHGN100 and MATH213, or consent of instructor. 3 hours lecture; 3 semester hours.

ESGN354/EGGN354. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II (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 organi-

zations in environmental management (relative to air, solid and hazardous waste). Prerequisite: CHGN122, PHGN100 and MATH213, or consent of instructor. 3 hours lecture; 3 semester hours.

ESGN398. SPECIAL TOPICS IN ENVIRONMENTAL SCIENCE AND ENGINEERING (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: Consent of instructor. Variable credit: 1-6 semester hours. Repeatable for credit under different titles.

ESGN399. INDEPENDENT STUDY (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 under different titles.

ESGN401. FUNDAMENTALS OF ECOLOGY (I) 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 the above. Three to four weekend field trips will be arranged during the semester. 3 hours lecture; 3 semester hours.

ESGN403/CHGN403. INTRODUCTION TO ENVIRONMENTAL CHEMISTRY (I) Processes by which natural and anthropogenic chemicals interact, react and are transformed and redistributed in various environmental compartments. Air, soil and aqueous (fresh and saline surface and groundwaters) environments are covered, along with specialized environments such as waste treatment facilities and the upper atmosphere. Prerequisites: SYGN101, DCGN209, and CHGN222. 3 hours lecture; 3 semester hours.

ESGN440/ESGN510. ENVIRONMENTAL POLLUTION: SOURCES, CHARACTERISTICS, TRANSPORT AND FATE (I) This course describes the environmental behavior of inorganic and organic chemicals in multimedia environments, including water, air, sediment and biota. Sources and characteristics of contaminants in the environment are discussed as broad categories, with some specific examples from various industries. Attention is focused on the persistence, reactivity, and partitioning behavior of contaminants in environmental media. Both steady and unsteady state multimedia environmental models are developed and applied to contaminated sites. The principles of contaminant transport in surface water, groundwater and air are also introduced. The course provides students with the conceptual basis and mathematical tools for predicting the behavior of contaminants in the environment. Prerequisite: EGGN/ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

ESGN453/EGGN453. WASTEWATER ENGINEERING (I) The goal of this course is to familiarize students with the fundamental phenomena involved in wastewater treatment processes (theory) and the engineering approaches used in designing such processes (design). This course will focus on the physical, chemical and biological processes applied to liquid wastes of municipal origin. Treatment objectives will be discussed as the driving force for wastewater treatment. Prerequisite: EGGN/ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

ESGN454/EGGN454. WATER SUPPLY ENGINEERING (II) Water supply availability and quality. Theory and design of conventional potable water treatment and processes. Design of distribution systems. Also includes regulatory analysis under the Safe Drinking Water Act (SDWA). Prerequisite: EGGN/ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

ESGN455/EGGN455. SOLID AND HAZARDOUS WASTE ENGINEERING (II) This course provides an introduction and overview of the engineering aspects of solid and hazardous waste management. The focus is on control technologies for solid wastes from common municipal and industrial sources and the end-of-pipe waste streams and process residuals that are generated in some key industries. Prerequisite: EGGN/ESGN354. 3 hours lecture; 3 semester hours.

ESGN456/EGGN456. SCIENTIFIC BASIS OF ENVIRONMENTAL REGULATIONS (I) A critical examination of the experiments, calculations and assumptions underpinning numerical and narrative standards contained in federal and state environmental regulations. Top-down investigations of the historical development of selected regulatory guidelines and permitting procedures. Student directed design of improved regulations. Prerequisite: EGGN/ESGN353. 3 hours lecture; 3 semester hours.

ESGN457/EGGN457. SITE REMEDIATION ENGINEERING (II) This course describes the engineering principles and practices associated with the characterization and remediation of contaminated sites. Methods for site characterization and risk assessment will be highlighted while the emphasis will be on remedial action screening processes and technology principles and conceptual design. Common isolation and containment and in-situ and ex-situ treatment technology will be covered. Computerized decision-support tools will be used and case studies will be presented. Prerequisites: EGGN/ESGN354 or consent of instructor. 3 hours lecture; 3 semester hours.

ESGN460. ONSITE WATER RECLAMATION AND REUSE (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: EGGN/ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

ESGN462/MTGN462/MTGN527. SOLID WASTE MINIMIZATION AND RECYCLING (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: EGGN/ESGN353 or EGGN/ESGN354 or consent of instructor. 3 hours lecture; 3 semester hours.

ESGN463. POLLUTION PREVENTION: FUNDAMENTALS AND PRACTICE (II) The objective of this course is to introduce the principles of pollution prevention, environmentally benign products and processes, and manufacturing systems. The course provides a thorough foundation in pollution prevention concepts and methods. Engineers and scientists are given the tools to incorporate environmental consequences into decision-making. Sources of pollution and its consequences are detailed. Focus includes sources and minimization of industrial pollution; methodology for life-cycle assessments and developing successful pollution prevention plans; technological means for minimizing the use of water, energy, and reagents in manufacturing; and tools for achieving a sustainable society. Materials selection, process and product design, and packaging are also addressed. Prerequisite: EGGN/ESGN353 or EGGN/ESGN354 or consent of instructor. 3 hours lecture; 3 semester hours.

ESGN490/ESGN502. ENVIRONMENTAL LAW (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: EGGN/ESGN353 or EGGN/ESGN354, or consent of instructor. 3 hours lecture; 3 semester hours.

ESGN497. SUMMER PROGRAMS

ESGN498. SPECIAL TOPICS IN ENVIRONMENTAL SCIENCE AND ENGINEERING (I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

ESGN499. INDEPENDENT STUDY (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 under different titles.

Geology and Geological Engineering

JOHN D. HUMPHREY, Associate Professor and Department Head
JOHN B. CURTIS, Professor
WENDY J. HARRISON, Professor and Associate Provost
MURRAY W. HITZMAN, Professor, Charles F. Fogarty Professor of Economic Geology
JOHN E. McCRAY, Professor and Division Director, Environmental Science & Engineering
PAUL SANTI, Professor
STEPHEN A. SONNENBERG, Professor, Charles Boettcher Distinguished Chair in Petroleum Geology
RICHARD F. WENDLANDT, Professor
DAVID A. BENSON, Associate Professor
JERRY D. HIGGINS, Associate Professor
REED M. MAXWELL, Associate Professor
PIRET PLINK-BJORKLUND, Associate Professor
BRUCE TRUDGILL, Associate Professor
WEI ZHOU, Associate Professor
JENNIFER L. ASCHOFF, Assistant Professor
NIGEL KELLY, Assistant Professor
YVETTE KUIPER, Assistant Professor
THOMAS MONECKE, Assistant Professor
CHRISTIAN V. SHOREY, Teaching Associate Professor
CHARLES F. KLUTH, Distinguished Scientist
DAVID PYLES, Research Professor
DONNA S. ANDERSON, Research Associate Professor
MASON DYKSTRA, Research Associate Professor
NICHOLAS B. HARRIS, Research Associate Professor
KARIN HOAL, Research Associate Professor
MAEVE BOLAND, Research Assistant Professor
MARY CARR, Research Assistant Professor
THOMAS L.T. GROSE, Professor Emeritus
JOHN D. HAUN, Professor Emeritus
NEIL F. HURLEY, Professor Emeritus
RICHARD W. HUTCHINSON, Professor Emeritus
KEENAN LEE, Professor Emeritus
EILEEN POETER, Professor Emerita
SAMUEL B. ROMBERGER, Professor Emeritus
A. KEITH TURNER, Professor Emeritus
JOHN E. WARME, Professor Emeritus
ROBERT J. WEIMER, Professor Emeritus
L. GRAHAM CLOSS, Associate Professor Emeritus
TIMOTHY A. CROSS, Associate Professor Emeritus
GREGORY S. HOLDEN, Associate Professor Emeritus
ERIC P. NELSON, Associate Professor Emeritus

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, gas and coal and their efficient extraction.

Mineral Exploration and Development Engineering. Careers in search for and development of natural deposits of metals, industrial materials and rock aggregate.

Geological Science. Students are also well prepared to pursue careers in basic geoscience. Graduates have become experts in fields as divergent as global climate change, the early history of the Earth, planetary science, fractal representation of ground-water flow and simulation of sedimentary rock sequences, to name a few. Careers are available in research and education.

The curriculum may be followed along two concentration paths with slightly different upper division requirements. Both concentrations are identical in the first two years as students study basic science, mathematics, engineering science, and geological science. In the junior year those students pursuing careers in ground-water engineering, engineering geology and geotechnics, or geoenvironmental engineering

applications follow the Environmental, Engineering Geology and Geotechnics, and Ground-Water Engineering Concentration. Students anticipating careers in resource exploration and development or who expect to pursue graduate studies in geological sciences follow the Mineral and Petroleum Exploration Engineering Concentration.

At all levels the Geological Engineering Program emphasizes laboratory and field experience. All courses have a laboratory session, and after the junior year students participate in a field course, which is six weeks of geologic and engineering mapping and direct observation. The course involves considerable time outdoors in the mountains and canyons of Utah and southwestern Colorado.

At the senior level, students begin to focus on a career path by taking course sequences in at least two areas of geological engineering specialization. The course sequences begin with a 4 unit course in the fundamentals of a field of geological engineering which is followed by a 3 unit design-oriented course that emphasizes experience in direct application of principles through design projects.

Combined Undergraduate/Graduate Programs

Several degree programs offer CSM undergraduate students the opportunity to begin work on a Graduate Certificate, Professional Degree, or Master Degree while completing the requirements for their Bachelor Degree. These programs can give students a head start on graduate education. An overview of these combined programs and description of the admission process and requirements are found in the Graduate Degrees and Requirements section of the Graduate Bulletin.

Program Educational Objectives (Bachelor of Science in Geological Engineering)

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

Objective 1. Engineering Competence

All graduates of the CSM Geological Engineering program shall be competent geological engineers. They shall be able to identify, formulate, and solve engineering problems by application of a strong knowledge of mathematics, science, and engineering principles and practices. They shall be able to design data acquisition programs to evaluate acquired data and to utilize data to design exploration, construction or remediation systems within economic guidelines. The capabilities shall be derived from classroom, project, and experiential aspects of students' degree programs.

Objective 2. Communication

Graduates must have the communication skills that permit them to convey technical information, geological engineering concepts, and results of technical studies to peers and the lay public. Communication skills will include oral, written and graphic presentations, computer-based retrieval, manipulation and analysis of technical information, and general computer literacy.

Objective 3. Leadership and Teamwork

Graduates should appreciate and respect the characteristics and value of both leadership and teamwork, and should possess the attitude that each is important

Objective 4. Provide motivation for life-long learning.

Undergrad students will be exposed to methods that motivate them to continue their personal and professional growth through life-long learning after graduation. We will introduce students to experiences that will help them appreciate that scientific curiosity, self-directed learning, post-graduate education, and attention to world events are crucial attributes to continued growth and success in their professional career.

Objective 5. Integrity and Ethics

Graduates must have integrity and must practice ethical behavior in their professional activities in the geological engineering discipline.

Program Requirements

In order to achieve the program goals listed above, every student working towards the Bachelor of Science Degree in Geological Engineering must complete the following requirements:

Degree Requirements (Geological Engineering)

Sophomore Year Fall Semester	lec.	lab.	sem.hrs.
GEGN203 Engineering Terrain Analysis	2		2
GEGN204 Geologic Principles and Processes	2		2
GEGN205 Advanced Physical Geology Laboratory		3	1
MATH213 Calc. for Scientists & Engn'rs III	4		4
DCGN241 Statics	3		3
SYGN200 Human Systems	3		3
PAGN201 Physical Education III		2	0.5
Total			15.5

Sophomore Year Spring Semester	lec.	lab.	sem.hrs.
EPIC264 Geology GIS	2	3	3
GEGN206 Earth Materials	2	3	3
MATH222 Differential Equations for Geologists and Geological Engineers	2		2
PHGN200 Physics II	3.5	3	4.5
EGGN320 Mechanics of Materials	3		3
PAGN202 Physical Education IV		2	0.5
Total			16

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.

Junior Year Fall Semester	lec.	lab.	sem.hrs.
GEOL309 Structural Geology	3	3	4
GEOL321 Mineralogy & Mineral Characterization	2	3	3
DCGN209 Thermodynamics	3		3
EBGN201 Principles of Economics	3		3
EGGN361 Soil Mechanics OR	3		3
MNGN321 Introduction to Rock Mechanics*	2	3	3
Total			16

Junior Year Spring Semester	lec.	lab.	sem.hrs.
GEGN307 Petrology	2	3	3
GEGN317 Field Methods	1	8	2
GEOL314 Stratigraphy	3	3	4
GEGN351 Geologic Fluid Mechanics	3		3
LAIS/EBGN H&SS GenEd Restricted Elective I	3		3
Tech Elective II *	3		3
Total			18

*Technical Electives I & II: Either MNGN321 or EGGN361 is required as ONE of the technical electives. An additional technical elective must be selected from a department list of approved courses. The technical elective credits must total a minimum of 6 hours of engineering topics with a minimum of 3 credit hours of engineering design.

Summer Term	lec.	lab.	sem.hrs.
GEGN316 Field Geology		6	6

Senior Year Fall Semester	lec.	lab.	sem.hrs.
GEGN4— Option Elective	3	3	4
GEGN4— Option Elective	3	3	4
GEGN432 Geological Data Management	1	6	3
LAIS/EBGN H&SS GenEd Restricted Elective II	3		3
Free Elective			3
Total			17

Senior Year Spring Semester	lec.	lab.	sem.hrs.
GEGN4— Design Elective	2	3	3
GEGN4— Design Elective	2	3	3
LAIS/EBGN H&SS GenEd Restricted Elective III	3		3
Free Elective			3
Free Elective			3
Total			15

Degree Total	136.5

Option Electives:

Students must take TWO of the following four courses.

GEGN401 Mineral Deposits	4 credits
GEGN438 Petroleum Geology	4 credits
GEGN467 Ground-Water Engineering	4 credits
GEGN468 Engineering Geology & Geotechnics	4 credits

Design Electives:

Students must take TWO design courses, corresponding in subject area to the Option Elective.

GEGN403 Mineral Exploration Design	3 credits
GEGN439 Multi-Disciplinary Petroleum Design	3 credits
GEGN469 Engineering Geology Design	3 credits
GEGN470 Ground-Water Engineering Design	3 credits

Environmental, Engineering Geology and Geotechnics, and Ground-Water Engineering Concentration

Recommended for students intending careers in geotechnical engineering, hydrogeology, or other environmental engineering careers.

Junior Year Fall Semester	lec.	lab.	sem.hrs.
GEGN 212 Petrography of Geol. Engineers	1	3	2
GEOL309 Structural Geology	3	3	4
DCGN209 Introduction to Thermodynamics	3		3
or			
EGGN371 Thermodynamics	3		3
EBGN201 Principles of Economics	3		3
EGGN361 Soil Mechanics	3		3
EGGN363 Soil Mechanics Lab		1	1
Total			16

Junior Year Spring Semester	lec.	lab.	sem.hrs.
GEGN317 Field Methods	1	8	2
GEGN473 Site Investigation	3		3
GEOL314 Stratigraphy	3	3	4
GEGN 351 Geologic Fluid Mechanics	3		3
LAIS/EBGN H&SS GenEd Restricted Elective I	3		3
MNGN321 Rock Mechanics	2	3	3
Total			18

Summer Term	lec.	lab.	sem.hrs.
GEGN316 Field Geology		6	6

Senior Year Fall Semester	lec.	lab.	sem.hrs.
GEGN468 Engineering Geology	3	3	4
GEGN467 Ground-Water Engineering	3	3	4
GEGN432 Geological Data Management	1	6	3
LAIS/EBGN H&SS GenEd Restricted Elective II	3		3
Free Elective	3		3
Total			17

Senior Year Spring Semester	lec.	lab.	sem.hrs.
GEGN469 Engineering Geology Design	3		3
GEGN470 Ground-Water Engineering Design	3		3
LAIS/EBGN H&SS GenEd Restricted Elective III	3		3
Free Elective	3		3
Free Elective	3		3
Total			15

Degree Total	136.5

Students in the Environmental, Engineering Geology and Geotechnics, and Ground-Water Engineering Concentration may further specialize by utilizing their free elective courses to emphasize a specific specialty. Suggested courses are presented below and should be selected in consultation with the student's advisor. The emphasis area is an informal designation only and it will not appear on the transcript.

Engineering Geology and Geotechnics Emphasis:
EGGN464 Foundations
GEGN475 Applications of Geographic Information Systems
EBGN321 Engineering Economics
EGGN465 Unsaturated Soil Mechanics
GEGN399 Independent Study in Engineering Geology
GEGN499 Independent Study in Engineering Geology
GEGN307 Petrology
GEOL321 Mineralogy & Mineral Characterization
CSCI261 Programming Concepts
MNGN404 Tunneling
MNGN408 Underground Design and Construction
MNGN410 Excavation Project Management
MNGN445/545 Rock Slope Design

Water Engineering Emphasis:
EBGN321 Engineering Economics
EGGN/ESGN353 Fundamentals of Environmental Sci. & Engr. I
EGGN/ESGN354 Fundamentals of Environmental Sci. & Engr. II
EGGN465 Unsaturated Soil Mechanics
EGGN473 Fluid Mechanics
EGGN/ESGN453 Wastewater Engineering
EGGN/ESGN454 Water Supply Engineering
ESGN401 Fundamentals of Ecology
ESGN440 Environmental Pollution
ESGN/EGGN455 Solid & Hazardous Waste Engineering
ESGN/EGGN456 Scientific Basis of Environmental Regulations
ESGN/EGGN457 Site Remediation Engineering
ESGN490 Environmental Law
ESGN/CHGN403 Intro. to Environmental Chemistry
GEGN499 Independent Study in Hydrogeology
GEGN475 Applications of Geographic Information Systems
GEGN481 Advanced Hydrology
GEGN483 Math Modeling of Ground-Water Systems
GEOL321 Mineralogy & Mineral Characterization
LAIS487 Environmental Politics & Policy
LAIS488 Water Politics & Policy
CSCI260 Fortran Programming
CSCI261 Programming Concepts
MATH332 Linear Algebra

Geological Engineering Minor and Area of Special Interest

To receive a minor or ASI, a student must take at least 12 (ASI) or 18 (minor) hours of a logical sequence of courses. This may include SYGN101 (4 hours) and up to 4 hours at the 200-level.

Description of Courses

Freshman Year

GEOL102. INTRODUCTION TO GEOLOGICAL ENGINEERING (II) Presentations by faculty members and outside professionals of case studies to provide a comprehensive overview of the fields of Geology and Geological Engineering and the preparation necessary to pursue careers in those fields. A short paper on an academic professional path will be required. Prerequisite: SYGN101 or concurrent enrollment. 1 hour lecture; 1 semester hour.

GEGN/GEOL198. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING (I, II) Special topics classes taught on a one-time basis. May include lecture, laboratory and field trip activities. Prerequisite: Approval of instructor and department head. Variable credit; 1 to 6 semester hours. Repeatable for credit under different titles.

GEGN199. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY (I, II) Individual special studies, laboratory and/or field problems in geological engineering or engineering hydrogeology. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GEOL199. INDEPENDENT STUDY IN GEOLOGY (I, II) Individual special studies, laboratory and/or field problems in geology. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Sophomore Year

GEGN203. ENGINEERING TERRAIN ANALYSIS (I) Analysis of landforms, geologic processes, principles of geomorphology, mapping, air photo and map interpretation, and engineering uses of geologic information.. Geomorphology of glacial, volcanic, arid, karst, and complex geological landscapes. Introduction to weathering, soils, hillslopes, and drainage systems. Prerequisite: SYGN101. Must be taken concurrently with GEGN204 and GEGN205 for GE majors. 2 hours lecture, 2 semester hours.

GEGN204. GEOLOGIC PRINCIPLES AND PROCESSES (I) Introduction to advanced concepts of physical and historical geology from a scientific perspective. Development of the geologic time scale, relative time, and geochronology. Chemical composition and cycling of elements in the Earth. Plate tectonics and how tectonics influence sea-level history and sedimentation patterns. Evolution and the fossil record. Critical events in Earth history with a focus on North America and Colorado geology. Prerequisite: SYGN101. Must be taken concurrently with GEGN203 and GEGN205 for GE majors. 2 hours lecture, 2 semester hours

GEGN205. ADVANCED PHYSICAL GEOLOGY LABORATORY (I) Basic geologic mapping and data gathering skills, with special emphasis on air photos and topographic and geologic maps. Course will include fieldwork in geomorphic regions of Colorado, with analysis of landforms and geologic processes. Applications of geologic information to solve geologic engineering problems. Prerequisite: SYGN101. Must be taken concurrently with GEGN203 and GEGN204 for GE majors. 3 hours laboratory, 1 semester hour.

GEGN206. EARTH MATERIALS (II) Introduction to Earth Materials, emphasizing the structure, composition, formation, and behavior of minerals. Laboratories emphasize the

recognition, description, and engineering evaluation of earth materials. Prerequisite: SYGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

GEGN 212. PETROGRAPHY FOR GEOLOGICAL ENGINEERS (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 near-surface 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: GEGN 206 or equivalent. 1 hour lecture, 3 hours lab; 2 semester hours.

GEGN/GEOL298. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING (I, II) Special topics classes taught on a one-time basis. May include lecture, laboratory and field trip activities. Prerequisite: Approval of instructor and department head. Variable credit; 1 to 6 semester hours. Repeatable for credit under different titles.

GEGN299. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY (I, II) Individual special studies, laboratory and/or field problems in geological engineering or engineering hydrogeology. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 semester hours. Repeatable for credit.

GEOL299. INDEPENDENT STUDY IN GEOLOGY (I, II) Individual special studies, laboratory and/or field problems in geology. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 semester hours. Repeatable for credit.

Junior Year

GEGN307. PETROLOGY (II) An introduction to igneous, sedimentary and metamorphic processes, stressing the application of chemical and physical mechanisms to study the origin, occurrence, and association of rock types. Emphasis on the megascopic and microscopic classification, description, and interpretation of rocks. Analysis of the fabric and physical properties. Prerequisite: GEOL321, DCGN209. 2 hours lecture, 3 hours lab; 3 semester hours.

GEOL308. INTRODUCTORY APPLIED STRUCTURAL GEOLOGY (II) Nature and origin of structural features of Earth's crust emphasizing oil entrapment and control of ore deposition. Structural patterns and associations are discussed in context of stress/strain and plate tectonic theories, using examples of North American deformed belts. Lab and field projects in structural geometry, map air photo and cross section interpretation, and structural analysis. Course required of all PEGN and MNGN students. Prerequisite: SYGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

GEOL309. STRUCTURAL GEOLOGY AND TECTONICS (I) (WI) Recognition, habitat, and origin of deformational structures related to stresses and strains (rock mechanics and microstructures) and modern tectonics. Structural development of the Appalachian and Cordilleran systems. Comprehensive laboratory projects use descriptive geometry, stereographic projection, structural contours, map and air photo interpretation, structural cross section and structural pattern analysis. Required of Geological and Geophysical Engineers. Prerequisite: SYGN101, GEGN203, GEGN204, GEGN205 and GEGN206 or GPGN200. 3 hours lecture, 3 hours lab; 4 semester hours.

GEOL310. EARTH MATERIALS AND RESOURCES (I) Introduction to Earth Materials, emphasizing the structure, formation, distribution and engineering behavior of minerals, rocks and ores. Laboratories emphasize the recognition, description and engineering evaluation of natural materials. Lectures present the knowledge of natural materials, processes and resources necessary for mining engineering careers. Prerequisite: SYGN101. 3 hours lecture, 3 hours lab: 4 semester hours.

GEOL311. STRUCTURAL GEOLOGY FOR MINING ENGINEERS (II) Nature and origin of structural features of Earth's crust emphasizing structural controls of ore deposits and analysis of structures related to rock engineering and mining. Structural features and processes are related to stress/strain theory and rock mechanics principles. Lab and field projects include deformation experiments, geologic map, cross section, and orientation data analysis of structural features including fractures, faults, folds, and rock cleavages. Prerequisite: SYGN101. 2 semester hours combined lecture and lab.

GEOL314. STRATIGRAPHY (II) Lectures and laboratory and field exercises in concepts of stratigraphy and biostratigraphy, facies associations in various depositional environments, sedimentary rock sequences and geometries in sedimentary basins, and geohistory analysis of sedimentary basins. . Prerequisite: SYGN101, GEGN203, GEGN204, GEGN205. 3 hours lecture, 3 hours lab; 4 semester hours.

GEOL315. SEDIMENTOLOGY AND STRATIGRAPHY (I) Integrated lecture, laboratory and field exercises on the genesis of sedimentary rocks as related to subsurface porosity and permeability development and distribution for non-geology majors. Emphasis is placed on siliciclastic systems of varying degrees of heterogeneity. Topics include diagenesis, facies analysis, correlation techniques, and sequence and seismic stratigraphy. Application to hydrocarbon exploitation stressed throughout the course. Required of all PEGN students. Prerequisite: SYGN101, PEGN308, or consent of instructor. 2 hours lecture, 3 hours lab; 3 semester hours.

GEGN316. FIELD GEOLOGY (S) Six weeks of field work, stressing geology of the Southern Rocky Mountain Province. Measurement of stratigraphic sections. Mapping of igneous, metamorphic, and sedimentary terrain using air photos, topographic maps, plane table, and other methods. Diversified

individual problems in petroleum geology, mining geology, engineering geology, structural geology, and stratigraphy. Formal reports submitted on several problems. Frequent evening lectures and discussion sessions. Field trips emphasize regional geology as well as mining, petroleum, and engineering projects. . Prerequisite: GEGN203, GEGN204, GEGN205, GEGN206, GEGN212 or GEGN307, GEOL314, GEOL309, and GEGN317. 6 semester hours (Summer Term).

GEGN317. GEOLOGIC FIELD METHODS (II) Methods and techniques of geologic field observations and interpretations. Lectures in field techniques and local geology. Laboratory and field project in diverse sedimentary, igneous, metamorphic, structural, and surficial terrains using aerial photographs, topographic maps and compass and pace methods. Geologic cross sections maps, and reports. Weekend exercises required. Prerequisite: GEGN203, GEGN204, GEGN205, GEOL309 or GEOL308. Completion or concurrent enrollment in GEGN307 and GEOL314. 1 hour lecture, 8 hours field; 2 semester hours.

GEOL321. MINERALOGY AND MINERAL CHARACTERIZATION (I) Principles of mineralogy and mineral characterization. Crystallography of naturally occurring materials. Principles of crystal chemistry. Interrelationships among mineral structure, external shape, chemical composition, and physical properties. Introduction to mineral stability. Laboratories emphasize analytical methods, including X-ray diffraction, scanning electron microscopy, and optical microscopy. Prerequisite: SYGN101, CHGN122, GEGN206. 2 hours lecture, 3 hours lab: 3 semester hours.

GEGN340. COOPERATIVE EDUCATION (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 (I) Study of interrelationships between internal and external earth processes, geologic materials, time, and resulting landforms on the Earth's surface. Influences of geomorphic processes on design of natural resource exploration programs and siting and design of geotechnical and geohydrologic projects. Laboratory analysis of geomorphic and geologic features utilizing maps, photo interpretation and field observations. Prerequisite: SYGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

GEGN351. GEOLOGICAL FLUID MECHANICS (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 stomosphere; sediment transport. Prerequisite: DCGN241 or permission of instructor. 3 hours lecture; 3 semester hours.

GEGN/GEOL398. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING (I, II) Special topics classes taught on a one-time basis. May include lecture, laboratory and field trip activities. Prerequisite: Approval of instructor and department head. Variable credit; 1 to 6 semester hours. Repeatable for credit under different titles.

GEGN399. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY (I, II) Individual special studies, laboratory and/or field problems in geological engineering or engineering hydrogeology. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GEOL399. INDEPENDENT STUDY IN GEOLOGY (I, II) Individual special studies, laboratory and/or field problems in geology. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 semester hours. Repeatable for credit.

Senior Year

GEGN401. MINERAL DEPOSITS (I) Introductory presentation of magmatic, hydrothermal, and sedimentary metallic ore deposits. Chemical, petrologic, structural, and sedimentological processes that contribute to ore formation. Description of classic deposits representing individual deposit types. Review of exploration sequences. Laboratory consists of hand specimen study of host rock-ore mineral suites and mineral deposit evaluation problems. Prerequisite: DCGN209, GEGN307, GEGN316, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

GEGN403. MINERAL EXPLORATION DESIGN (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 EPIC264. 2 hours lecture, 3 hours lab; 3 semester hours.

GEGN404. ORE MICROSCOPY (II) Identification of ore minerals using reflected light microscopy, micro-hardness, and reflectivity techniques. Interpretation of common ore mineral textures, including those produced by magmatic segregation, open space filling, replacement, exsolution, and recrystallization. Guided research on the ore mineralogy and ore textures of classical ore deposits. Prerequisite: GEOL321, GEGN401, or consent of instructor. 6 hours lab; 3 semester hours.

GEOL410. PLANETARY GEOLOGY (II) Geology of the terrestrial planets and moons, specifically the Moon and Mars. Emphasis will be placed on the geomorphology, planetary materials, geologic structure, geologic history, and natural resource potential of terrestrial planetary bodies. Lectures present the knowledge of materials, geomorphic processes, and geologic history. Prerequisite: SYGN101. 2 hours lecture: 2 semester hours.

GEGN 432. GEOLOGICAL DATA MANAGEMENT (I) Techniques for managing and analyzing geological data, including statistical analysis procedures and computer programming. Topics addressed include elementary probability, populations and distributions, estimation, hypothesis testing, analysis of data sequences, mapping, sampling and sample representativity, linear regression, and overview of univariate and multivariate statistical methods. Practical experience with principles of software programming and statistical analysis for geological applications via supplied software and data sets from geological case histories. Prerequistes: Senior standing in Geological Engineering or permission of instructor. 1 hour lecture, 6 hours lab; 3 semester hours.

GEOL443. UNDERGRADUATE FIELD SEMINAR Special advanced classroom and field programs emphasizing detailed study of some aspects of the geology of an area or region. Field studies normally conducted away from the Golden campus. Classroom course content dependent on area of study. Consent of instructor and/or Department Head required. Fees assessed for field and living expenses and transportation. 1 to 3 semester hours; may be repeated for credit with consent of instructor.

GEGN438. PETROLEUM GEOLOGY (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/GPGN439/PEGN439. MULTI-DISCIPLINARY PETROLEUM DESIGN (II) (WI) This is a multi-disciplinary design course that integrates fundamentals and design concepts in geological, geophysical, and petroleum engineering. Students work in integrated teams from each of the disciplines. Open-ended design problems are assigned including the development of a prospect in an exploration play and a detailed engineering field study. Detailed reports are required for the prospect evaluation and engineering field study. Prerequisite: GE Majors: GEOL309, GEGN438, GEGN316, EPIC 251; PE majors: PEGN316, PEGN414, PEGN422, PEGN423, PEGN424 (or concurrent) GEOL308, EPIC264; GP Majors: GPGN302 , GPGN303 and EPIC268. 2 hours lecture; 3 hours lab; 3 semester hours.

GEGN466. GROUNDWATER ENGINEERING (I) Theory of groundwater occurrence and flow. Relation of groundwater to surface; potential distribution and flow; theory of aquifer tests; water chemistry, water quality, and contaminant transport. Prerequisite: mathematics through calculus and MATH225, GEOL309, GEOL315, and GEGN351,or EGGN351 or consent of instructor. 3 hours lecture, 3 semester hours.

GEGN467. GROUNDWATER ENGINEERING (I) Theory of groundwater occurrence and flow. Relation of groundwater to surface water; potential distribution and flow; theory of aquifer tests; water chemistry, water quality, and contaminant transport. Laboratory sessions on water budgets, water chemistry, properties of porous media, solutions to hydraulic flow problems, analytical and digital models, and hydrogeologic interpretation. Prerequisite: mathematics through calculus and MATH225, GEOL309, GEOL314 or GEOL315, and GEGN351, or EGGN 351 or consent of instructor. For GE Majors only. 3 hours lecture, 3 hours lab; 4 semester hours.

GEGN468. ENGINEERING GEOLOGY AND GEOTECHNICS (I) Application of geology to evaluation of construction, mining, and environmental projects such as dams, waterways, tunnels, highways, bridges, buildings, mine design, and land-based waste disposal facilities. Design projects including field, laboratory, and computer analysis are an important part of the course. Prerequisite: MNGN321 and concurrent enrollment in EGGN361/EGGN363 or consent of instructor. 3 hours lecture, 3 hours lab, 4 semester hours.

GEGN469. ENGINEERING GEOLOGY DESIGN (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 (II) (WI) Application of the principles of hydrogeology and ground-water engineering to water supply, geotechnical, or water quality problems involving the design of well fields, drilling programs, and/or pump tests. Engineering reports, complete with specifications, analysis, and results, will be required. Prerequisite: GEGN467 or equivalent or consent of instructor and EPIC264. 2 hours lecture, 3 hours lab; 3 semester hours.

GEOL470/GPGN470. APPLICATIONS OF SATELLITE REMOTE SENSING (II) Students are introduced to geoscience applications of satellite remote sensing. Introductory lectures provide background on satellites, sensors, methodology, and diverse applications. One or more areas of application are presented from a systems perspective. Guest lecturers from academia, industry, and government agencies present case studies focusing on applications, which vary from semester to semester. Students do independent term projects, under the supervision of a faculty member or guest lecturer, that are presented both written and orally at the end of the term. Prerequisites: PHGN200 and MATH225 or consent of instructor. 3 hours lecture; 3 semester hours.

GEGN473. GEOLOGICAL ENGINEERING SITE INVESTIGATION (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 (II) An introduction to Geographic Information Systems (GIS) and their applications to all areas of geology and geological engineering. Lecture topics include: principles of GIS, data structures, digital elevation models, data input and verification, data analysis and spatial modeling, data quality and error propagation, methods of GIS projects, as well as video presentations. Prerequisite: SYGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

GEGN481. ADVANCED HYDROGEOLOGY (I) Lectures, assigned readings, and discussions concerning the theory, measurement, and estimation of ground water parameters, fractured-rock flow, new or specialized methods of well hydraulics and pump tests, tracer methods, and well construction design. Design of well tests in variety of settings. Prerequisites: GEGN467 or consent of instructor. 3 hours lecture; 3 semester hours.

GEGN483. MATHEMATICAL MODELING OF GROUNDWATER SYSTEMS (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

GEGN/GEOL498. SEMINAR IN GEOLOGY OR GEOLOGICAL ENGINEERING (I, II) Special topics classes taught on a one-time basis. May include lecture, laboratory and field trip activities. Prerequisite: Approval of instructor and department head. Variable credit; 1 to 6 semester hours. Repeatable for credit under different titles.

GEGN499. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY (I, II) Individual special studies, laboratory and/or field problems in geological engineering or engineering hydrogeology. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

GEOL499. INDEPENDENT STUDY IN GEOLOGY (I, II) Individual special studies, laboratory and/or field problems in geology. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Oceanography

GEOC407. ATMOSPHERE, WEATHER AND CLIMATE (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 (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.

Geophysics

TERENCE K. YOUNG, Professor and Department Head
MICHAEL L. BATZLE, Baker Hughes Professor of Petrophysics and Borehole Geophysics
THOMAS L. DAVIS, Professor
DAVE HALE, Charles Henry Green Professor of Exploration Geophysics
GARY R. OLHOEFT, Professor
ROEL K. SNIEDER, Keck Foundation Professor of Basic Exploration Science
ILYA D. TSVANKIN, Professor
THOMAS M. BOYD, Associate Professor and Dean of Graduate Studies
YAOGUO LI, Associate Professor
ANDRÉ REVIL, Associate Professor
PAUL C. SAVA, Associate Professor
JEFFREY ANDREWS-HANNA, Assistant Professor
NORMAN BLEISTEIN, Research Professor and University Emeritus Professor
KENNETH L. LARNER, Research Professor and University Emeritus Professor
ROBERT D. BENSON, Research Associate Professor
RICHARD KRAHENBUHL, Research Assistant Professor
STEPHEN J. HILL, Adjunct Associate Professor
DAVID J. WALD, Adjunct Associate Professor
GAVIN P. HAYES, Adjunct Assistant Professor
CHARLES P. ODEN, Adjunct Assistant Professor
WARREN B. HAMILTON, Distinguished Senior Scientist
MISAC N. NABIGHIAN, Distinguished Senior Scientist
FRANK A. HADSELL, Emeritus Professor
ALEXANDER A. KAUFMAN, Emeritus Professor
GEORGE V. KELLER, Emeritus Professor
PHILLIP R. ROMIG, JR., Emeritus Professor

Program Description

What is Geophysics? Geophysicists study the Earth's interior through physical measurements collected at the Earth's surface, in boreholes, from aircraft, or from satellites. Using a combination of mathematics, physics, geology, chemistry, hydrology, and computer science, both geophysicists and geophysical engineers analyze these measurements to infer properties and processes within the Earth's complex interior. Non-invasive imaging beneath the surface of Earth and other planets by geophysicists is analogous to non-invasive imaging of the interior of the human body by medical specialists.

The Earth supplies all materials needed by our society, serves as the repository of used products, and provides a home to all its inhabitants. Geophysics and geophysical engineering have important roles to play in the solution of challenging problems facing the inhabitants of this planet, such as providing fresh water, food, and energy for Earth's growing population, evaluating sites for underground construction and containment of hazardous waste, monitoring non-invasively the aging infrastructures of developed nations, mitigating the threat of geohazards (earthquakes, volcanoes, landslides, avalanches) to populated areas, contributing to homeland security (including detection and re-

moval of unexploded ordnance and land mines), evaluating changes in climate and managing humankind's response to them, and exploring other planets.

Energy companies and mining firms employ geophysicists to explore for hidden resources around the world. Engineering firms hire geophysical engineers to assess the Earth's near-surface properties when sites are chosen for large construction projects and waste-management operations. Environmental organizations use geophysics to conduct groundwater surveys and to track the flow of contaminants. On the global scale, geophysicists employed by universities and government agencies (such as the United States Geological Survey, NASA, and the National Oceanographic and Atmospheric Administration) try to understand such Earth processes as heat flow, gravitational, magnetic, electric, thermal, and stress fields within the Earth's interior. For the past decade, 100% of CSM's geophysics graduates have found employment in their chosen field, with about 70% choosing to pursue graduate studies.

Founded in 1926, the Department of Geophysics at the Colorado School of Mines is recognized and respected around the world for its programs in applied geophysical research and education. With 20 active faculty and an average class size of 25, students receive individualized attention in a close-knit department.

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:

- Objective 1. Graduates of CSM's Geophysical Engineering Program will be competent geophysical engineers who think for themselves, and are capable of taking conventional formulations of problems and solving these problems independently using a solid foundation in mathematics, science and engineering.
  - Outcome 1A: Graduates will have successfully completed a required curriculum containing the mathematical, scientific, and engineering background necessary for a geophysical engineering career.
  - Outcome 1B: Graduates can work independently, solving mathematical and scientific problems inspired from the geophysical engineering practice.
- Objective 2. Graduates will be creative, innovative problem solvers who are able to question conventional formulations of problems, and to conceive and test new hypotheses, new problem descriptions, and new methods for analyzing data.
  - Outcome 2A: Graduates can independently read and understand textbooks and research papers and can comprehend and apply concepts and theories beyond those taught in their classes.
  - Outcome 2B: 80% of graduates will have gained practical experience through employment on departmental research projects, summer jobs, industry internships, or co-op positions.
- Objective 3. Graduates will be capable of designing and carrying out a geophysical survey or laboratory experiment, ensuring that the recorded data are of the highest-possible quality, and quantifying uncertainty and incompleteness of data.
  - Outcome 3A: Geophysical Engineering graduates will have participated in designing and conducting field and lab experiments in which they acquire data from measuring physical properties with the objective of solving earth-related engineering problems.
  - Outcome 3B: In their lab and field experiments, students will have encountered limitations and uncertainties in data and learned quantitative means for handling them.
- Objective 4: Graduates will be capable of writing computer programs in a high-level language to acquire, process, model and display scientific data.
  - Outcome 4A: Graduates will be able to translate geophysical concepts into computer programs that simulate, exploit, and test those concepts.
  - Outcome 4B: Graduates will have demonstrated their ability to analyze (process, model, visualize) data acquired in their own experiments and from other sources using computer software they have written or customized.
- Objective 5: Graduates of CSM's Geophysical Engineering Program will be imbued with leadership qualities including, but not limited to, the ability to communicate well both orally and in writing, and the ability to make sound decisions in a context with risk and uncertainty.
  - Outcome 5A: Students will engage in collaborative projects requiring interaction with peers and providing opportunity to develop behaviors associated with good leadership and good followership.

- Outcome 5B: Graduates will be capable of producing concise, appropriately written, easily understandable documents, and will be capable of giving effective oral presentations using computer-based graphical supporting materials.
- Outcome 5C: Graduates will be capable of analyzing uncertainty and errors in both data acquisition and processing, and their effects on data interpretation and decision making.

Geophysics Field Camp. Each summer, a base of field operations is set up for four weeks in the mountains of Colorado for students who have completed their junior year. Students prepare geological maps and cross sections and then use these as the basis for conducting seismic, gravimetric, magnetic, and electrical surveys. After acquiring these various geophysical datasets, the students process the data and develop an interpretation that is consistent with all the information. In addition to the required four-week program, students can also participate in other diverse field experiences. In recent years these have included cruises on seismic ships in the Gulf of Mexico, studies at an archeological site, investigations at an environmental site, a ground-penetrating radar survey on an active volcano in Hawaii, and a well-logging school offered by Baker Atlas.

Study Abroad. The Department of Geophysics encourages its undergraduates to spend one or two semesters studying abroad. At some universities credits can be earned that substitute for course requirements in the geophysical engineering program at CSM. Information on universities that have established formal exchange programs with CSM can be obtained either from the Department of Geophysics or the Office of International Programs.

Combined BS/MS Program. Undergraduate students in the Geophysical Engineering program who would like to continue directly into the Master of Science program in Geophysics or Geophysical Engineering are allowed to fulfill part of the requirements of their graduate degree by including up to six hours of specified course credits which also were used in fulfilling the requirements of their undergraduate degree. Students interested to take advantage of this option should meet with their advisor or department head as early as possible in their undergraduate program to determine which elective courses will be acceptable and advantageous for accelerating them through their combined BS/MS studies.

Summer Jobs in Geophysics. In addition to the summer field camp experience, students are given opportunities every summer throughout their undergraduate career to work as summer interns within the industry, at CSM, or for government agencies. Students have recently worked outdoors with geophysics crews in various parts of the U.S., South America, and offshore in the Gulf of Mexico.

Undergraduate Research. Students are encouraged to try their hand at research by working on a project with a faculty member either part-time during the semester or full-time during the summer.

The Cecil H. and Ida Green Graduate and Professional Center. The lecture rooms, laboratories, and computer-aided instruction areas of the Department of Geophysics are located in the Green Center. The department maintains equipment for conducting geophysical field measurements, including magnetometers, gravity meters, ground-penetrating radar, and instruments for recording seismic waves. Students have access to the Department petrophysics laboratory for measuring properties of porous rocks.

Curriculum

Geophysics is an applied and interdisciplinary science, hence students must have a strong foundation in physics, mathematics, geology and computer sciences. Superimposed on this foundation is a comprehensive body of courses on the theory and practice of geophysical methods. As geophysics and geophysical engineering involve the study and exploration of the entire earth, our graduates have great opportunities to work anywhere on, and even off, the planet. Therefore, emphasis is placed on electives in the humanities that give students an understanding of international issues and different cultures. To satisfy all these requirements, every student who obtains a Bachelor's Degree in Geophysical Engineering at CSM must complete the courses in the CSM Core Curriculum plus the following (see the course flowchart on the Department of Geophysics webpage):

Degree Requirements (Geophysical Engineering)

Sophomore Year Fall Semester	lec.	lab.	sem.hrs.
GPGN200 Introduction to Geophysics	3		3
[1]GEGN203/204/205 Physical Geology	2	3	3
EBGN201 Principles of Economics	3		3
MATH213 Calculus for Scientists & Engineers III	4		4
PAGN201 Physical Education	2		0.5
PHGN200 Physics II	3.5	3	4.5
Total			18

Sophomore Year Spring Semester	lec.	lab.	sem.hrs.
GPGN221 Theory of Fields I: Static Fields	3		3
[2] CSCI261 Programming Concepts in Java	3		3
EPIC268 Geophysical Engineering	3		3
MATH225 Differential Equations	3		3
PAGN202 Physical Education	2		0.5
SYGN200 Human Systems	3		3
Total			15.5

Junior Year Fall Semester	lec.	lab.	sem.hrs.
GPGN303 Introduction to Gravity Magnetic & Electrical Methods	3	3	4
GPGN322 Theory of Fields II: Time-Varying Fields	3		3
GPGN315 Field Methods for Geophysicists		6	2
[3]MATH348 Advanced Engineering Mathematics or PHGN311 Introduction to Mathematical Physics	3		3
[4]Electives	6		6
Total			18

Junior Year Spring Semester	lec.	lab.	sem.hrs.
[5]GEOL308 Introductory Applied Structural Geology	2	3	3
GPGN320 Continuum Mechanics	3		3
GPGN302 Introduction to Electromagnetic & Seismic Methods	3	3	4
[4]Electives	6		6
Total			16

Summer Session	lec.	lab.	sem.hrs.
GPGN486 Geophysics Field Camp	4		4
Total			4

Senior Year Fall Semester	lec.	lab.	sem.hrs.
GPGN404 Digital Systems Analysis	3		3
[6]GPGN Advanced Elective	3	3	4
[6]GPGN Advanced Elective	3	3	4
[7]GPGN438 Senior Design or GPGN439 in Spring Semester	1.5		1.5
[4]Electives	3		3
Total			15.5

Senior Year Spring Semester	lec.	lab.	sem.hrs.
GPGN409 Inversion	3		3
[6]GPGN Advanced Elective	3		3
[7]GPGN439 Multi-disciplinary Petro. Design or GPGN438 beginning Fall Semester	1.5		1.5
[5]GEOL314 Stratigraphy	3	3	4
[4]Electives	3		3
Total			14.5

Grand Total			133.5

[1]Students must take GEGN205 (1 credit hour) with either GEGN203 or GEGN204 (2 credit hours).
[2]Students should enroll in the Java section of CSCI261, although C++ is accepted.
[3]Students should enroll in the special section of MATH348 for Geophysics majors.
[4]Electives must include at least 9 hours that meet LAIS core requirements. The Department of Geophysics encourages its students to consider organizing their electives to form a Minor or an Area of Special Interest (ASI). A guide suggesting various Minor and ASI programs can be obtained from the Department office.
[5]Students must take either GEOL308 or GEOL309, and either GEOL314 or GEOL315.
[6]Students must take 11 credits of advanced GPGN elective courses at the 400- or 500-level.
[7]Students can take either GPGN438 or GPGN439 to satisfy the senior design requirement. The multidisciplinary design course GPGN439, a 3 credit hour course offered only in Spring semester, is strongly recommended for students interested in petroleum exploration and production. Students interested in non-petroleum applications of geophysics take GPGN438 for 3 credit hours, either by enrolling for all 3 credit hours in one semester (Fall or Spring) or by enrolling for a portion of the 3 hours in Fall and the remainder in Spring.

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
GPGN302, Electromagnetic & Seismic Methods
GPGN303, Gravity, Magnetic & Electrical Methods
GPGN404, Digital Signal Analysis
GPGN409, Inversion
GPGN432, Formation Evaluation
GPGN470, Applications of Satellite Remote Sensing

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.

Description of Courses

Freshman/Sophomore Year

GPGN198. SPECIAL TOPICS IN GEOPHYSICS (I, II) New topics in geophysics. Each member of the academic faculty is invited to submit a prospectus of the course to the department head for evaluation as a special topics course. If selected, the course can be taught only once under the 198 title before becoming part of the regular curriculum under a new course number and title. Prerequisite: Consent of department. Credit – variable, 1 to 6 hours. Repeatable for credit under different titles.

GPGN199. GEOPHYSICAL INVESTIGATION (I, II) Individual project; instrument design, data interpretation, problem analysis, or field survey. Prerequisites: Consent of department and "Independent Study" form must be completed and submitted to the Registrar. Credit dependent upon nature and extent of project. Variable 1 to 6 hours. Repeatable for credit.

GPGN200. INTRODUCTION TO GEOPHYSICS (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 (II) Introduction to the theory of gravitational, magnetic, and electrical fields encountered in geophysics. Emphasis on the mathematical and physical foundations of the various phenomena and the similarities and differences in the various field properties. Physical laws governing the behavior of the gravitational, electric, and magnetic fields. Systems of equations of these fields. Boundary value problems. Uniqueness theorem. Influence of a medium on field behavior. Prerequisites: PHGN200, MATH213, and concurrent enrollment in MATH225, or consent of instructor. 3 hours lecture; 3 semester hours.

GPGN298. SPECIAL TOPICS IN GEOPHYSICS (I, II) New topics in geophysics. Each member of the academic faculty is invited to submit a prospectus of the course to the department head for evaluation as a special topics course. If selected, the course can be taught only once under the 298 title before becoming a part of the regular curriculum under a new course number and title. Prerequisite: Consent of department. Credit - Variable, 1 to 6 hours. Repeatable for credit under different titles.

GPGN299 GEOPHYSICAL INVESTIGATION (I, II) Individual project; instrument design, data interpretation, problem analysis, or field survey. Prerequisites: Consent of department and "Independent Study" form must be completed and submitted to the Registrar. Credit dependent upon nature and extent of project. Variable 1 to 6 hours. Repeatable for credit.

Junior Year

GPGN302. INTRODUCTION TO ELECTROMAGNETIC AND SEISMIC METHODS (II) (WI) This is an introductory study of electromagnetic and seismic methods for imaging the Earth's subsurface. The course begins with the connection between geophysical measurements and subsurface materials. It introduces basic concepts, mathematics, and physics of electromagnetic and seismic wave propagation, emphasizing similarities with the equations and physics that underlie all geophysical methods. These methods are employed in geotechnical and environmental engineering and resources exploration for base and precious metals, industrial minerals, geothermal and hydrocarbons. The discussion of each method includes the principles, instrumentation, procedures of data acquisition, analysis, and interpretation. Prerequisites: PHGN200, MATH213, MATH225, and MATH348 or PHGN311, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

GPGN303. INTRODUCTION TO GRAVITY, MAGNETIC AND ELECTRICAL METHODS (I) This is an introductory study of gravity, magnetic and electrical methods for imaging the earth's subsurface. The course begins with the connection between geophysical measurements and subsurface materials. It introduces basic concepts, mathematics, and physics of gravity, magnetic and electrical fields, emphasizing similarities with the equations and physics that underlie all geophysical methods. These methods are employed in geotechnical and environmental engineering and resources exploration for base and precious metals, industrial minerals, geothermal and hydrocarbons. The discussion of each method includes the principles, instrumentation, and procedures of data acquisition, analysis, and interpretation. Prerequisites: PHGN200, MATH213, MATH225, and concurrent enrollment in MATH348 or PHGN311, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

GPGN315. SUPPORTING GEOPHYSICAL FIELD INVESTIGATIONS (I) Prior to conducting a geophysical investigation, geophysicists often need input from related specialists such as geologists, surveyors, and land-men. Students are introduced to the issues that each of these specialists must address so that they may understand how each affects the design and outcome of geophysical investigations. Students learn to use and understand the range of applicability of a variety of surveying methods, learn the tools and techniques used in geological field mapping and interpretation, and explore the logistical and permitting issues directly related to geophysical field investigations. 6 hours lab, 2 semester hours.

GPGN320. ELEMENTS OF CONTINUUM MECHANICS AND WAVE PROPAGATION (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 waves and their reflection/transmission at interfaces. Prerequisites: MATH213, PHGN200. 3 hours lecture; 3 semester hours.

GPGN322. THEORY OF FIELDS II: TIME-VARYING FIELDS (I) Constant electric field. Coulomb's law. System of equations of the constant electric field. Stationary electric field and the direct current in a conducting medium. Ohm's law. Principle of charge conservation. Sources of electric field in a conducting medium. Electromotive force. Resistance. System of equations of the stationary electric field. The magnetic field, caused by constant currents. Biot-Savart law. The electromagnetic induction. Faraday's law. Prerequisite: GPGN221, or consent of instructor. 3 hours lecture; 3 semester hours.

GPGN340. COOPERATIVE EDUCATION (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 IN GEOPHYSICS (I, II) New topics in geophysics. Each member of the academic faculty is invited to submit a prospectus of the course to the department head for evaluation as a special topics course. If selected, the course can be taught only once under the 398 title before becoming a part of the regular curriculum under a new course number and title. Prerequisite: Consent of department. Credit-variable, 1 to 6 hours. Repeatable for credit under different titles.

GPGN399. GEOPHYSICAL INVESTIGATION (I, II) Individual project; instrument design, data interpretation, problem analysis, or field survey. Prerequisites: Consent of department and "Independent Study" form must be completed and submitted to the Registrar. Credit dependent upon nature and extent of project. Variable 1 to 6 hours. Repeatable for credit.

Senior Year

GPGN404. DIGITAL SIGNAL ANALYSIS (I) The fundamentals of one-dimensional digital signal processing as applied to geophysical investigations are studied. Students explore the mathematical background and practical consequences of the sampling theorem, convolution, deconvolution, the Z and Fourier transforms, windows, and filters. Emphasis is placed on applying the knowledge gained in lecture to exploring practical signal processing issues. This is done through homework and in-class practicum assignments requiring the programming and testing of algorithms discussed in lecture. Prerequisites: MATH213, MATH225, and MATH348 or PHGN311, or consent of instructor. Knowledge of a computer programming language is assumed. 2 hours lecture; 2 hours lab, 3 semester hours.

GPGN409. INVERSION (II) The fundamentals of inverse problem theory as applied to geophysical investigation are studied. Students explore the fundamental concepts of inversion in a Bayesian framework as well as practical methods for solving discrete inverse problems. Topics studied include Monte Carlo methods, optimization criteria, convex optimization methods, and error and resolution analysis. Weekly homework assignments addressing either theoretical or numerical problems through programming assignments illustrate the concepts discussed in class. Prerequisites: MATH213, MATH225, GPGN404 and MATH348 or PHGN311, or consent of instructor. Knowledge of a programming language is assumed. 3 hours lecture, 3 semester hours.

GPGN411. ADVANCED GRAVITY AND MAGNETIC METHODS (I) Instrumentation for land surface, borehole, sea floor, sea surface, and airborne operations. Reduction of observed gravity and magnetic values. Theory of potential field effects of geologic distributions. Methods and limitations of interpretation. Prerequisite: GPGN303, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

GPGN419/PEGN419. WELL LOG ANALYSIS AND FORMATION EVALUATION (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 (I) In-depth study of the application of electrical and electromagnetic methods to crustal studies, minerals exploration, oil and gas exploration, and groundwater. Laboratory work with scale and mathematical models coupled with field work over areas of known geology. Prerequisite: GPGN302 and GPGN303, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

GPGN432. FORMATION EVALUATION (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 (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/GEGN439/PEGN439. GEOPHYSICS PROJECT DESIGN / MULTI-DISCIPLINARY PETROLEUM DESIGN (II) (WI) This is a multidisciplinary design course that integrates fundamentals and design concepts in geological, geophysical, and petroleum engineering. Students work in integrated teams consisting of students from each of the disciplines. Multiple open-end 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: GP majors: GPGN302, GPGN303 and EPIC268. GE Majors: GEOL308 or GEOL309, GEGN316, GEGN438, and EPIC264. PE majors: PEGN316, PEGN414, PEGN422, PEGN423, PEGN424 (or concurrent). 2 hours lecture, 3 hours lab; 3 semester hours.

GPGN461. ADVANCED SEISMIC METHODS (I) Historical survey. Propagation of body and surface waves in elastic media; transmission and reflection at single and multiple interfaces; energy relationships; attenuation factors; data processing (including velocity interpretation, stacking, and migration); and interpretation techniques. Acquisition, processing, and interpretation of laboratory model data; seismic processing using an interactive workstation. Prerequisites: GPGN302 and concurrent enrollment in GPGN404, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

GPGN470/GEOL470. APPLICATIONS OF SATELLITE REMOTE SENSING (II) An introduction to geoscience applications of satellite remote sensing of the Earth and planets. The lectures provide background on satellites, sensors, methodology, and diverse applications. Topics include visible, near infrared, and thermal infrared passive sensing, active microwave and radio sensing, and geodetic remote sensing. Lectures and labs involve use of data from a variety of instruments, as several applications to problems in the Earth and planetary sciences are presented. Students will complete independent term projects that are presented both written and orally at the end of the term. Prerequisites: PHGN200 and MATH225 or consent of instructor. 2 hours lecture, 2 hours lab; 3 semester hours.

GPGN475. PLANETARY GEOPHYSICS (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: PHGN 100, MATH 225, and GEGN 205 or GEOL 410. Senior or graduate standing recommended. 3 hours lecture; 3 semester hours.

GPGN486. GEOPHYSICS FIELD CAMP (S) Introduction to geological and geophysical field methods. The program includes exercises in geological surveying, stratigraphic section measurements, geological mapping, and interpretation of geological observations. Students conduct geophysical surveys related to the acquisition of seismic, gravity, magnetic, and electrical observations. Students participate in designing the appropriate geophysical surveys, acquiring the observations, reducing the observations, and interpreting these observations in the context of the geological model defined from the geological surveys. Prerequisites: GEOL308 or GEOL309, GPGN302, GPGN303, and GPGN315 or consent of instructor. Repeatable to a maximum of 6 hours.

GPGN497. SUMMER PROGRAMS

GPGN498. SPECIAL TOPICS IN GEOPHYSICS (I, II) New topics in geophysics. Each member of the academic faculty is invited to submit a prospectus of the course to the department head for evaluation as a special topics course. If selected, the course can be taught only once under the 498 title before becoming a part of the regular curriculum under a new course number and title. Prerequisite: Consent of department. Credit-variable, 1 to 6 hours. Repeatable for credit under different topics.

GPGN499. GEOPHYSICAL INVESTIGATION (I, II) Individual project; instrument design, data interpretation, problem analysis, or field survey. Prerequisite: Consent of department, and "Independent Study" form must be completed and submitted to the Registrar. Credit dependent upon nature and extent of project. Variable 1 to 6 hours. Repeatable for credit.

Liberal Arts and International Studies

ELIZABETH VAN WIE DAVIS, Professor and Division Director
CARL MITCHAM, Professor
HUSSEIN A. AMERY, Associate Professor
TINA L. GIANQUITTO, Associate Professor
KATHLEEN J. HANCOCK, Associate Professor
JOHN R. HEILBRUNN, Associate Professor
JON LEYDENS, Associate Professor
JUAN C. LUCENA, Associate Professor
KENNETH OSGOOD, Associate Professor and Director, McBride Honors Program
JAMES D. STRAKER, Associate Professor
JASON DELBORNE, Assistant Professor
SYLVIA GAYLORD, Assistant Professor
DERRICK HUDSON, Assistant Professor
JENNIFER SCHNEIDER, Assistant Professor
JAMES V. JESUDASON, Teaching Professor
ROBERT KLIMEK, Teaching Professor
TONI LEFTON, Teaching Professor
SANDY WOODSON, Teaching Professor and Undergraduate Advisor
DAN MILLER, Teaching Associate Professor and Assistant Division Director
ROSE PASS, Teaching Associate Professor
JONATHAN H. CULLISON, Teaching Assistant Professor
PAULA A. FARCA, Teaching Assistant Professor
CORTNEY E. HOLLES, Teaching Assistant Professor
SHIRA RICHMAN, Teaching Assistant Professor
BETTY J. CANNON, Emerita Associate Professor
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T. GRAHAM HEREFORD, Emeritus Professor
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KATHLEEN H. OCHS, Emerita Associate Professor
BARBARA M. OLDS, Emerita Professor
EUL-SOO PANG, Emeritus Professor
LAURA J. PANG, Emerita Associate Professor
ANTON G. PEGIS, Emeritus Professor
THOMAS PHILIPOSE, University Emeritus Professor
ARTHUR B. SACKS, Emeritus Professor
JOSEPH D. SNEED, Emeritus Professor
KAREN B. WILEY, Emerita Associate Professor
ROBERT E.D. WOOLSEY, Emeritus Professor

Program Description

As the 21st century unfolds, individuals, communities, and nations face major challenges in energy, natural resources, and the environment. While these challenges demand practical ingenuity from engineers and applied scientists, solutions must also take into account social, political, economic, cultural, ethical, and global contexts. CSM students, as citizens and future professionals, confront a rapidly changing society that demands core technical skills complemented by flexible intelligence, original thought, and cultural sensitivity.

Courses in Liberal Arts and International Studies (LAIS) expand students' professional and personal capacities by providing opportunities to explore the humanities, social sciences, and fine arts. Our curricula encourage the development of critical thinking skills that will help students make more informed choices as national and world citizens - promoting more complex understandings of justice, equality, culture, history, development, and sustainability. Students study ethical reasoning, compare and contrast different economies and cultures, develop arguments from data, and interrogate globalization. LAIS courses also foster creativity by offering opportunities for self-discovery. Students conduct literary analyses, improve communication skills, play music, learn media theory, and write poetry. These experiences foster intellectual agility, personal maturity, and respect for the complexity of our world.

Undergraduate Minors. At the undergraduate level, LAIS offers minors in Literature, Society, and the Environment; International Political Economy; Science, Technology, Engineering, and Policy; Humanitarian Studies; and an Individualized Undergraduate minor. See below for details. LAIS also is the home for the minor in the McBride Honors Program in Public Affairs.

Graduate Degree and Programs. At the graduate level, LAIS offers a 36-hour degree, a Master of International Political Economy of Resources (MIPER). It also offers a Graduate Certificate in International Political Economy, a Graduate Certificate in Science & Technology Policy (in collaboration with the Center for Science and Technology Policy Research, Cooperative Institute for Research in Environmental Science [CIRES], at the University of Colorado at Boulder), and a Graduate Individual Minor. See the Graduate Bulletin for details.

Required Undergraduate Core Courses. Two of three required undergraduate core courses in the Humanities and Social Sciences are delivered by LAIS, namely, LAIS 100, Nature and Human Values; and SYGN 200, Human Systems. The third H&SS core course, EBGN 201, Principles of Economics, is delivered by the Division of Economics & Business.

Required Undergraduate Humanities & Social Sciences (H&SS) General Education Restricted Electives. Beyond the core, LAIS offers the majority of the courses that meet the 9 credit-hour General Education requirement in the Humanities and Social Sciences (H&SS). The Division of Economic and Business also offers specific courses that may be used to meet the H&SS requirements.

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, Environ-

mental Studies, Ethics, History, Literature, Philosophy, and Social Theory as well as the interdisciplinary fields of Environmental Policy, and Science-Technology-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.

LAIS Writing Center. The LAIS Division operates the LAIS Writing Center, which provides students with instruction tailored to their individual writing problems (including non-native speakers of English). It also provides faculty with support for courses associated with the Writing Across the Curriculum program. Faculty and staff are welcome to make use of the Writing Center's expertise for writing projects and problems. The Writing Center is located on the 3rd floor of Stratton Hall.

Communication Center. The Communication Center, like the Writing Center, serves students and faculty by offering individual instruction in oral presentations.

Program Educational Objectives

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria, the coursework in the Division of Liberal Arts and International Studies is designed to help CSM develop in students the ability to engage in lifelong learning and recognize the value of doing so by acquiring the broad education necessary to

a) understand the impact of engineering solutions in contemporary, global, international, societal, political, and ethical contexts;

b) understand the role of Humanities and Social Sciences in identifying, formulating, and solving engineering problems;

c) prepare to live and work in a complex world;

d) understand the meaning and implications of "stewardship of the Earth"; and

e) communicate effectively in writing and orally.

Curriculum

Key to courses offered by the LAIS Division:

LAIS	Humanities and Social Sciences
LIFL	Foreign Language
LIMU	Music
SYGN	Systems

CSM students in all majors must take 19 credit-hours in Humanities and Social Sciences General Education courses, ranging from freshman through senior levels of course work. These courses are housed in LAIS and in the Division of Economics and Business (EB).

Required Core Courses

1. All Undergraduate students are required to take the following two core courses from the Division of Liberal Arts & International Studies:

   a. LAIS 100 Nature and Human Values 4 semester hours

   b. SYGN 200 Human Systems 3 semester hours

2. All Undergraduate students are also required to take EBGN201 Principles of Economics (3 semester hours) from the Division of Economics and Business.

3. Students in the McBride Honors Program must take LAIS100, Nature and Human Values and EBGN 201. Please see the McBride Honors Program web site for further information.

Required Humanities & Social Sciences (H&SS) General Education Restricted Electives

Beyond the core, all Undergraduate students must take an additional three courses (9 semester hours) from the list that appears below. The following restrictions apply to these three courses:

1. At least one of the three courses must be taken from the Division of Liberal Arts & International Studies.

2. At least one of the three courses must be a 400-level course. In any given semester, either LAIS or EB may offer 400-level Special Topics courses that will be numbered as either LAIS 498 or EBGN 498. Even though no Special Topics courses appear in the list below, these courses may be used to fulfill the H&SS General Education restricted electives requirement as follows:

   a. All courses that are numbered "LAIS 498."

   b. Some "EBGN 498" courses as determined on a case-by-case basis. Consult either LAIS or EBGN in any given semester for EBGN 498 courses that satisfy the requirement.

3. The other two courses are "midlevel" courses, i.e., 200 or 300 level classes. The only exception to this rule are Foreign Language courses (see below).

4. A maximum of two Foreign Language courses (LIFL) may be applied toward satisfying the H&SS General Education restricted electives requirement. However, **no LIFL 400-level course** may be used to satisfy the 400-level course requirement in Item 2 above.

5. Music (LIMU) courses may not be used to meet the H&SS General Education restricted electives requirement. They may be used for Free Elective credit only. **A maximum of 3 semester hours of concert band chorus, physical education, athletics or other activity credit combined may be used toward free elective credit in a degree granting program.**

6. Single majors in Economics may not use Economics courses to meet the H&SS General Education restricted electives requirement. In other words, they must meet this requirement with courses from the Division of Liberal Arts & International Studies, as per the above restrictions and requirements. Students other than single majors in Economics may take up to 6 semester hours (2 courses)

of approved EBGN courses, listed below to satisfy the H&SS General Education restricted electives requirement.

7. During Pre-Registration each semester, only students with senior standing or instructor's permission are initially allowed to register for 400-level LAIS courses. If 400-level courses do not fill up during Pre-Registration or soon thereafter, the Division Director may elect to open course registration to sophomores and juniors who have met the LAIS100 pre-requisite and SYGN200 co-requisite for 400-level courses.
8. Except for foreign languages, **NO AP or IB credit can be used to meet the General Education Restricted Elective requirements**. AP/IB credits will be applied as free electives.

List of LAIS & EB Courses Satisfying the H&SS General Education Restricted Electives Requirement

EBGN301 Intermediate Microeconomics
EBGN302 Intermediate Macroeconomics
EBGN310 Environment & Resource Economics
EBGN320 Economics and Technology
EBGN330 Energy Economics
EBGN340 Energy and Environmental Policy
EBGN342 Economic Development
EBGN437 Regional Economics
EBGN441 International Economics
EBGN443 Public Economics
EBGN470 Environmental Economics

LAIS220 Introduction to Philosophy
LAIS221 Introduction to Religions
LAIS286 Introduction to Government & Politics
LAIS298 Special Topics
LAIS300 Creative Writing: Fiction
LAIS301 Creative Writing: Poetry
LAIS305 American Literature: Colonial Period to the Present
LAIS307 Explorations in Comparative Literature
LAIS309 Literature and Society
LAIS310 Modern European Literature
LAIS311 British Literature: Medieval to Modern
LAIS315 Musical Traditions of the Western World
LAIS320 Ethics
LAIS322 Logic
LAIS323 Introduction to Science Communication
LAIS325 Cultural Anthropology
LAIS335 International Political Economy of Latin America
LAIS337 International Political Economy of Asia
LAIS339 International Political Economy of the Middle East
LAIS341 International Political Economy of Africa
LAIS344 International Relations
LAIS345 International Political Economy
LAIS365 History of War
LAIS370 History of Science
LAIS371 History of Technology
LAIS375 Engineering Cultures
LAIS398 Special Topics
LAIS401 Creative Writing: Poetry
LAIS402 Writing Proposals for a Better World
LAIS404 Women, Literature & Society
LAIS406 The Literature of War & Remembrance
LAIS407 Science in Literature
LAIS408 Life Stories
LAIS409 Shakespearean Drama
LAIS410 Critical Perspectives in 20th Century Literature
LAIS411 Modern African Literature
LAIS412 Literature & the Environment
LAIS415 Mass Media Studies
LAIS416 Film Studies
LAIS418 Narrating the Nation
LAIS419 Media and the Environment
LAIS421 Environmental Philosophy and Policy
LAIS423 Advanced Science Communication
LAIS430 Corporate Social Responsibility
LAIS431 Religion and Security
LAIS435 Latin American Development
LAIS437 Asian Development
LAIS439 Middle East Development
LAIS440 War and Peace in the Middle East
LAIS441 African Development
LAIS442 Natural Resources & War in Africa
LAIS446 Globalization
LAIS448 Global Environmental Issues
LAIS450 Political Risk Assessment
LAIS452 Corruption and Development
LAIS453 Ethnic Conflict in Global Perspective
LAIS456 Power and Politics in Eurasia
LAIS457 Introduction to Conflict Management
LAIS460 Global Geopolitics
LAIS475 Engineering Cultures in the Developing World
LAIS477 Engineering and Sustainable Community Development
LAIS485 Constitutional Law and Politics
LAIS486 Science and Technology Policy
LAIS487 Environmental Politics and Policy
LAIS488 Water Politics and Policy
LAIS489 Nuclear Power and Public Policy
LAIS490 Energy and Society
LAIS498 Special Topics

LIFL113 Spanish I
LIFL123 Spanish II
LIFL213 Spanish III
LIFL114 Arabic I
LIFL124 Arabic II
LIFL214 Arabic III
LIFL115 German I
LIFL125 German II
LIFL215 German III
LIFLx98 Special Topics

Minor Programs

LAIS offers several minor programs. Students who elect to pursue a minor **usually** will satisfy their H&SS General Education requirements; the Music Technology ASI will not satisfy these requirements. Students will need to use their free elective hours to complete a minor. Minors are a minimum of 18 credit-hours; ASIs are a minimum of 12 credit-hours. No

more than half the credits to be applied towards an LAIS minor or ASI may be transfer credits. The LAIS Undergraduate Advisor must approve all transfer credits that will be used for an LAIS minor or ASI.

Prior to the completion of the sophomore year, a student wishing to declare an LAIS Minor must fill out an LAIS Minor form (available in the LAIS Office) and obtain approval signatures from the appropriate minor advisor in LAIS and from the LAIS Director. The student must also fill out a Minor/Area of Special Interest Declaration (available in the Registrar's Office) and obtain approval signatures from the student's CSM advisor, from the Head or Director of the student's major department or division, and from the LAIS Director. Students should consult the listed advisors for the specific requirements of each minor.

The six minors or ASIs available and their advisors are:

Literature, Society, and the Environment Minor and ASI

Program Advisors: Prof. Tina Gianquitto and Prof. Jay Straker. The Literature, Society, and the Environment Minor (LSE) is 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 interdisciplinary emphasis creates unique opportunities for students to forge connections between literary studies and diverse fields of inquiry, spanning the humanities and qualitative and quantitative sciences. In the process of acquiring the minor, students will develop forms of intellectual creativity and sensitivity to social and environmental dynamics increasingly expected of twenty-first century scientists and engineers.

International Political Economy Minor and ASI

Program Advisor: Prof. James Jesudason. This minor is ideal for students anticipating careers in the earth resources industries. The International Political Economy (IPE) Program at CSM was the first such program in the U.S. designed with the engineering and applied science student in mind, and remains one of the very few international engineering programs with this focus. International Political Economy is the study of the interplay among politics, the economy, and culture. In today's global economy, international engineering and applied science decisions are fundamentally political decisions made by sovereign nations. Therefore, International Political Economy theories and models are often used in evaluating and implementing engineering and science projects. Project evaluations and feasibilities now involve the application of such IPE methods as political risk assessment and mitigation. The IPE minor is also a gateway to the Graduate Program in International Political Economy.

Science, Technology, Engineering, and Policy Minor and ASI

Program Advisor: Prof. Jason Delborne. The Science, Technology, Engineering, and Policy (STEP) Minor and ASI focus on science, technology, and engineering in the societal and policy context: how STE influence society, politics, and policy, and how society, politics, and policy influence STE. Courses provide historical, social scientific, ethical, and policy approaches to issues that inevitably confront professional applied scientists, engineers, managers, and administrators in both public and private sectors. Such issues concern, for example, professional ethical responsibilities, intellectual property rights, regulatory regimes, assessments of societal impacts, science policy implementation, and the roles of technical innovation in economic development or international competitiveness. LAIS 486 Science and Technology Policy is required. Students work with the STEP Advisor to tailor a sequence of other courses appropriate to their background and interests.

Humanitarian Studies Minor and ASI

Program Advisor: Prof. Sandy Woodson. The Humanitarian Studies (HS) Minor and ASI focus on the intersection of science, technology, and engineering in humanitarian projects. Scientific, technological, and engineering oriented humanitarian projects are intended to help marginalized communities meet basic human needs (such as water, food, and shelter) when these are missing or inadequate. LAIS 320 Ethics is required. Other HS courses are offered through LAIS along with selected technical electives by other academic units across campus. Students may also wish to investigate the 28-credit minor in Humanitarian Engineering offered in cooperation with the Division of Engineering.

Individualized Undergraduate Minor

Program Advisor: Prof. Sandy Woodson. Students declaring an Undergraduate Individual Minor in LAIS must choose 18 restricted elective hours in LAIS in accordance with a coherent rationale reflecting some explicit focus that the student wishes to pursue. A student desiring this minor must design it in consultation with a member of the LAIS faculty who approves the rationale and the choice of courses, eg., pre-law or pre-med courses.

Area of Special Interest in Music Technology

Program Advisor: Prof. Bob Klimek. The Area of Special Interest in Music Technology is comprised of a sequence of courses that allows students to combine interests and abilities in both the science and theory of music production. Completion of this ASI will train students in the technical aspects of the music recording industry, including sound and video recording, sound effects and software design.

The Guy T. McBride, Jr. Honors Program in Public Affairs

Program Director: Prof. Kenneth Osgood. As of Fall 2011, the curriculum of the McBride Honors Program in Public Affairs has been modified for all incoming students. Continuing

students will follow their existing curriculum. The new Program offers a 21-semester-hour honors minor consisting of seminars, courses, and off-campus activities that has the primary goal of providing a select number of students the opportunity to cross the boundaries of their technical expertise into the ethical, cultural, socio-political, and environmental dimensions of science and technology. Students will gain the knowledge, skills, and values to anticipate, analyze, and evaluate the social, cultural, ethical, and environmental implications of their future professional judgments and activities, and as responsible citizens in global, national, and local contexts. Themes, approaches and perspectives from the humanities and the social sciences are integrated with science and engineering perspectives to develop in students habits of thought necessary for a comprehensive understanding of societal and cultural issues that enhance critical thinking, social responsibility, and enlightened leadership. Please see the McBride Honors Program entry in the Bulletin or their website for further information.

Description of Courses

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

LAIS101. SHORT FORM NATURE AND HUMAN VALUES For transfer students with a minimum of six strong composition and related transfer credits, this course will, **with LAIS undergraduate advisory permission**, complete the LAIS100 Nature and Human and Value requirement. Prerequisite: two transfer college composition courses. 2 hours lecture/discussion; 2 semester hours.

LAIS115. ART STUDIO This is a hands-on art lab with an interdisciplinary, experimental and multi-cultural focus. Students are exposed to a number of media in order to learn how each medium is used, and will produce art works that are two-dimensional and three-dimensional, such as drawings, paintings and sculpture. No prerequisites. 2 hours/studio, 2 semester hours.

LAIS198. SPECIAL TOPICS 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 semester hours. Repeatable for credit under different titles.

LAIS199. INDEPENDENT STUDY Individual research or special problem projects supervised by a faculty member. Primarily for students who have completed their Humanities and Social Science requirements. Instructor consent required. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit: 1 to 6 semester hours. Repeatable for credit.

LAIS220. INTRODUCTION TO PHILOSOPHY A general introduction to philosophy that explores historical and analytic traditions. Historical exploration may compare and contrast ancient and modern, rationalist and empiricist, European and Asian approaches to philosophy. Analytic exploration may consider such basic problems as the distinction between illusion and reality, the one and the many, the structure of knowledge, the existence of God, the nature of mind or self. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 credit hours.

LAIS221. INTRODUCTION TO RELIGIONS A selective examination of world religions in terms of their historical developments, popular expressions, central teachings, institutional forms, and practical implications, especially with relation to science and technology. Religions to be considered include: Hinduism, Buddhism, Judaism, Christianity, Confucianism, Taoism and Islam. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS286. INTRODUCTION TO GOVERNMENT AND POLITICS Introduction to Government and Politics is a beginning-level course intended to familiarize students with the study of politics across societies. The method is comparative in that it approaches the task of studying the world's different political systems by contrasting and comparing them along different dimensions, and by seeking generalizations about them. The class focuses on cases, topics, and methodologies in American and comparative politics. No background in political science is required or expected. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS298. SPECIAL TOPICS 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: LAIS100. Prerequisite or co-requisite: SYGN200. Variable credit: 1 to 6 semester hours. Repeatable for credit under different topics.

LAIS299. INDEPENDENT STUDY Individual research or special problem projects supervised by a faculty member. Primarily for students who have completed their Humanities

and Social Science requirements. Instructor consent required. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit: 1 to 6 semester hours. Repeatable for credit.

LAIS300. CREATIVE WRITING: FICTION 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: SYGN200. 3 hours lecture; 3 semester hours.

LAIS301. CREATIVE WRITING: POETRY I This course focuses on reading and writing poetry. Students will learn many different poetic forms to compliment prosody, craft, and technique. Aesthetic preferences will be developed as the class reads, discusses, and models some of the great American poets. Weekly exercises reflect specific poetic tools, encourage the writing of literary poetry, and stimulate the development of the student's craft. The purpose of the course is to experience the literature and its place in a multicultural society, while students "try on" various styles and contexts in order to develop their own voice. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS305. AMERICAN LITERATURE: COLONIAL PERIOD TO THE PRESENT This course offers an overview of American literature from the colonial period to the present. The texts of the class provide a context for examining the traditions that shape the American nation as a physical, cultural and historical space. As we read, we will focus on the relationships between community, landscape, history, and language in the American imagination. We will concentrate specifically on conceptions of the nation and national identity in relation to race, gender, and class difference. Authors may include: Rowlandson, Brown, Apess, Hawthorne, Douglass, Melville, Whitman, James, Stein, Eliot, Hemingway, Silko, and Auster. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS307. EXPLORATIONS IN COMPARATIVE LITERATURE This course examines major figures and themes in the modern literatures of Africa, the Caribbean, and Latin America. Reading, discussion and writing will focus on fiction and poetry representing Francophone, Arabic, and Hispanophone traditions within these world regions. Engaging these texts will foster understanding of some of the pivotal philosophical, political, and aesthetic debates that have informed cultural practices in diverse colonial territories and nation-states. Thematic and stylistic concerns will include imperialism, nationalism, existentialism, Orientalism, negritude, and social and magical realisms. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS309. LITERATURE AND SOCIETY Before the emergence of sociology as a distinct field of study, literary artists had long been investigating the seemingly infinite complexity of human societies, seeking to comprehend the forces shaping collective identities, socio-cultural transformations, technological innovations, and political conflicts. Designed to enrich recognition and understanding of the complex interplay of artistic creativity and social inquiry over time, this course compares influential literary and social-scientific responses to the Enlightenment, the Industrial Revolution, and other dynamic junctures integral to the forging of "modernity" and the volatile world we inhabit today. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS310. MODERN EUROPEAN LITERATURE This course will introduce students to some of the major figures and generative themes of post-Enlightenment European and British literature. Reading, discussion, and writing will focus on fiction, poetry, drama, and critical essays representing British, French, Germanic, Italian, Czech, and Russian cultural traditions. Engaging these texts will foster understanding of some of the pivotal philosophical, political, and aesthetic movements and debates that have shaped modern European society and culture. Thematic concerns will include the French Enlightenment and its legacies, imperialism within and beyond Europe, comparative totalitarianisms, the rise of psychoanalytic theory and existentialism, and modernist and postmodern perspectives on the arts. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS311. BRITISH LITERATURE: MEDIEVAL TO MODERN 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: SYGN200. 3 hours lecture; 3 semester hours.

LAIS315. MUSICAL TRADITIONS OF THE WESTERN WORLD An introduction to music of the Western world from its beginnings to the present. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS320/BELS320. ETHICS A general introduction to ethics that explores its analytic and historical traditions. Reference will commonly be made to one or more significant texts by such moral philosophers as Plato, Aristotle, Augustine, Thomas Aquinas, Kant, John Stuart Mill, and others. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS322. LOGIC A general introduction to logic that explores its analytic and historical traditions. Coverage will commonly consider informal and formal fallacies, syllogistic logic, sentential logic, and elementary quantification theory. Reference will commonly be made to the work of such logical theorists as Aristotle, Frege, Russell and Whitehead, Quine, and others. Prerequisite: LAIS100. Co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS323. INTRODUCTION TO SCIENCE COMMUNICATION (I) 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. Prerequisite: LAIS100. Co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS325. CULTURAL ANTHROPOLOGY A study of the social behavior and cultural development of humans. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS335. INTERNATIONAL POLITICAL ECONOMY OF LATIN AMERICA A broad survey of the interrelationship between the state and economy in Latin America as seen through an examination of critical contemporary and historical issues that shape polity, economy, and society. Special emphasis will be given to the dynamics of interstate relationships between the developed North and the developing South. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS337. INTERNATIONAL POLITICAL ECONOMY OF ASIA A broad survey of the interrelationship between the state and economy in East and Southeast Asia as seen through an examination of critical contemporary and historical issues that shape polity, economy, and society. Special emphasis will be given to the dynamics of interstate relationships between the developed North and the developing South. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS339. INTERNATIONAL POLITICAL ECONOMY OF THE MIDDLE EAST A broad survey of the interrelationships between the state and market in the Middle East as seen through an examination of critical contemporary and historical issues that shape polity, economy, and society. Special emphasis will be given to the dynamics between the developed North and the developing South. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS341. INTERNATIONAL POLITICAL ECONOMY OF AFRICA A broad survey of the interrelationships between the state and market in Africa as seen through an examination of critical contemporary and historical issues that shape polity, economy, and society. Special emphasis will be given to the dynamics between the developed North and the developing South. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS344. INTERNATIONAL RELATIONS This course surveys major topics and theories of international relations. Students will evaluate diverse perspectives and examine a variety of topics including war and peace, economic globalization, human rights and international law, international environmental issues, and the role of the US as the current superpower. Prerequisite: LAIS 100. Prerequisite or co-requisite: SYGN 200. 3 hours lecture; 3 semester hours.

LAIS345. INTERNATIONAL POLITICAL ECONOMY International Political Economy is a study of contentious and harmonious relationships between the state and the market on the nation-state level, between individual states and their markets on the regional level, and between region-states and region-markets on the global level. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS365. HISTORY OF WAR. History of War looks at war primarily as a significant human activity in the history of the Western World since the times of Greece and Rome to the present. The causes, strategies, results, and costs of various wars will be covered, with considerable focus on important military and political leaders as well as on noted historians and theoreticians. The course is primarily a lecture course with possible group and individual presentations as class size permits. Tests will be both objective and essay types. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS370. HISTORY OF SCIENCE. An introduction to the social history of science, exploring significant people, theories, and social practices in science, with special attention to the histories of physics, chemistry, earth sciences, ecology, and biology. Prerequisite: LAIS100. Prerequisite or co-requisite SYGN200. 3 hours lecture; 3 semester hours.

LAIS371. HISTORY OF TECHNOLOGY A survey of the history of technology in the modern period (from roughly 1700 to the present), exploring the role technology has played in the political and social history of countries around the world. Prerequisite: LAIS100. Prerequisite or co-requisite SYGN200. 3 hours lecture; 3 semester hours.

LAIS375. ENGINEERING CULTURES 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 present-day Russia, Europe, Southeast Asia, and Latin America. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS398. SPECIAL TOPICS 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 semester hours. Repeatable for credit under different topics.

LAIS399. INDEPENDENT STUDY Individual research or special problem projects supervised by a faculty member. Primarily for students who have completed their Humanities and Social Science requirements. Instructor consent required. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit: 1 to 6 semester hours. Repeatable for credit.

LAIS401. CREATIVE WRITING: POETRY II 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. Prerequisites: LAIS100 and LAIS301. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS402. WRITING PROPOSALS FOR A BETTER WORLD This course develops the student's writing and higher-order thinking skills and helps meet the needs of underserved populations, particularly via funding proposals written for nonprofit organizations. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS404 WOMEN, LITERATURE, AND SOCIETY This *reading and writing intensive course* examines the role that women writers have played in a range of literary traditions. Far from residing in the margins of key national debates, women writers have actively contributed their voices to demands for social, racial, economic, and artistic equality. We will examine the writing produced by women from a diversity of racial, ethnic, and social backgrounds, as we examine the ways in which women writers respond to the various pressures placed on them as artists and activists. Prerequisite: LAIS100. Prerequisite or co-requisite SYGN200. 3 hours seminar; 3 semester hours.

LAIS406. THE LITERATURE OF WAR AND REMEMBRANCE In "The Literature of War and Remembrance," students survey poetry, prose, and film ranging from classicial 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. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS407 SCIENCE IN LITERATURE 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. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS408. LIFE STORIES 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. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS409. SHAKESPEAREAN DRAMA Shakespeare, the most well known writer in English and perhaps the world, deals with universal themes and the ultimate nature of what it is to be a human being. His plays are staged, filmed, and read around the globe, even after 400 years. This seminar will explore why Shakespeare's plays and characters have such lasting power and meaning to humanity. The seminar will combine class discussion, lecture, and video. Grades will be based on participation, response essays, and a final essay. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS410. CRITICAL PERSPECTIVES ON 20TH CENTURY LITERATURE This course introduces students to texts and cultural productions of the 20th Century literature. We will examine a diverse collection of materials, including novels and short stories, poems, plays, films, painting, and

sculpture. Science, technology, violence, history, identity, language all come under the careful scrutiny of the authors we will discuss in this course, which may include Conrad, Fanon, Achebe, Eliot, Kafka, Barnes, Camus, Borges, and Marquez, among others. We will also screen films that comment upon the fragility of individual identity in the face of modern technology. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS411. LITERATURES OF THE AFRICAN WORLD This course examines wide-ranging writers' depictions of collective transformations and conflicts integral to the making and remaking of African and Afro-diasporic communities worldwide. Fiction, poetry, and essays representing diverse linguistic, aesthetic, and philosophical traditions will constitute the bulk of the reading. Alongside their intrinsic expressive values, these texts illuminate religious and popular cultural practices important to social groups throughout much of sub-Saharan Africa, the Caribbean, Latin America, and the United States. Primary socio-historical themes may include the slave trade, plantation cultures, generational consciousness, ethnicity, gender relations, urbanization, and collective violence. Prerequisite: LAIS 100. Prerequisite or co-requisite: SYGN 200. 3 hours seminar; 3 semester hours.

LAIS412. LITERATURE AND THE ENVIRONMENT 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-requesite SYGN200. 3 hours seminar; 3 semester hours.

LAIS415. MASS MEDIA STUDIES 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 motions 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 co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS416. FILM STUDIES This course introduces students to the basics of film history, form, and criticism. Students will be exposed to a variety of film forms, including documentary, narrative, and formalist films, and will be encouraged to discuss and write about these forms using critical film language. Students will have an opportunity to work on their own film projects and to conduct research into the relationship between films and their historical, cultural, and ideological origins. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS418. NARRATING THE NATION 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 nation-states. Beyond their intrinsic literary values, these texts illuminate distinctive religious, ritual, and popular cultural practices that have shaped collective imaginings of the nation, as well as oscillations in nationalist sentiment across specific regions and historical junctures. Studies in relevant visual media -films, paintings, and telenovelas - will further our comparative inquiry into the relationships between artistic narrative and critical perspectives on "the nation." Alongside the focal literary and visual texts, the course will address major historians' and social theorists' accounts of the origins, spread, and varied careers of nationalist thought and practice across our modern world. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS419. MEDIA AND THE ENVIRONMENT This course explores the ways that messages about the environment and environmentalism are communicated in the mass media, fine arts, and popular culture. The course will introduce students to key readings in environmental communication, media studies, and cultural studies in order to understand the many ways in which the images, messages, and politics of environmentalism and the natural world are constructed. Students will analyze their role as science communicators and will participate in the creation of communication projects related to environmental research on campus or beyond. Prerequisite: LAIS100. Prerequisite or co-requisite SYGN200. 3 hours seminar; 3 semester hours.

LAIS421 ENVIRONMENTAL PHILOSOPHY AND POLICY A critical examination of environmental ethics and the philosophical theories on which they depend. Topics may include preservation/conservation, animal welfare, deep ecology, the land ethic, eco-feminism, environmental justice, sustainability, or non-western approaches. This class may also include analyses of select, contemporary environmental issues. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS423 ADVANCED SCIENCE COMMUNICATION (II) 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 or LAIS101, Corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS430. CORPORATE SOCIAL RESPONSIBILITY Businesses are largely responsible for creating the wealth upon which the well-being of society depends. As they create that wealth, their actions impact society, which is composed of a wide variety of stakeholders. In turn, society shapes the rules and expectations by which businesses must navigate their internal and external environments. This interaction between corporations and society (in its broadest sense) is the concern of Corporate Social Responsibility (CSR). This course explores the dimensions of that interaction from a multi-stakeholder perspective using case studies, guest speakers and field work. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS431. RELIGION & SECURITY This course introduces students to 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 co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS435. LATIN AMERICAN DEVELOPMENT A seminar designed to explore the political economy of current and recent past development strategies, models, efforts, and issues in Latin America, one of the most dynamic regions of the world today. Development is understood to be a nonlinear, complex set of processes involving political, economic, social, cultural, and environmental factors whose ultimate goal is to improve the quality of life for individuals. The role of both the state and the market in development processes will be examined. Topics to be covered will vary as changing realities dictate but will be drawn from such subjects as inequality of income distribution; the role of education and health care; region-markets; the impact of globalization, institution-building, corporate-community-state interfaces, neoliberalism, privatization, democracy, and public policy formulation as it relates to development goals. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS437. ASIAN DEVELOPMENT This international political economy seminar deals with the historical development of Asia Pacific from agrarian to post-industrial eras; its economic, political, and cultural transformation since World War II, contemporary security issues that both divide and unite the region; and globalization processes that encourage Asia Pacific to forge a single trading bloc. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS439. MIDDLE EAST DEVELOPMENT This international political economy seminar analyzes economic, political and social dynamics that affect the progress and direction of states, markets, and peoples of the region. It examines the development of the Middle East from agrarian to post-industrial societies; economic, political and cultural transformations since World War II; contemporary security issues that both divide and unite the region; and the effects of globalization processes on economies and societies in the Middle East. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS440. WAR AND PEACE IN THE MIDDLE EAST This course introduces students to theories of war and then discusses a select number of historical wars and contemporary ones. It also analyzes efforts at peace-making efforts and why some fail and others succeed. The global consequences of war and peace in the Middle East will be explored in terms of oil supply and of other geostrategic interests that America has in that region. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS441. AFRICAN DEVELOPMENT This course provides a broad overview of the political economy of Africa. Its goal is to give students an understanding of the possibilities of African development and the impediments that currently block its economic growth. Despite substantial natural resources, mineral reserves, and human capital, most African countries remain mired in poverty. The struggles that have arisen on the continent have fostered thinking about the curse of natural resources where countries with oil or diamonds are beset with political instability and warfare. Readings give first an introduction to the continent followed by a focus on the specific issues that confront African development today. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS442. NATURAL RESOURCES AND WAR IN AFRICA 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, misman-

agement of government and corruption, and specific cases of unrest and war in Africa. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS446. GLOBALIZATION This international political economy seminar is an historical and contemporary analysis of globalization processes examined through selected issues of world affairs of political, economic, military, and diplomatic significance. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar, 3 semester hours.

LAIS448. GLOBAL ENVIRONMENTAL ISSUES 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 co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS450. POLITICAL RISK ASSESSMENT This course will review the existing methodologies and techniques of risk assessment in both country-specific and global environments. It will also seek to design better ways of assessing and evaluating risk factors for business and public diplomacy in the increasingly globalized context of economy and politics wherein the role of the state is being challenged and redefined. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. **Prerequisite: At least one IPE 300- or 400-level course and permission of instructor**. 3 hours seminar; 3 semester hours.

LAIS451. POLITICAL RISK ASSESSMENT RESEARCH SEMINAR 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 co-requisite: SYGN200. Concurrent enrollment in LAIS450. 1 hour seminar; 1 semester hour.

LAIS452. CORRUPTION AND DEVELOPMENT This course addresses the problem of corruption and its impact on development. Readings are multidisciplinary and include policy studies, economics, and political science. Students will acquire an understanding of what constitutes corruption, how it negatively affects development, and what they, as engineers in a variety of professional circumstances, might do in circumstances in which bribe paying or bribe taking might occur. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS453. ETHNIC CONFLICT IN GLOBAL PERSPECTIVE Many scholars used to believe that with modernization, racial, religious, and cultural antagonisms would weaken as individuals developed more rational outlooks and gave primacy to their economic concerns. Yet, with the waning of global ideological conflict of the left-right nature, conflict based on cultural and "civilization" differences have come to the fore in both developing and developed countries. This course will examine ethnic conflict, broadly conceived, in a variety of contexts. Case studies will include the civil war in Yugoslavia, the LA riots, the antagonism between the Chinese and "indigenous' groups in Southeast, the so-called war between the West and Islam, and ethnic relations in the U.S. We will consider ethnic contention in both institutionalized, political processes, such as the politics of affirmative action, as well as in non-institutionalized, extra-legal settings, such as ethnic riots, pogroms, and genocide. We will end by asking what can be done to mitigate ethnic conflict and what might be the future of ethnic group identification. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS456. POWER AND POLITICS IN EURASIA This seminar covers the major internal and international issues confronting the fifteen states that once comprised the Soviet Union. After an overview of the USSR and its collapse in 1991, the course explores subsequent economic and security dilemmas facing the "new" nations of Eurasia. Special attention will be paid to oil, natural gas, and other energy sectors in the region. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS457. INTRODUCTION TO CONFLICT MANAGEMENT This course introduces students to central topics in conflict management. It assesses the causes of contemporary conflicts with an initial focus on weak states, armed insurgencies, and ethnic conflict. It then examines a range of peace-building efforts, and strategies for reconstructing post-conflict states. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS459. INTERNATIONAL FIELD PRACTICUM For students who go abroad for an on-site practicum involving their technical field as practiced in another country and culture; required course for students pursuing a certificate in International Political Economy; all arrangements for this course are to be supervised and approved by the advisor of the International Political Economy minor program. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS460. GLOBAL GEOPOLITICS 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: LAIS 100 or LAIS101. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 credit hours.

LAIS475. ENGINEERING CULTURES IN THE DEVELOPING WORLD An investigation and assessment of engineering problem-solving in the developing world using historical and cultural cases. Countries to be included range across Africa, Asia, and Latin America. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS477. ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT. This course is an introduction to the relationship between engineering and sustainable community development (SCD) from historical, political, ethical, cultural, and practical perspectives. Students will study and analyze different dimensions of sustainability, community, and "helping," and the role that engineering might play in them. Also students will critically explore strengths and limitations of dominant methods in engineering problem solving and design for working in SCD. Through case-studies, students will learn to analyze and evaluate projects in SCD and develop criteria for their evaluation. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN 200. 3 hours seminar; 3 semester hours.

LAIS485. CONSTITUTIONAL LAW AND POLITICS This course presents a comprehensive survey of the U.S. Constitution with special attention devoted to the first ten Amendments, also known as the Bill of Rights. Since the Constitution is primarily a legal document, the class will adopt a legal approach to constitutional interpretation. However, as the historical and political context of constitutional interpretation is inseparable from the legal analysis, these areas will also be covered. Significant current developments in constitutional jurisprudence will also be examined. The first part of the course deals with Articles I through III of the Constitution, which specify the division of national governmental power among the executive, legislative, and judicial branches of government. Additionally, the federal nature of the American governmental system, in which governmental authority is apportioned between the national government and the state governments, will be studied. The second part of the course examines the individual rights specifically protected by the amendments to the Constitution, principally the First, Fourth, Fifth, Sixth, Eighth, and Fourteenth Amendments. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS486. SCIENCE AND TECHNOLOGY POLICY An examination of current issues relating to science and technology policy in the United States and, as appropriate, in other countries. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS487. ENVIRONMENTAL POLITICS AND POLICY Seminar on environmental policies and the political and governmental processes that produce them. Group discussion and independent research on specific environmental issues. Primary but not exclusive focus on the U.S. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS488. WATER POLITICS AND POLICY 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. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS489. NUCLEAR POWER AND PUBLIC POLICY A general introduction to research and practice concerning policies and practices relevant to the development and management of nuclear power. Prerequisite: LAIS 100. Prerequisite or co-requisite: SYGN 200. 3 hours seminar; 3 semester hours.

LAIS/ENGY490. ENERGY AND SOCIETY (I,II) An interdisciplinary capstone seminar that explores a spectrum of approaches to the understanding, planning, and implementation of energy production and use, including those typical of diverse private and public (national and international) corporations, organizations, states, and agencies. Aspects of global energy policy that may be considered include the historical, social, cultural, economic, ethical, political, and environmental aspects of energy together with comparative methodologies and assessments of diverse forms of energy development as these affect particular communities and societies. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS497. SUMMER PROGRAMS

LAIS498. SPECIAL TOPICS 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 semester hours. Repeatable for credit under different titles.

LAIS499. INDEPENDENT STUDY Individual research or special problem projects supervised by a faculty member. Primarily for students who have completed their Humanities and Social Science requirements. Instructor consent required. Prerequisite: “Independent Study” form must be completed and submitted to the Registrar. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. Variable credit: 1 to 6 semester hours. Repeatable for credit.

Systems (SYGN)

SYGN 200. HUMAN SYSTEMS A core undergraduate course that helps students at an applied science and engineering university understand the structure of the world in which they will be working and their roles in that world. This social science course uses readings and lecture to explore historical, scientific, technological, sociological, political, and eco-

nomic changes in the world and their culmination in contemporary globalization. Students are encouraged to consider a conceptual map that should allow them to think critically about the world in which they live and the events that shaped that world.

Foreign Languages (LIFL)

Three foreign languages are taught through the LAIS Division. Students interested in a particular language should check with the LAIS Division Office to determine when these languages might be scheduled. 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. If there is sufficient demand, the Division can provide third- and fourth-semester courses in a given foreign language. **No student is permitted to take a foreign language that is either his/her native language or second language.**

Description of Courses

LIFL113. SPANISH I Fundamentals of spoken and written Spanish with an emphasis on vocabulary, idiomatic expressions of daily conversation, and Spanish American culture. 3 semester hours.

LIFL123. SPANISH II 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.

LIFL213. SPANISH III Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and Spanish American culture. 3 semester hours.

LIFL114. ARABIC I 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.

LIFL124. ARABIC II 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.

LIFL214. ARABIC III Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and culture of Arabic-speaking societies. 3 semester hours.

LIFL115. GERMAN I Fundamentals of spoken and written German with an emphasis on vocabulary, idiomatic expressions of daily conversation, and German culture. 3 semester hours.

LIFL125. GERMAN II 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.

LIFL215. GERMAN III Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and German culture. 3 semester hours.

LIFL 198, 298, 398, and 498. SPECIAL TOPICS 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 semester hours. Repeatable for credit under different topics.

LIFL 199, 299, 399, and 499. INDEPENDENT STUDY Individual research or special problem projects supervised by a faculty member. Instructor consent required. Prerequisite: "Independent Study" form must be completed and submitted to the Registrar. Variable credit: 1 to 6 semester hours. Repeatable for credit.

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. A maximum of 3 semester hours of concert band, chorus, physical education, athletics or other activity credit combined may be used toward free elective credit in a degree granting program.**

LIMU101, 102, 201, 202, 301, 302, 401, 402. BAND 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, 112, 211, 212, 311, 312, 411, 412. CHORUS Study, rehearsal, and performance of choral music of the classical, romantic, and modern periods with special emphasis on principles of diction, rhythm, intonation, phrasing, and ensemble. 2 hours rehearsal; 1 semester hour. Not repeatable using same course number. See rules limiting the number of hours applicable to a degree above.

LIMU340. MUSIC THEORY The course begins with the fundamentals of music theory and moves into their more complex applications. Music of the common practice period is considered. Aural and visual recognition of harmonic materials covered is emphasized. Prerequisite: LAIS315 or consent of instructor. 3 hours lecture; 3 semester hours.

(See also LAIS315. MUSICAL TRADITIONS OF THE WESTERN WORLD in preceding list of LAIS courses.)

LIMU341. BASIC MUSIC OMPOSITION AND ARRANGING This course begins with the fundamentals of music composition and works towards basic vocal and instrumental arrangement skills. Upon completion of this course the student should: 1) demonstrate basic knowledge of (music_ compositional techniques; 2) demonstrate primary concepts of vocal and instrumental ensemble arrangement; 3) demonstrate an ability to use notational software and Midi station hardware. Prerequisite; LIMU 340 or permission of instructor. 1 hour lecture; 1 semester hour.

LIMU350. MUSIC TECHNOLOGY 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.

LIMU421. JAZZ ENSEMBLE/PEP BAND - 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 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 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 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.

Mathematical and Computer Sciences

TRACY CAMP, Professor and Interim Department Head
BERNARD BIALECKI, Professor
MAHADEVAN GANESH, Professor
WILLY HEREMAN, Professor
PAUL A. MARTIN, Professor
DINESH MEHTA, Professor
BARBARA M. MOSKAL, Professor
WILLIAM C. NAVIDI, Professor
QI HAN, Associate Professor
LUIS TENORIO, Associate Professor
CORY AHRENS, Assistant Professor
ZIZHONG (JEFFREY) CHEN, Assistant Professor
JON M. COLLIS, Assistant Professor
AMANDA HERING, Assistant Professor
IRENE POLYCARPOU, Assistant Professor
ANDRZEJ SZYMCZAK, Assistant Professor
G. GUSTAVE GREIVEL, Teaching Professor
CYNDI RADER, Teaching Professor
TERRY BRIDGMAN, Teaching Associate Professor
HOLLY EKLUND, Teaching Associate Professor
KEITH HELLMAN, Teaching Associate Professor
JENNIFER STRONG, Teaching Associate Professor
SCOTT STRONG, Teaching Associate Professor
ROMAN TANKELEVICH, Teaching Associate Professor
WILLIAM R. ASTLE, Professor Emeritus
NORMAN BLEISTEIN, Professor Emeritus
ARDEL J. BOES, Professor Emeritus
AUSTIN R. BROWN, Professor Emeritus
JOHN A. DESANTO, Professor Emeritus
RAYMOND R. GUTZMAN, Professor Emeritus
FRANK G. HAGIN, Professor Emeritus
DONALD C.B. MARSH, Professor Emeritus
STEVEN PRUESS, Professor Emeritus
ROBERT E. D. WOOLSEY, Professor Emeritus
BARBARA B. BATH, Associate Professor Emerita
RUTH MAURER, Associate Professor Emerita
ROBERT G. UNDERWOOD, Associate Professor Emeritus

Program Description

The Mathematical and Computer Sciences Department (MCS) offers an undergraduate degree in which the student may select a program in the mathematical and computer sciences. There are three tracks: (i) the Computational and Applied Mathematics (CAM) option, (ii) the Statistics option, and (iii) the Computer Science option. Each track offers a unique opportunity to study mathematical and computer sciences in an engineering environment. All three tracks emphasize technical competence, problem solving, teamwork, projects, relation to other disciplines, and verbal, written, and graphical skills.

The department provides the teaching skills and technical expertise to develop mathematical and computer sciences capabilities for all Colorado School of Mines students. In addition, MCS programs support targeted undergraduate majors in mathematical and computer sciences and also graduate degree programs relevant to mathematical and computer sciences aspects of the CSM mission.

In a broad sense, these programs stress the development of practical applications techniques to enhance the overall attractiveness of mathematical and computer sciences majors to a wide range of employers in industry. More specifically, we utilize a summer session program in Computer Science and the senior capstone experiences in Computational and Applied Mathematics, and Statistics to engage high-level undergraduate students in problems of practical applicability for potential employers. These courses are designed to simulate an industrial job or research environment. The close collaboration with potential employers or professors improves communication between our students and the private sector as well as with sponsors from other disciplines on campus.

Mathematical and Computer Sciences majors can use their free electives to take additional courses of special interest to them. This adds to the flexibility of the program and qualifies students for a wide variety of careers.

Any program of this type requires emphasis in study areas which utilize the special skills of the Department. These areas are:

Computational and Applied Mathematics: Classical scattering theory, dynamical systems, nonlinear partial differential equations, numerical analysis, symbolic computing, and mathematics education.

Applied Computer Sciences: Artificial intelligence, ad-hoc networks, applied algorithms, high performance and fault-tolerant computing, parallel and distributed systems, computer graphics, visualization, middleware, and educational technologies and human-computer interaction.

Statistics: Stochastic modeling, Monte Carlo methods, biostatistics, statistical methods in cosmology, and inverse problems.

Program Educational Objectives (Bachelor of Science in Mathematical and Computer Sciences)

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

Students will demonstrate technical expertise within mathematics/computer science by:

- Designing and implementing solutions to practical problems in science and engineering,
- Using appropriate technology as a tool to solve problems in mathematics/computer science, and
- Creating efficient algorithms and well-structured computer programs.

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

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

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

- Applying mathematics/computer science to solve problems in other fields,
- Working in cooperative multi-disciplinary teams, and
- Choosing appropriate technology to solve problems in other disciplines.

Students will demonstrate an ability to communicate mathematics/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 mathematics/computer science.

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 underprepared 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 and computer sciences 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, team work, assessment, and communications emphasis directly address ABET criteria and the CSM graduate profile. The curriculum offers the following three study options:

Degree Requirements (Mathematical and Computer Sciences)

Computational and Applied Mathematics Option

Freshman Year - Fall	lec.	lab.	sem.hrs
CHGN121 - Principles of Chemistry I	3.0	3.0	4.0
MATH111 - Calculus for Sci. & Eng. I	4.0		4.0
CSCI101 - Intro to Computer Science	3.0		3.0
LAIS100 - Nature & Human Values	4.0		4.0
CSM101 - Freshman Success Seminar	0.5		0.5
PAGN101 - Physical Education I	0.5		0.5
Total			16.0

Freshman Year - Spring	lec.	lab.	sem.hrs
DSCI - Distributed Sci. Elective			4.0*
MATH112 - Calculus for Sci. & Eng. II	4.0		4.0
EPIC151 - Design I	3.0		3.0
PHGN100 - Physics I	3.0	3.0	4.5
PAGN102 - Physical Education II	0.5		0.5
Total			16.0

Sophomore Year - Fall	lec.	lab.	sem.hrs
MATH213 - Calculus for Sci. & Eng. III	4.0		4.0
CSCI261 - Programming Concepts	3.0		3.0
PHGN200 - Physics II	3.0	3.0	4.5
EBGN201 - Principles of Economics	3.0		3.0**
PAGN2xx - Physical Education III	0.5		0.5
Total			15.0

Sophomore Year - Spring	lec.	lab.	sem.hrs
CSCI262 - Data Structures	3.0		3.0
MATH225 - Differential Equations	3.0		3.0
MATH342 - Honors Linear Algebra	3.0		3.0
SYGN200 - Human Systems	3.0		3.0**
FREE - Free Elective	3.0		3.0
PAGN2xx - Physical Education II	0.5		0.5
Total			15.5

Summer Session	lec.	lab.	sem.hrs
MACS300 - Foundations of Adv. Math.	4.0		4.0

Junior Year - Fall	lec.	lab.	sem.hrs
MATH401 - Introduction to Analysis	3.0		3.0
MATH334 - Introduction to Probability	3.0		3.0
CSCI/MATH407 - Intro. to Sci. Computing	3.0		3.0
LAIS/EBGN - H&SS Cluster Elective I	3.0		3.0
FREE - Free Elective	3.0		3.0
FREE - Free Elective	3.0		3.0
Total			18.0

Junior Year - Spring	lec.	lab.	sem.hrs
MATH458 - Abstract Algebra	3.0		3.0
MATH454 - Complex Analysis	3.0		3.0
MATH - Mathematics Elective	3.0		3.0
LAIS/EBGN - H&SS Cluster Elective II	3.0		3.0
FREE - Free Elective	3.0		3.0
FREE - Free Elective	1.0		1.0
Total			16.0

Senior Year - Fall	lec.	lab.	sem.hrs
MATH455 - Partial Differential Eq.	3.0		3.0
MATH433 - Mathematical Biology	3.0		3.0
MATH441 - Computer Graphics	3.0		3.0
LAIS/EBGN - H&SS Cluster Elective III	3.0		3.0
FREE - Free Elective	3.0		3.0
Total			15.0

Senior Year - Spring	lec.	lab.	sem.hrs
MATH440 - Parallel Sci. Computing	3.0		3.0
MATH484 - Math. Modeling (Capstone)	3.0		3.0
MATH - Mathematics Elective	3.0		3.0
MATH - Mathematics Elective	3.0		3.0
FREE - Free Elective	3.0		3.0
Total			15.0

Degree Total:	130.5

* Students may choose from the remainder of the Distributed Science (SYGN101 (4 Cr. Hr.), BELS101 (4 Cr. Hr.), CHGN122 (4 Cr. Hr.)) course list for this course.

** Students should take EBGN201 with one of these courses and SYGN200 with the other.

Statistics Option

Freshman Year - Fall	lec.	lab.	sem.hrs
CHGN121 - Principles of Chemistry I	3.0	3.0	4.0
MATH111 - Calculus for Sci. & Eng. I	4.0		4.0
CSCI101 - Intro to Computer Science	3.0		3.0
LAIS100 - Nature & Human Values	4.0		4.0
CSM101 - Freshman Success Seminar	0.5		0.5
PAGN101 - Physical Education I	0.5		0.5
Total			16.0

Freshman Year - Spring	lec.	lab.	sem.hrs
DSCI - Distributed Sci. Elective			4.0*
MATH112 - Calculus for Sci. & Eng. II	4.0		4.0
EPIC151 - Design I	3.0		3.0
PHGN100 - Physics I	3.0	3.0	4.5
PAGN102 - Physical Education II	0.5		0.5
Total			16.0

Sophomore Year - Fall	lec.	lab.	sem.hrs
MATH213 - Calculus for Sci. & Eng. III	4.0		4.0
CSCI261 - Programming Concepts	3.0		3.0
PHGN200 - Physics II	3.0	3.0	4.5
EBGN201 - Principles of Economics	3.0		3.0**
PAGN2xx - Physical Education III	0.5		0.5
Total			15.0

Sophomore Year - Spring	lec.	lab.	sem.hrs
CSCI262 - Data Structures	3.0		3.0
MATH225 - Differential Equations	3.0		3.0
MATH342 - Honors Linear Algebra	3.0		3.0
SYGN200 - Human Systems	3.0		3.0**
FREE - Free Elective	3.0		3.0
PAGN2xx - Physical Education II	0.5		0.5
Total			15.5

Summer Session	lec.	lab.	sem.hrs
MACS300 - Foundations of Adv. Math.	4.0		4.0

Junior Year - Fall	lec.	lab.	sem.hrs
MATH401 - Introduction to Analysis	3.0		3.0
MATH334 - Introduction to Probability	3.0		3.0
CSCI/MATH407 - Intro. to Sci. Computing	3.0		3.0
LAIS/EBGN - H&SS Cluster Elective I	3.0		3.0
FREE - Free Elective	3.0		3.0
FREE - Free Elective	3.0		3.0
Total			18.0

Junior Year - Spring	lec.	lab.	sem.hrs
MATH458 - Abstract Algebra	3.0		3.0
MATH335 - Intro to Math Statistics	3.0		3.0
MATH - Mathematics Elective	3.0		3.0
LAIS/EBGN - H&SS Cluster Elective II	3.0		3.0
FREE - Free Elective	3.0		3.0
FREE - Free Elective	1.0		3.0
Total			16.0

Senior Year - Fall	lec.	lab.	sem.hrs
MATH424 - Intro to Applied Statistics	3.0		3.0
MATH438 - Stochastic Models	3.0		3.0
MATH433 - Mathematical Biology	3.0		3.0
LAIS/EBGN - H&SS Cluster Elective III	3.0		3.0
FREE - Free Elective	3.0		3.0
Total			15.0

Senior Year - Spring	lec.	lab.	sem.hrs
MATH436 - Adv. Statistical Modeling	3.0		3.0
MATH482 - Stat. Practicum (Capstone)	3.0		3.0
MATH - Mathematics Elective	3.0		3.0
MATH - Mathematics Elective	3.0		3.0
FREE - Free Elective	3.0		3.0
Total			15.0

Degree Total			130.5

* Students may choose from the remainder of the Distributed Science (SYGN101 (4 Cr. Hr.), BELS101 (4 Cr. Hr.), CHGN122 (4 Cr. Hr.)) course list for this course.

** Students should take EBGN201 with one of these courses and SYGN200 with the other.

Computer Sciences Option

Freshman Year - Fall	lec.	lab.	sem.hrs
CHGN121 - Principles of Chemistry I	3.0	1.0	4.0
MATH111 - Calculus for Sci. & Eng. I	4.0		4.0
CSCI101 - Intro to Computer Science	3.0		3.0
LAIS100 - Nature & Human Values	4.0		4.0
CSM101 - Freshman Success Seminar	0.5		0.5
PAGN101 - Physical Education I	0.5		0.5
Total			16.0

Freshman Year - Spring	lec.	lab.	sem.hrs
DSCI - Distributed Sci. Elective			4.0*
MATH112 - Calculus for Sci. & Eng. II	4.0		4.0
EPIC151 - Design I	3.0		3.0
PHGN100 - Physics I	4.5		4.5
PAGN102 - Physical Education II	0.5		0.5
Total			16.0

Sophomore Year - Fall	lec.	lab.	sem.hrs
MATH213 - Calculus for Sci. & Eng. III	4.0		4.0
CSCI261 - Programming Concepts	3.0		3.0
PHGN200 - Physics II	4.5		4.5
EBGN201 - Principles of Economics	3.0		3.0**
PAGN2xx - Physical Education III	0.5		0.5
Total			15.0

Sophomore Year - Spring	lec.	lab.	sem.hrs
CSCI262 - Data Structures	3.0		3.0
MATH225 - Differential Equations	3.0		3.0
CSCI358 - Discrete Mathematics	3.0		3.0
CSCI341 - Computer Organization	3.0		3.0
SYGN200 - Human Systems	3.0		3.0**
PAGN2xx - Physical Education II	0.5		0.5
Total			15.5

Junior Year - Fall	lec.	lab.	sem.hrs
CSCI306 - Software Engineering	3.0		3.0
MATH323 - Prob. & Stat. for Engineers	3.0		3.0
MATH332 - Linear Algebra	3.0		3.0
FREE - Free Elective	3.0		3.0
FREE - Free Elective	3.0		3.0
Total			15.0

Junior Year - Spring	lec.	lab.	sem.hrs
CSCI406 - Algorithms	3.0		3.0
CSCI410 – Elements of Computing Systems	3.0		3.0
CSCI - Computer Science Elective	3.0		3.0
LAIS/EBGN - H&SS Cluster Elective I	3.0		3.0
FREE - Free Elective	3.0		3.0
FREE - Free Elective	1.0		1.0
Total			16.0

Summer Session	lec.	lab.	sem.hrs
CSCI370 - Field Course			6.0

Senior Year - Fall	lec.	lab.	sem.hrs
CSCI442 - Operating Systems	3.0		3.0
CSCI - Computer Science Elective	3.0		3.0
CSCI - Computer Science Elective	3.0		3.0
LAIS/EBGN - H&SS Cluster Elective II	3.0		3.0
FREE - Free Elective	3.0		3.0
Total			15.0

Senior Year - Spring	lec.	lab.	sem.hrs
CSCI400 - Princ. Of Programming Lang.	3.0		3.0
CSCI - Computer Science Elective	3.0		3.0
LAIS/EBGN - H&SS Cluster Elective III	3.0		3.0
FREE - Free Elective	3.0		3.0
FREE - Free Elective	3.0		3.0
Total			15.0

Degree Total: 129.5

* Students may choose from the remainder of the Distributed Science (SYGN101 (4 Cr. Hr.), BELS101 (4 Cr. Hr.), CHGN122 (4 Cr. Hr.)) course list for this course.

** Students should take EBGN201 with one of these courses and SYGN200 with the other.

Minor/ASI Mathematical and Computer Sciences

Computational and Applied Math (CAM)

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

MATH225 or MATH235 – Differential Equations
MATH332 or MATH342 – Linear Algebra
MATH/CSCI407 – Intro. to Scientific Computing

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

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

MATH225 or MATH235 – Differential Equations
MATH332 or MATH342 – Linear Algebra
MATH/CSCI407 – Intro. to Scientific Computing

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

CAM Courses:

MATH348 – Advanced Engineering Mathematics
MATH401 – Intro. to Analysis
MATH/CSCI406 - Algorithms
MATH433 – Mathematical Biology
MATH440 – Parallel Scientific Computing
MATH/CSCI441 – Computer Graphics
MATH454 – Complex Analysis
MATH455 – Partial Differential Equations
MATH484 – Mathematical & Computational Modeling
MATH498 – Special Topics in CAM
MATH5xx – Graduate CAM Electives

Statistics:

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

MATH323– Probability & Statistics for Engineers
MATH334 – Intro. to Probability
MATH335 – Intro. to Mathematical Statistics
MATH424 – Intro. to Applied Statistics

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

MATH323– Probability & Statistics for Engineers
MATH334 – Intro. to Probability
MATH335 – Intro. to Mathematical Statistics
MATH424 – Intro. to Applied Statistics

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

Statistics Courses:

MATH332 or MATH342 – Linear Algebra
MATH436 – Advanced Statistical Modeling
MATH437 – Multivariate Analysis
MATH438 – Stochastic Models
MATH482 – Statistics Practicum
MATH498 – Special Topics in Statistics
MATH5xx – Graduate Statistics Elective

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 or MATH235 – Differential Equations

9 credit hours of Mathematics courses (3 courses) from the Mathematical Sciences Courses List below, including one course at the 400-level.

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

MATH225 or MATH235 – Differential Equations

15 credit hours of Mathematics courses (5 courses) from the Mathematical Sciences

Courses List below, including one course at the 400-level.

Mathematical Sciences Courses:

MATH323– Probability & Statistics for Engineers
MATH332 or MATH342 – Linear Algebra
MATH334 – Intro. to Probability
MATH335 – Intro. to Mathematical Statistics
MATH348 – Advanced Engineering Mathematics
MATH358 – Discrete Mathematics
MATH401 – Intro. to Analysis
MATH/CSCI406 - Algorithms
MATH/CSCI407 – Intro. to Scientific Computing
MATH424 – Intro. to Applied Statistics
MATH433 – Mathematical Biology
MATH436 – Advanced Statistical Modeling
MATH437 – Multivariate Analysis
MATH438 – Stochastic Models
MATH440 – Parallel Scientific Computing
MATH/CSCI441 – Computer Graphics
MATH/CSCI444 – Advanced Computer Graphics
MATH/CSCI447 – Scientific Visualization
MATH454 – Complex Analysis
MATH455 – Partial Differential Equations

MATH482 – Statistics Practicum
MATH484 – Mathematical & Computational Modeling
MATH498 – Special Topics
MATH5xx – Graduate Electives

Computer Science

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

CSCI262 Data Structures
CSCI306 Software Engineering
and either:
CSCI358 Discrete Mathematics & Algebraic Structures and
CSCI406 Algorithms
–or-
CSCI341 Computer Organization and
CSCI442 Operating Systems

For the **Minor in Computer Sciences**, the student should take:

CSCI262 Data Structures
CSCI306 Software Engineering
and either:
CSCI358 Discrete Math & Algebraic Structures and
CSCI406 Algorithhms
-or-
CSCI341 Computer Organization
CSCI442 Operating Systems
and:
CSCI4XX – 2 400-level Computer Science courses, which may not be languages transferred from another university

Combined BS/MS in Mathematical and Computer Sciences

The Department of Mathematical and Computer Sciences offers a combined Bachelor of Science/Master of Science program in both Computer Science and Applied Mathematics that enables students to complete a Bachelor of Science and a Master of Science simultaneously. The student takes an additional 30 credit hours of coursework at the graduate level, in addition to the undergraduate requirements, and completes both degrees at the same time. Interested students should contact the department for further information.

Description of Courses

MATH100. INTRODUCTORY TOPICS FOR CALCULUS (S) An introduction and/or review of topics which are essential to the background of an undergraduate student at CSM. This course serves as a preparatory course for the Calculus curriculum and includes material from Algebra, Trigonometry, Mathematical Analysis, and Calculus. Topics include basic algebra and equation solving, solutions of inequalities, trigonometric functions and identities, functions of a single variable, continuity, and limits of functions. Does not apply toward undergraduate degree or g.p.a. Prerequisite: Consent of Instructor. 2 hours lecture, 2 semester hours.

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

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

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

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

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

MATH/CSCI198. SPECIAL TOPICS (I, II, S) 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: Consent of Instructor. Variable credit: 1 to 6 semester hours. Repeatable for credit under different titles.

MATH/CSCI199. INDEPENDENT STUDY (I, II, S) 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.

Sophomore Year

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

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

MATH222. INTRODUCTION TO DIFFERENTIAL EQUATIONS FOR GEOLOGISTS & GEOLOGICAL ENGINEERS (II). An introduction to differential equations with a special emphasis on problems in the earth related fields. Topics include first and second order ordinary differential equations, Laplace Transforms, and applications relevant to the earth related fields. Prerequisites: MATH213 or MATH223 or MATH224. Student must also be a declared major in Geology and Geological Engineering. 2 hours lecture; 2 semester hours.

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

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

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

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

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

CSCI260. FORTRAN PROGRAMMING (I, II) Computer programming in Fortran90/95 with applications to science and engineering. Program design and structure, problem analysis, debugging, program testing. Language skills: arithmetic, input/output, branching and looping, functions, arrays, data types. Introduction to operating systems. Prerequisite: none. 2 hours lecture; 2 semester hours.

CSCI261. PROGRAMMING CONCEPTS (I, II, S) Computer programming in a contemporary language such as C++ or Java, using software engineering techniques. Problem solving, program design, documentation, debugging practices. Language skills: input/output, control, repetition, functions, files, classes and abstract data types, arrays, and pointers. Introduction to operating systems and object-oriented programming. Application to problems in science and engineering. Prerequisite: none. 3 hours lecture; 3 semester hours.

CSCI262. DATA STRUCTURES (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. 3 hours lecture; 3 semester hours.

MATH/CSCI298. SPECIAL TOPICS (I, II, S) Selected topics chosen from special interests of instructor and students. Prerequisite: Consent of Department Head. 1 to 3 semester hours. Repeatable for credit under different titles.

MATH/CSCI299. INDEPENDENT STUDY (I, II, S) 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 (S) (WI) This course is an introduction to communication in mathematics as well computational tools for mathematics. This writing intensive course provides a transition from the Calculus sequence to the upper-division mathematics curriculum at CSM. Topics include logic and recursion, techniques of mathematical proofs, reading and writing proofs, mathematics software. Prerequisites: MATH213, MATH223 or MATH224. 2 hours lecture, 1 hour seminar, 2 hours lab; 4 semester hours.

Junior Year

CSCI306. SOFTWARE ENGINEERING (I, II) Introduction to the software life cycle, including planning, design, implementation and testing. Topics include top down program design, problem decomposition, iterative refinement, program modularity and abstract data types. Course work emphasizes good programming practices via models, metrics and documents created and used throughout the software engineering process. Prerequisite: CSCI262. 3 hours lecture; 3 semester hours.

MATH323. PROBABILITY AND STATISTICS FOR ENGINEERS I (I, II, S) Elementary probability, propagation of error, discrete and continuous probability models, interval estimation, hypothesis testing, and linear regression with emphasis on applications to science and engineering. Prerequisite: MATH213, MATH223 or MATH224. 3 hours lecture; 3 semester hours.

MATH332. LINEAR ALGEBRA (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 (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 (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.

MATH/CSCI340. COOPERATIVE EDUCATION (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 (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. This course provides insight into the way computers operate at the machine level. Prerequisite: CSCI261. 3 hours lecture; 3 semester hours.

MATH342. HONORS LINEAR ALGEBRA (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 (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 majors. Prerequisite: MATH225 or MATH235. 3 hours lecture; 3 semester hours.

MATH/CSCI358. DISCRETE MATHEMATICS (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. FIELD COURSE (S) (WI) This is the Computer Science option's capstone course where the students apply their course work knowledge to a challenging applied problem in mathematics or computer science. In this course they analyze, modify and solve a significant applied problem. The students work in groups of three or four for a period of six forty-hour weeks. By the end of the field session they must have a finished product with appropriate supporting documents. At a minimum CS students should have completed coursework through CSCI306. Prerequisite: Consent of Instructor. 6-week summer session; 6 semester hours.

MATH/CSCI398. SPECIAL TOPICS (I, II, S) Selected topics chosen from special interests of instructor and students. Prerequisite: Consent of Department Head. 1 to 3 semester hours. Repeatable for credit under different titles.

MATH/CSCI399. INDEPENDENT STUDY (I, II, S) Individual research or special problem projects supervised by a faculty member given agreement 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.

Senior Year

CSCI400. PRINCIPLES OF PROGRAMMING LANGUAGES (I, II) Study of the principles relating to design, evaluation and implementation of programming languages of historical and technical interest, considered as individual entities and with respect to their relationships to

other languages. Topics discussed for each language include: history, design, structural organization, data structures, name structures, control structures, syntactic structures, and implementation of issues. The primary languages discussed are FORTRAN, PASCAL, LISP, ADA, C/C++, JAVA, PROLOG, PERL.
Prerequisite: CSCI262 and CSCI306 or knowledge of JAVA. 3 hours lecture; 3 semester hours.

MATH401 INTRODUCTION TO ANALYSIS (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.

CSCI403. DATA BASE MANAGEMENT (I) Design and evaluation of information storage and retrieval systems, including defining and building a data base and producing the necessary queries for access to the stored information. Generalized data base management systems, query languages, and data storage facilities. General organization of files including lists, inverted lists and trees. System security and system recovery, and system definition. Interfacing host language to data base systems. Prerequisite: CSCI262. 3 hours lecture; 3 semester hours.

CSCI404. ARTIFICIAL INTELLIGENCE (I) General investigation of the Artificial Intelligence field. During the first part of the course a working knowledge of the LISP programming language is developed. Several methods used in artificial intelligence such as search strategies, knowledge representation, logic and probabilistic reasoning are developed and applied to problems. Learning is discussed and selected applications presented. Prerequisite: CSCI262, MATH358. 3 hours lecture; 3 semester hours.

MATH/CSCI406. ALGORITHMS (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, MATH213, MATH223 or MATH224, MATH/CSCI358. 3 hours lecture; 3 semester hours.

MATH/CSCI407. INTRODUCTION TO SCIENTIFIC COMPUTING (I, II) Round-off error in floating point arithmetic, conditioning and stability, solution techniques (Gaussian elimination, LU factorization, iterative methods) of linear algebraic systems, curve and surface fitting by the method of least-squares, zeros of nonlinear equations and systems by iterative methods, polynomial interpolation and cubic splines, numerical integration by adaptive quadrature and multivariate quadrature, numerical methods for initial value problems in ordinary differential equations. Emphasis is on problem solving using efficient numerical methods in scientific computing. Prerequisite: MATH225 or MATH235 and knowledge of computer programming. 3 hours lecture; 3 semester hours.

CSCI410. ELEMENTS OF COMPUTING SYSTEMS (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: CSCI261, CSCI341. 3 lecture hours, 3 semester hours.

MATH/CSCI411. INTRODUCTION TO EXPERT SYSTEMS (II) General investigation of the field of expert systems. The first part of the course is devoted to designing expert systems. The last half of the course is implementation of the design and construction of demonstration prototypes of expert systems. Prerequisite: CSCI262, MATH/CSCI358. 3 hours lecture; 3 semester hours.

CSCI422. USER INTERFACES (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 textbook, and researching and analyzing the capabilities of various software development tools. Students will also learn a variety of techniques to guide the software design process, including Goal-Directed Design, Cognitive Walkthrough, Talk-aloud and others. Prerequisite: CSCI262. 3 hours lecture; 3 semester hours.

MATH424. INTRODUCTION TO APPLIED STATISTICS (I) Linear regression, analysis of variance, and design of experiments, focusing on the construction of models and evaluation of their fit. Techniques covered will include stepwise and best subsets regression, variable transformations, and residual analysis. Emphasis will be placed on the analysis of data with statistical software. Prerequisites: MATH323 or MATH335. 3 hours lecture; 3 semester hours.

MATH433/BELS433. MATHEMATICAL BIOLOGY (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, pharmcokinetics and modeling of physiologic systems.

Modern Control Theory will be introduced and used to model living systems. Some concepts related to self-organizing systems will be introduced. Prerequisite: MATH225 or MATH235. 3 hours lecture, 3 semester hours.

MATH436. ADVANCED STATISTICAL MODELING (II) Modern methods for constructing and evaluating statistical models. Topics include generalized linear models, generalized additive models, hierarchical Bayes methods, and resampling methods. Prerequisites: MATH335 and MATH424. 3 hours lecture; 3 semester hours.

MATH437. MULTIVARIATE ANALYSIS (II) Introduction to applied multivariate techniques for data analysis. Topics include principal components, cluster analysis, MANOVA and other methods based on the multivariate Gaussian distribution, discriminant analysis, classification with nearest neighbors.Prerequisites: MATH335 or MATH323. 3 hours lecture; 3 semester hours.

MATH438. STOCHASTIC MODELS (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.

CSCI440. PARALLEL COMPUTING FOR SCIENTISTS AND ENGINEERS (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. They will be introduced to various software and hardware issues related to high performance computing. Prerequisite: Programming experience in C++, consent of instructor. 3 hours lecture; 3 semester hours.

MATH440. PARALLEL SCIENTIFIC COMPUTING (I). This course is designed to facilitate students' learning of parallel programming techniques to efficiently simulate various complex processes modeled by mathematical equations usin 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: CSCI/MATH407. 3 hours lecture; 3 semester hours.

MATH/CSCI441. COMPUTER GRAPHICS (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.

CSCI442. OPERATING SYSTEMS (I, II) Covers the basic concepts and functionality of batch, timesharing and single-user operating system components, file systems, processes, protection and scheduling. Representative operating systems are studied in detail. Actual operating system components are programmed on a representative processor. This course provides insight into the internal structure of operating systems; emphasis is on concepts and techniques which are valid for all computers. Prerequisite: CSCI262, CSCI341. 3 hours lecture; 3 semester hours.

CSCI443. ADVANCED PROGRAMMING CONCEPTS USING JAVA. (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. Prerequisites: CSCI261, CSCI262. 3 hours lecture, 3 semester hours

MATH/CSCI444. ADVANCED COMPUTER GRAPHICS (I) 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. Basic understanding of computer graphics and prior exposure to graphics-related programming required. Prerequisite: MATH441. 3 lecture hours, 3 semester hours.

CSCI445. WEB PROGRAMMING (II) Web Programming is a course for programmers who want to develop Web-based applications. It covers basic web site design extended by client-side and server-side programming. Students should know the elements of HTML and Web architecture and be able to program in a high level language such as C++ or Java. The course builds on this knowledge by presenting topics such as Cascading Style Sheets, JavaScript, PERL and database connectivity that will allow the students to develop dynamic Web applications. Prerequisites: Fluency in a high level computer language/consent of instructor. 3 hours lecture, 3 semester hours.

CSCI446. WEB APPLICATIONS (I) Web Applications is a course for programmers who want to learn how to create effective, dynamic web pages. At the completion of this course, students should know Hypertext Markup Language (HTML), Cascading Style Sheets (CSS), JavaScript and JavaScript Object Notation (JSON), Ajax, Ruby and Flash. Additionally students should have considered a variety of issues related to web site design, including but not limited to web security, web server performance and content management. Prerequisites: CSCI262. 3 hours lecture, 3 semester hours.

MATH/CSCI447. SCIENTIFIC VISUALIZATION (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 (II) The complex plane. Analytic functions, harmonic functions. Mapping by elementary functions. Complex integration, power series, calculus of residues. Conformal mapping. Prerequisite: MATH225 or MATH235. 3 hours lecture, 3 semester hours.

MATH455. PARTIAL DIFFERENTIAL EQUATIONS (I) Linear partial differential equations, with emphasis on the classical second-order equations: wave equation, heat equation, Laplace's equation. Separation of variables, Fourier methods, Sturm-Liouville problems. Prerequisite: MATH225 or MATH235. 3 hours lecture; 3 semester hours.

MATH458. ABSTRACT ALGEBRA (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 and MATH223 or MATH224, and MATH300 or consent of the instructor. 3 hours lecture; 3 semester hours.

CSCI471. COMPUTER NETWORKS I (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), reliable data transfer, connection management, and congestion control. In addition, students will build a computer network from scratch and program client/server network applications. Prerequisite: CSCI442 or consent of instructor. 3 hours lecture, 3 semester hours.

MATH/CSCI474. INTRODUCTION TO CRYPTOGRAPHY 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, MATH334/335, MATH358. 3 credit hours.

CSCI475. INFORMATION SECURITY AND PRIVACY (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, and the legal and political dimensions of information security. Prerequisite: CSCI 442 or consent of instructor. 3 hours lecture; 3 semester hours.

MATH482 STATISTICS PRACTICUM (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) (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: MACS407, MACS433 and MACS455. 3 hours lecture; 3 semester hours.

MATH/CSCI491. UNDERGRADUATE RESEARCH (I) (WI) Individual investigation under the direction of a department faculty member. Written report required for credit. Prerequisite: Consent of Department Head. Variable - 1 to 3 semester hours. Repeatable for credit to a maximum of 12 hours.

MATH/CSCI492. UNDERGRADUATE RESEARCH (II) (WI) Individual investigation under the direction of a department faculty member. Written report required for credit. Prerequisite: Consent of Department Head. Variable - 1 to 3 semester hours. Repeatable for credit to a maximum of 12 hours.

MATH/CSCI497. SUMMER PROGRAMS

MATH/CSCI498. SPECIAL TOPICS (I, II, S) Selected topics chosen from special interests of instructor and students. Prerequisite: Consent of Department Head. Variable - 1 to 3 semester hours. Repeatable for credit under different titles.

MATH/CSCI499. INDEPENDENT STUDY (I, II, S) Individual research or special problem projects supervised by a faculty member; also, given agreement 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

MICHAEL J. KAUFMAN, Professor and Department Head
CORBY G. ANDERSON, Harrison Western Professor
STEPHEN LIU, Professor
GERARD P. MARTINS, Professor
DAVID K. MATLOCK, Charles S. Fogarty Professor
BRAJENDRA MISHRA, Professor
DAVID L. OLSON, John H. Moore Distinguished Professor
IVAR E. REIMANIS, Professor
JOHN G. SPEER, Professor
PATRICK R. TAYLOR, George S. Ansell Distinguished Professor of Chemical Metallurgy
CHESTER J. VAN TYNE, FIERF Professor and Associate Department Head
BRIAN P. GORMAN, Associate Professor
RYAN P. O'HAYRE, Associate Professor
STEVEN W. THOMPSON, Associate Professor
REED A. AYERS, Assistant Professor
KIP O. FINDLEY, Assistant Professor
JEFFREY C. KING, Assistant Professor
HONGJIN LIANG, Assistant Professor
CORINNE E. PACKARD, Assistant Professor
GERALD BOURNE, Teaching Associate Professor
JOHN P. CHANDLER, Teaching Associate Professor
GEORGE S. ANSELL, President Emeritus and Professor Emeritus
W. REX BULL, Professor Emeritus
GERALD L. DePOORTER, Associate Professor Emeritus
GLEN R. EDWARDS, University Professor Emeritus
ROBERT H. FROST, Associate Professor Emeritus
JOHN P. HAGER, University Professor Emeritus
GEORGE KRAUSS, University Professor Emeritus
JOHN J. MOORE, Professor Emeritus
DENNIS W. READEY, University Professor Emeritus

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 plasma and high-temperature reaction systems. Support analytical laboratories for surface analysis, emission spectrometry, X-ray analysis, optical microscopy and image analysis, electron microscopy, including both scanning and transmission electron microscopy, and micro-thermal-analysis/mass spectrometry. Metallurgical and materials engineering involves all of the processes which 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 program leading to the degree Bachelor of Science in Metallurgical and Materials Engineering is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 - telephone (410) 347-7700.

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 an option of earning an "area of special interest" (ASI) in one of four focus areas (MME 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 Focus Areas: There are four focus areas within the Metallurgical and Materials Engineering curriculum. Students have the option to select one of these focus areas to earn recognition with a designation of "area of special interest" (ASI) on their transcript. To earn an ASI the student must take a specific set of courses within MME. The specific courses for each focus area are listed below. As with any ASI at CSM only one of the ASI designated courses can be specifically required for the BS degree. The focus areas in MME are:

1. Physical and Manufacturing Metallurgy
2. Ceramic, Ionic & Electronic Materials
3. Physicochemical Processing of Materials
4. Biomaterials

The present areas of special interest (ASI) offered by the department as well as the course(s) required for the ASI are as follows:

ASI in Physical and Manufacturing Metallurgy requires:

MTGN442 Engineering Alloys (required for ASI)
and three out of the following four courses:
MTGN300/1 Foundry Metallurgy and Foundry Metallurgy Laboratory
MTGN456/8 Electron Microscopy and Electron Microscopy Laboratory
MTGN464 Forging and Forming
MTGN475/7 Metallurgy of Welding and Metallurgy of Welding Laboratory

ASI in Ceramic, Electronic, and Ionic Materials requires:

MTGN412 Ceramic Engineering (required for ASI)
MTGN415 Electronic Properties and Applications of Materials (required for ASI)

and two out of the following courses
MTGN469 Fuel Cell Science and Technology
MTGN498 Solid State Ionics
MTGN465/565 Mechanical Properties of Ceramics and Composites
MTGN598 Thin Film Mechanical Properties
or other suitable electives as approved by the faculty in the Colorado Center for Advanced Ceramics (CCAC)

ASI in Physicochemical Processing of Materials requires:
MTGN334 Chemical Processing of Materials (required for ASI)
and three out of the following five courses.
MTGN430 Physical Chemistry of Iron and Steelmaking
MTGN431 Hydro- and Electro-Metallurgy
MTGN432 Pyrometallurgy
MTGN532 Particulate Materials Processing I (can be taken as a senior)
MTGN533 Particulate Materials Processing II (can be taken as a senior)
or other suitable electives as approved by the faculty in the Kroll Institute for Extractive Metallurgy (KIEM)

ASI in Biomaterials requires:
MTGN470 Introduction to Biocompatibility (required for ASI)
MTGN498 Surfaces and Colloids (required for ASI)
MTGN463 Polymer Engineering (required for ASI)
and one out of the following two courses:
MTGN451 Corrosion Engineering
MTGN412 Ceramic Engineering

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)

Sophomore Year Fall Semester	lec.	lab.	sem.hrs.
DCGN209 Introduction to Thermodynamics	3		3
MATH213 Calculus for Scientists & Engnr's III	4		4
PHGN200 Physics II	3.5	3	4.5
MTGN202 Engineered Materials	3		3
PAGN201 Physical Education III		2	0.5
Total			15

Sophomore Year Spring Semester	lec.	lab.	sem.hrs.
MATH225 Differential Equations	3		3
Restricted Technical Elective*	3		3
DCGN241 Statics	3		3
EPIC251 Design II	2	3	3
EBGN201 Principles of Economics	3		3
SYGN200 Human Systems	3		3
PAGN202 Physical Education IV		2	0.5
Total			18.5

Summer Session	lec.	lab.	sem.hrs.
MTGN272 Particulate Materials Processing			3
Total			3

Junior Year Fall Semester	lec.	lab.	sem.hrs.
MTGN311 Structure of Materials	3	3	4
MTGN381 Phase Equilibria	2		2
MTGN351 Metallurgical & Materials Thermodynamics	3		3
EGGN320 Mechanics of Materials	3		3
LAIS/EBGN H&SS GenEd Restricted Elective I	3		3
Free Elective	3		3
Total			18

Junior Year Spring Semester	lec.	lab.	sem.hrs.
MTGN334 Chemical Processing of Materials	3	3	4
MTGN348 Microstructural Develop of Materials	3	3	4
MTGN352 Metallurgical & Materials Kinetics	3		3
LAIS/EBGN H&SS GenEd Restricted Elective II	3		3
Free Elective	3		3
Total			17

Senior Year Fall Semester	lec.	lab.	sem.hrs.
MTGN445 Mechanical Behavior of Materials	3	3	4
MTGN461 Trans. Phen. & Reactor Design for Met. & Mat. Engs.	2	3	3
MTGN450 Stat Process Control & Design of Experiments	3		3
MTGN—MTGN Elective	3		3
LAIS/EBGN H&SS GenEd Restricted Elective III	3		3
Total			16

Senior Year Spring Semester	lec.	lab.	sem.hrs.
MTGN466 Design, Selection & Use of Mats	1	6	3
MTGN415 Electronic Properties & Applications of Materials	3		3
MTGN—MTGN Elective	3		3
MTGN—MTGN Elective	3		3
MTGN—MTGN Elective	3		3
Free Elective	3		3
Total			18

Degree Total	138.5

*Restricted Technical Electives

BELS301 General Biology I
CSCI261 Programming Concepts
CHGN221 Organic Chemistry I
CHGN335 Instrumental Analysis
CHGN336 Analytical Chemistry
CHGN353 Physical Chemistry I
EGGN381 Introduction to Electrical Circuits
ENGY200 Introduction to Energy
ESGN353 Fundamentals of Environmental Science I
MATH323 Probability and Statistics
MATH332 Linear Algebra
MATH348 Advanced Engineering Math
PHGN215 Analog Electronics
PHGN300 Modern Physics

Minor in Metallurgical and Materials Engineering

General Requirements: A minor program in metallurgical and materials engineering consists of a minimum of 18 credit hours of a logical sequence of courses. Only three of these hours may be taken in the student's degree-granting department and no more than three of these hours may be at the 100- or 200- level. Students majoring in metallurgical and material engineering are not eligible to earn a minor in the department.

A minor program declaration (available in the Registrar's Office) must be submitted for approval prior to the student's completion of half of the hours proposed to constitute the program. Approvals are required from the department head of metallurgical and materials engineering, the student's advisor, and the department head or division director in the department or division in which the student is enrolled.

Recommended Courses: The following courses are recommended for students seeking to earn a minor in metallurgical and materials engineering:

MTGN202 Engineered Materials Systems	3 sem hrs
MTGN311 Structure of Materials	4 sem hrs
MTGN348 Microstructural Develop. of Materials	4 sem hrs
MTGN445 Mechanical Behavior of Materials	4 sem hrs

plus an additional 3-hour course at the 300- or 400- level in metallurgical and materials engineering.

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.

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 for 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.

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.

Description of Courses

Freshman Year

MTGN198. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING (I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). The course topic is generally offered only once. Prerequisite: consent of instructor. 1 to 3 semester hours. Repeatable for credit under different titles.

MTGN199. INDEPENDENT STUDY (I, II, S) Independent work leading to a comprehensive report. This work may take the form of conferences, library, and laboratory work. Choice of problem is arranged between student and a specific department faculty-member. Prerequisite: Selection of topic with consent of faculty supervisor; "Independent Study Form" must be completed and submitted to Registrar. 1 to 3 semester hours. Repeatable for credit.

Sophomore Year

MTGN202 ENGINEERED MATERIALS (I,II) Introduction to the structure, properties, and processing of materials. The historical role that engineered and natural materials have made on the advance of civilization. Engineered materials and their life cycles through processing, use, disposal, and recycle. The impact that engineered materials have on selected systems to show the breadth of properties that are important and how they can be controlled by proper material processing. Recent trends in materials development mimicking natural materials in the context of the structure and functionality of material in living systems. Corequisites: CHGN122, MATH112, PHGN100. 3 hours lecture; 3 semester hours.

MTGN272/CHEN272. PARTICULATE MATERIALS PROCESSING (S) Summer session. Characterization and production of particles. Physical and interfacial phenomena associated with particulate processes. Applications to metal and ceramic powder processing. Laboratory projects and plant visits. Prerequisites: DCGN209 and PHGN200. 3 weeks; 3 semester hours.

MTGN298. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING (I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). The course topic is generally offered only once. Prerequisite: consent of instructor. 1 to 3 semester hours. Repeatable for credit under different titles.

MTGN299. INDEPENDENT STUDY (I, II, S) Independent work leading to a comprehensive report. This work may take the form of conferences, library, and laboratory work. Choice of problem is arranged between student and a specific department faculty-member. Prerequisite: Selection of topic with consent of faculty supervisor; "Independent Study Form" must be completed and submitted to Registrar. 1 to 3 semester hours. Repeatable for credit.

Junior Year

MTGN300. FOUNDRY METALLURGY (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: PHGN200/210. Co-requisite: MTGN302 or consent of instructor. 2 hours lecture; 2 semester hours.

MTGN301. MATERIALS ENGINEERING DESIGN AND MAINTENANCE (I) Introduction of the necessary metallurgical concepts for effective mine maintenance. Topics to include steel selection, heat treatment, mechanical properties, casting design and alloys, casting defects, welding materials and processes selection, weld defects, weld design, forms of corrosion protection, stainless steel, mechanical forming, aluminum and copper alloy systems, and metal failure identification. This course is designed for students from outside the Metallurgical and Materials Engineering Department. Prerequisite: consent of instructor. 3 hours lecture; 3 semester hours.

MTGN302. FOUNDRY METALLURGY LABORATORY (II) Experiments in the foundry designed to supplement the lectures of MTGN300. Co-requisite: MTGN300. 3 hours lab; 1 semester hour.

MTGN311/CHEN311. STRUCTURE OF MATERIALS (I) (WI) Principles of crystallography and crystal chemistry. Characterization of crystalline materials using X-ray diffraction techniques. Applications to include compound identification, lattice parameter measurement, orientation of single crystals, and crystal structure determination. Laboratory experiments to supplement the lectures. Prerequisites: PHGN200/210 and MTGN202. 3 hours lecture, 3 hours lab; 4 semester hours.

MTGN334/CHEN334. CHEMICAL PROCESSING OF MATERIALS (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. This general formalism provides for a transferable knowledge-base to other systems not specifically covered in the course. Prerequisite: MTGN272, MTGN351 and EPIC251. 3 hours lecture, 3 hours lab; 4 semester hours.

MTGN340. COOPERATIVE EDUCATION (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/CHEN348. MICROSTRUCTURAL DEVELOPMENT (II) (WI) An introduction to the relationships between microstructure and properties of materials, with emphasis on metallic and ceramic systems; Fundamentals of imperfections in crystalline materials on material behavior; recrystallization and grain growth; strengthening mechanisms: grain refinement, solid solution strengthening, precipitation strengthening, and microstructural strengthening; and phase transformations. Prerequisite: MTGN311 and MTGN351. 3 hours lecture, 3 hours lab; 4 semester hours.

MTGN351. METALLURGICAL AND MATERIALS THERMODYNAMICS (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 principles of phase diagrams in material systems, defect equilibrium and interactions. Prerequisite: DCGN209. 3 hours lecture; 3 semester hours.

MTGN352. METALLURGICAL AND MATERIALS KINETICS (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 (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.

MTGN390/EGGN390. MATERIALS AND MANUFACTURING PROCESSES (I) Engineering materials and the manufacturing processes used in their conversion into a product or structure as critical considerations in design. Properties, characteristics, typical selection criteria, and applications are reviewed for ferrous and nonferrous metals, plastics and composites. Characteristics, features, and economics of basic shaping operations are addressed with regard to their limitations and applications and the types of processing equipment available. Related technology such as measurement and inspection procedures, numerical control systems and automated operations are introduced concomitantly. Prerequisite: EGGN320 and MTGN202 or consent of instructor. 3 hours lecture; 3 semester hours.

MTGN398. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING (I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). The course topic is generally offered only once. Prerequisite: consent of instructor. 1 to 3 semester hours. Repeatable for credit under different titles.

MTGN399. INDEPENDENT STUDY (I, II,S) Independent work leading to a comprehensive report. This work may take the form of conferences, library, and laboratory work. Choice of problem is arranged between student and a specific department faculty-member. Prerequisite: Selection of topic with consent of faculty supervisor; "Independent Study Form" must be completed and submitted to Registrar. 1 to 3 semester hours. Repeatable for credit.

Senior Year

MTGN403. SENIOR THESIS (I, II) Two semester individual research under the direction of members of the Metallurgical and Materials Engineering faculty. Work may include library and laboratory research on topics of relevance. Oral presentation will be given at the end of the second semester and written thesis submitted to the committee for evaluation. Prerequisites: Senior standing in the Department of Metallurgical and Materials Engineering and consent of department head. 3 hours per semester. Repeatable for credit to a maximum of 6 hours.

MTGN412/MLGN512. CERAMIC ENGINEERING (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/MLGN544. PROCESSING OF CERAMICS (II) Principles of ceramic processing and the relationship between processing and microstructure. Raw materials and raw materials preparation, forming and fabrication, thermal processing, and finishing of ceramic materials will be covered. Principles will be illustrated by case studies on specific ceramic materials. A project to design a ceramic fabrication process is required. Field trips to local ceramic manufacturing operations. Prerequisite: MTGN311 or consent of the instructor. 3 hours lecture; 3 semester hours.

MTGN415/MLGN515. ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS (II) Survey of the electrical properties of materials, and the applications of materials as electrical circuit components. The effects of chemistry, processing and microstructure on the electrical properties. Functions, performance requirements and testing methods of materials for each type of circuit component. General topics covered are conductors, resistors, insulators, capacitors,

energy converters, magnetic materials and integrated circuits. Prerequisites: PHGN200, MTGN311 or MLGN501, or consent of instructor. 3 hours lecture; 3 semester hours.

MTGN416/MLGN516. PROPERTIES OF CERAMICS (II) Survey of the properties of ceramic materials and how these properties are determined by the chemical structure (composition), crystal structure, and the microstructure of crystalline ceramics and glasses. Thermal, optical, and mechanical properties of single-phase and multiphase ceramics, including composites, are covered. Prerequisites: PHGN200, MTGN311 or MLGN501, MTGN412 or consent of instructor. 3 hours lecture, 3 semester hours.

MTGN417. REFRACTORY MATERIALS (I) Refractory materials in metallurgical construction. Oxide phase diagrams for analyzing the behavior of metallurgical slags in contact with materials of construction. Prerequisite: consent of instructor. 3 hours lecture; 3 semester hours.

MTGN419/MLGN519. NON-CRYSTALLINE MATERIALS (II) Introduction to the principles of glass science-and-engineering and non-crystalline materials in general. Glass formation, structure, crystallization and properties will be covered, along with a survey of commercial glass compositions, manufacturing processes and applications. Prerequisites: MTGN311 or MLGN501, MLGN512/MTGN412, or consent of instructor. 3 hours lecture; 3 semester hours.

MTGN422. PROCESS ANALYSIS AND DEVELOPMENT (II) Aspects of process development, plant design and management. Prerequisite: MTGN334. Co-requisite: MTGN424 or consent of instructor. 2 hours lecture; 2 semester hours.

MTGN424. PROCESS ANALYSIS AND DEVELOPMENT LABORATORY (II) Projects to accompany the lectures in MTGN422. Co-requisite: MTGN422 or consent of instructor. 3 hours lab; 1 semester hour.

MTGN429. METALLURGICAL ENVIRONMENT (I) Examination of the interface between metallurgical process engineering and environmental engineering. Wastes, effluents and their point sources in metallurgical processes such as mineral concentration, value extraction and process metallurgy are studied in context. Fundamentals of metallurgical unit operations and unit processes with those applicable to waste and effluent control, disposal and materials recycling are covered. Engineering design and engineering cost components are also included for selected examples. Fundamentals and applications receive equal coverage. Prerequisites: MTGN334 or consent of Instructor. 3 hours lecture; 3 semester hours.

MTGN430. PHYSICAL CHEMISTRY OF IRON AND STEELMAKING (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 (I) Physicochemical principles associated with the extraction and refining of metals by hydro- and electrometallurgical techniques. Discussion of unit processes in hydrometallurgy, electrowinning, and electrorefining. Analysis of integrated flowsheets for the recovery of nonferrous metals. Prerequisites: MTGN334, MTGN351 and MTGN352. Co-requisite: MTGN461, or consent of instructor. 3 hours lecture; 3 semester hours.

MTGN432. PYROMETALLURGY (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.

MTGN434. DESIGN AND ECONOMICS OF METALLURGICAL PLANTS (II) Design of metallurgical processing systems. Methods for estimating process costs and profitability. Performance, selection, and design of process equipment. Integration of process units into a working plant and its economics, construction, and operation. Market research and surveys. Prerequisites: DCGN209, MTGN351 or Consent of Instructor. 3 hours lecture; 3 semester hours.

MTGN436. CONTROL AND INSTRUMENTATION OF METALLURGICAL PROCESSES (II) Analysis of processes for metal extraction and refining using classical and direct-search optimization methods and classical process control with the aid of chemical functions and thermodynamic transfer operations. Examples from processes in physicochemical and physical metallurgy. Prerequisite: MTGN334 or consent of instructor. Co-requisite: MTGN438 or consent of instructor. 2 hours lecture; 2 semester hours.

MTGN438. CONTROL AND INSTRUMENTATION OF METALLURGICAL PROCESSES LABORATORY (II) Experiments designed to supplement the lectures in MTGN436. Co-requisite: MTGN436 or consent of instructor. 3 hours lab; 1 semester hour.

MTGN442. ENGINEERING ALLOYS (II) This course is intended to be an important component of the physical metallurgy sequence, to reinforce and integrate principles from earlier courses, and enhance the breadth and depth of understanding of concepts in a wide variety of alloy systems. Metallic systems considered include iron and steels, copper, aluminum, titanium, superalloys, etc. Phase stability, microstructural evolution and structure/property relationships are emphasized. Prerequisite: MTGN348 or consent of instructor. 3 hours lecture; 3 semester hours.

MTGN445/MLGN505*. MECHANICAL PROPERTIES OF MATERIALS (I) (WI) Mechanical properties and relationships. Plastic deformation of crystalline materials. Relationships of microstructures to mechanical strength. Fracture, creep, and fatigue. Laboratory sessions devoted to advanced

mechanical-testing techniques to illustrate the application of the fundamentals presented in the lectures. Prerequisite: MTGN348. 3 hours lecture, 3 hours lab; 4/3* semester hours. *This is a 3 semester-hours graduate-course in the Materials Science Program (ML) and a 4 semester-hours undergraduate-course in the Metallurgical and Materials Engineering program.

MTGN450/MLGN550. STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS (I) Introduction to statistical process control, process capability analysis and experimental design techniques. Statistical process control theory and techniques developed and applied to control charts for variables and attributes involved in process control and evaluation. Process capability concepts developed and applied to the evaluation of manufacturing processes. Theory of designed experiments developed and applied to full factorial experiments, fractional factorial experiments, screening experiments, multilevel experiments and mixture experiments. Analysis of designed experiments by graphical and statistical techniques. Introduction to computer software for statistical process control and for the design and analysis of experiments. Prerequisite: Consent of Instructor. 3 hours lecture, 3 semester hours.

MTGN451. CORROSION ENGINEERING (II) Principles of electrochemistry. Corrosion mechanisms. Methods of corrosion control including cathodic and anodic protection and coatings. Examples, from various industries, of corrosion problems and solutions. Prerequisite: DCGN209. 3 hours lecture; 3 semester hours

MTGN452. CERAMIC AND METAL MATRIX COMPOSITES (I) Introduction to the synthesis, processing, structure, properties and performance of ceramic and metal matrix composites. Survey of various types of composites, and correlation between processing, structural architecture and properties. Prerequisites: MTGN272, MTGN311, MTGN348, MTGN351. 3 hours lecture; 3 semester hours

MTGN453. PRINCIPLES OF INTEGRATED CIRCUIT PROCESSING (I) Introduction to the electrical conductivity of semiconductor materials; qualitative discussion of active semiconductor devices; discussion of the steps in integrated circuit fabrication; detailed investigation of the materials science and engineering principles involved in the various steps of VLSI device fabrication; a presentation of device packaging techniques and the processes and principles involved. Prerequisite: Consent of Instructor. 3 hours lecture; 3 semester hours.

MTGN456. ELECTRON MICROSCOPY (II) Introduction to electron optics and the design and application of transmission and scanning electron microscopes. Interpretation of images produced by various contrast mechanisms. Electron diffraction analysis and the indexing of electron diffraction patterns. Prerequisite: MTGN311 or Consent of Instructor. Co-requisite: MTGN458. 2 hours lecture; 2 semester hours.

MTGN458. ELECTRON MICROSCOPY LABORATORY (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 (I) Introduction to the conserved-quantities: momentum, heat, and mass transfer, and application of chemical kinetics to elementary reactor-design. Examples from materials processing and process metallurgy. Molecular transport properties: viscosity, thermal conductivity, and mass diffusivity of materials encountered during processing operations. Uni-directional transport: problem formulation based on the required balance of the conserved- quantity applied to a control-volume. Prediction of velocity, temperature and concentration profiles. Equations of change: continuity, motion, and energy. Transport with two independent variables (unsteady-state behavior). Interphase transport: dimensionless correlations friction factor, heat, and mass transfer coefficients. Elementary concepts of radiation heat-transfer. Flow behavior in packed beds. Design equations for: continuous- flow/batch reactors with uniform dispersion and plug flow reactors. Digital computer methods for the design of metallurgical systems. Laboratory sessions devoted to: tutorials/demonstrations to facilitate the understanding of concepts related to selected topics; and, Projects with the primary focus on the operating principles and use of modern electronic-instrumentation for measurements on lab-scale systems in conjunction with correlation and prediction strategies for analysis of results. Prerequisites: MATH225, MTGN334 and MTGN352. 2 hours lecture, 3 hours lab; 3 semester hours.

MTGN462/ESGN462. SOLID WASTE MINIMIZATION AND RECYCLING (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: EGGN/ESGN353, EGGN/ESGN354, and ESGN302/CHGN403 or consent of instructor. 3 hours lecture; 3 semester hours.

MTGN463. POLYMER ENGINEERING (II) Introduction to the structure and properties of polymeric materials, their deformation and failure mechanisms, and the design and fabrication of polymeric end items. Molecular and crystallographic structures of polymers will be developed and related to the elastic, viscoelastic, yield and fracture properties of

polymeric solids and reinforced polymer composites. Emphasis on forming and joining techniques for end-item fabrication including: extrusion, injection molding, reaction injection molding, thermoforming, and blow molding. The design of end-items in relation to: materials selection, manufacturing engineering, properties, and applications. Prerequisite: consent of instructor. 3 hours lecture; 3 semester hours.

MTGN464/MTGN564. FORGING AND FORMING (II) Introduction to plasticity. Survey and analysis of working operations of forging, extrusion, rolling, wire drawing and sheet-metal forming. Metallurgical structure evolution during working. Prerequisites: EGGN320 and MTGN348 or EGGN350. 2 hours lecture; 3 hours lab, 3 semester hours

MTGN465. MECHANICAL PROPERTIES OF CERAMICS (II) Mechanical properties of ceramics and ceramic-based composites; brittle fracture of solids; toughening mechanisms in composites; fatigue, high temperature mechanical behavior, including fracture, creep deformation. Prerequisites: MTGN445, MTGN412 or consent of instructor. 3 hours lecture; 3 semester hours.

MTGN466. MATERIALS DESIGN: SYNTHESIS, CHARACTERIZATION AND SELECTION (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 or consent of instructor. 1 hour lecture, 6 hours lab; 3 semester hours.

MTGN475. METALLURGY OF WELDING (I) Introduction to welding processes; thermal aspects; selection of filler metals; stresses; stress relief and annealing; pre- and post-weld heat treating; weld defects; welding ferrous and nonferrous alloys; weld metal phase transformations; metallurgical evaluation of resulting weld microstructures and properties; and welding tests. Prerequisite: MTGN348. Co-requisite: MTGN477. 2 hours lecture; 2 semester hours.

MTGN477. METALLURGY OF WELDING LABORATORY (I) Experiments designed to supplement the lectures in MTGN475. Co-requisite: MTGN475. 3 hours lab; 1 semester hour.

MTGN497. SUMMER PROGRAMS

MTGN498. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING (I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). The course topic is generally offered only once. Prerequisite: consent of instructor. 1 to 3 semester hours. Repeatable for credit under different titles.

MTGN499. INDEPENDENT STUDY (I, II, S) Independent advanced-work leading to a comprehensive report. This work may take the form of conferences, library, and laboratory work. Selection of problem is arranged between student and a specific Department faculty-member. Prerequisite: Selection of topic with consent of faculty supervisor; “Independent Study Form” must be completed and submitted to Registrar. 1 to 3 semester hours. Repeatable for credit to a maximum of 6 hours.

Mining Engineering

KADRI DAGDELEN, Professor and Department Head
UGUR OZBAY, Professor
MARK KUCHTA, Associate Professor
HUGH MILLER, Associate Professor
MASAMI NAKAGAWA, Associate Professor
CHRISTIAN FRENZEL, Associate Professor
MANOHAR ARORA, Teaching Professor
VILEM PETR, Research Associate Professor

Program Description

Mining engineering is a broad profession, which embraces all required activities to facilitate the recovery of valuable minerals and products from the earth's crust for the benefit of humanity. It is one of the oldest engineering professions, which continues to grow in importance. It has often been said: "If it was not grown in the field or fished out of the water, then it must have been mined." An adequate supply of mineral products at competitive prices is the life-blood of the continuing growth of industrialized nations and the foundation of the progress for the developing countries.

The function of the mining engineer is to apply knowledge of pertinent scientific theory, engineering fundamentals, and improved technology to recover natural resources. Mining is a world-wide activity involving the extraction of non-metallics, metal ores of all kinds, and solid fuel and energy sources such as coal and nuclear materials. In addition to mineral extraction, the skills of mining engineers are also needed in a variety of fields where the earth's crust is utilized, such as the underground construction industry. The construction industry, with its requirements of developing earth (rock) systems, tunnels and underground chambers, and the hazardous waste disposal industry are examples of such applications. These are expanding needs, with a shortage of competent people; the mining engineer is well qualified to meet these needs.

The importance of ecological and environmental planning is recognized and given significant attention in all aspects of the mining engineering curriculum.

CSM mining engineering students study the principles and techniques of mineral exploration, and underground and surface mining operations, as well as, mineral processing technologies. Studies include rock mechanics, rock fragmentation, plant and mine design, mine ventilation, surveying, valuation, industrial hygiene, mineral law, mine safety, computing, mineral processing, solution mining and operations research. Throughout the mining engineering curriculum, a constant effort is made to maintain a balance between theoretical principles and their engineering applications. The mining engineering graduate is qualified for positions in engineering, supervision, and research.

The 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)

Sophomore Year Fall Semester	lec.	lab.	sem.hrs.
MATH213 Calc. for Scientists & Engn'rs III	4		4
PHGN200 Physics II	3.5	3	4.5
EBGN201 Principles of Economics	3		3
DCGN241 Statics	3		3
EPIC251 Design II	2	3	3
PAGN201 Physical Education III		2	0.5
Total			18

Sophomore Year Spring Semester	lec.	lab.	sem.hrs.
EGGN351 Fluid Mechanics	3		3
MATH225 Differential Equations	3		3
MNGN210 Introductory Mining	3		3
SYGN200 Human Systems	3		3
MNGN317 Dynamics for Mn. Engs.	1		1
EGGN320 Mechanics of Materials	3		3
PAGN202 Physical Education IV		2	0.5
Total			16.5

Summer Session	lec.	lab.	sem.hrs.
MNGN308 Mine Safety	1		1
MNGN300 Summer Field Session			3
Total			4

Junior Year Fall Semester	lec.	lab.	sem.hrs.
EGGN371 Engineering Thermodynamics	3		3
MNGN309 Mine Engineering Lab		8	2
MNGN312 Surface Mine Design	2	3	3
MNGN321 Introductory Rock Mechanics	2	3	3
GEOL310 Earth Materials and Resources	4		4
Free Elective	3		3
Total			18

Junior Year Spring Semester	lec.	lab.	sem.hrs.
EGGN381 Electrical Circuits, Elec. & Pwr	3		3
LAIS/EBGN H&SS Elective I	3		3
MNGN314 Underground Mine Design	3		3
MNGN316 Coal Mining Methods and Design	2	3	3
GEOL311 Structural Geology	2		2
Free Elective	3		3
Total			17

Senior Year Fall Semester	lec.	lab.	sem.hrs.
MNGN408 Underground Design and Const.	2		2
MNGN414 Mine Plant Design	2	3	3
MNGN428 Mining Eng. Design Report I	3		1
MNGN438 Geostatistics	2	3	3
MNGN322/323 Intro. to Mineral Processing	3	2	3
LAIS/EBGN H&SS Elective II	3		3
Free Elective	3		3
Total			18

Senior Year Spring Semester	lec.	lab.	sem.hrs.
MNGN429 Mining Eng. Design Report II		3	2
MNGN433 Mine Systems Analysis I	3		3
MNGN427 Mine Valuation	2		2
MNGN424 Mine Ventilation	2	3	3
MNGN410 Excavation Project Management	2		2
LAIS/EBGN H&SS Elective III	3		3
Total			15

Degree Total	139.5

Minor Programs

The Mining Engineering Department offers two minor programs; the traditional mining engineering program for non-mining majors and in explosive engineering.

Mining Engineering Minor

The minor program in mining engineering requires students to take MNGN210, Introduction to Mining, 3 credit hours, two from the following three courses; MNGN312, Surface Mine Design, MNGN314, Underground Mine Design or MNGN316, Coal Mining Methods and Design plus nine credit hours of other courses from mining engineering. The list of available courses can be found in the mining engineering department office.

Area of Specialization in mining engineering (12 credit hours of course work) is also available and should be discussed with a faculty member in the mining engineering department and approved by the Department Head.

Explosive Engineering Minor
Program Advisor: Dr. Vilem Petr

There are very few academic explosive engineering programs world wide. In fact, Colorado School of Mines is the only educational institution that offers an explosive engineering minor program in the U.S.A. Developed in the CSM tradition of combining academic education with hands-on experience, this minor program will prepare students for new and developing applications involving the use of explosives in the mining and materials engineering, underground construction, oil and gas operations, demolition, homeland security, military, forensic investigations, manufacturing and material synthesis.

With the proper program development of courses and basic knowledge in explosive engineering, students enrolled in this program will discover and gain insight into the exciting industrial applications of explosives, selection of explosives, and the correct and safe use of the energetic materials. With the help of the program advisor, the students will design and select the proper course sequence and complete a hands-on research project under the supervision of a faculty advisor

Explosive Engineering Area of Special Interest (ASI)
Program Advisor: Dr. Vilem Petr

A total of 12 credit hours are needed to complete the Area of Special Interest in Explosive Engineering Program. This is the preferred route for students that would like to specialize in explosive engineering. The first three (required) courses will provide the students with basic knowledge in explosive engineering. And the forth 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	sem.hrs.
MNGN429 333 Introduction to Explosive Engineering I	3
MNGN 407 Rock Fragmentation	3
MNGN 444 Advanced Explosive Engineering II	3

Plus at least one course from the following:	
MNGN 210 Introductory Mining	3
MNGN 308 Mine Safety I	3
MNGN 309 Mining Engineering Laboratory	3
MNGN 312 Surface Mine Design	3
MNGN 314 Underground Mine Design	3
MNGN 316 Coal Mining Methods and Design	3
MNGN 321 Introduction to Rock Mechanics	3
MNGN 404 Tunneling	3
MNGN 405 Rock Mechanics in Mining	3
MNGN 406 Design & Support of Underground Excavation	3
MNGN 408 Underground Construction	3
MNGN 498 Advanced Rock Fragmentation	3
MNGN 499 Independent Research Project	3

Total	12

Description of Courses

Freshman Year

MNGN198. SPECIAL TOPICS IN MINING ENGINEERING (I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MNGN199. INDEPENDENT STUDY (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.

Sophomore Year

MNGN210. 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 (S) A basic introduction to explosive engineering and applied explosive science for students that recently completed their freshman or sophomore years at CSM. Topics covered will include safety and explosive regulations, chemistry of explosives, explosives physics, and detonation properties. The course features a significant practical learning component with several sessions held at the Explosives Research Laboratory in Idaho Springs. Students completing this course will be well prepared for more advanced work in MNGN 333 and MNGN 444. Prerequisites: PHGN100, MATH111, MATH112, CHGN121, and CHGN122. 3 hours lecture, 3 semester hours.

MNGN298. SPECIAL TOPICS IN MINING ENGINEERING (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.

MNGN299. INDEPENDENT STUDY (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 (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.

MNGN317. DYNAMICS FOR MINING ENGINEERS (II) For mining engineering majors only. Absolute and relative motions, kinetics, work-energy, impulse-momentum and angular impulse-momentum. Prerequisite: MATH213/223, DCGN241. 1 hour lecture; 1 semester hour.

Junior Year

MNGN308. MINE SAFETY (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 (I, II) Training in practical mine labor functions including: operation of jackleg drills, jumbo drills, muckers, and LHD machines. Training stresses safe operation of equipment and safe handling of explosives. Introduction to front-line management techniques. Prerequisite: MNGN210, MNGN308 or consent of instructor. 2 semester hours.

MNGN312. SURFACE MINE DESIGN (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 long-range planning, road layouts, dump planning, and cost estimation. Prerequisite: MNGN210 and MNGN300. 2 hours lecture, 3 hours lab; 3 semester hours.

MNGN316. COAL MINING METHODS (II) (WI) Devoted to surface and underground coal mining methods and design. The surface mining portion emphasizes area-mining methods, including pertinent design-related regulations, and overburden removal systems. Pit layout, sequencing, overburden equipment selection and cost estimation are presented. The underground mining portion emphasizes general mine layout; detailed layout of continuous, conventional, longwall, and shortwall sections. General cost and manning requirements; and production analysis. Federal and state health and safety regulations are included in all aspects of mine layout. Prerequisite: MNGN210. 2 hours lecture, 3 hours lab, 3 semester hours

MNGN321. INTRODUCTION TO ROCK MECHANICS Physical properties of rock, and fundamentals of rock substance and rock mass response to applied loads. Principles of elastic analysis and stress-strain relationships. Elementary principles of the theoretical and applied design of underground openings and pit slopes. Emphasis on practical applied aspects. Prerequisite: DCGN241 or MNGN317. 2 hours lecture, 3 hours lab; 3 semester hours.

MNGN333. EXPLOSIVES ENGINEERING 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 experts' lectures from government, industry and the explosives engineering community. Pre-requisites: none. 3 semester hours.

MNGN340. COOPERATIVE EDUCATION (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.

MNGN398. SPECIAL TOPICS IN MINING ENGINEERING (I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: Instructor consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MNGN399. INDEPENDENT STUDY (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.

Senior Year

MNGN314. UNDERGROUND MINE DESIGN (II) Selection, design, and development of most suitable underground mining methods based upon the physical and the geological properties of mineral deposits (metallics and nonmetallics), conservation considerations, and associated environmental impacts. Reserve estimates, development and production planning, engineering drawings for development and extraction, underground haulage systems, and cost estimates. Prerequisite: MNGN210. 2 hours lecture, 3 hours lab; 3 semester hours.

MNGN322/323. INTRODUCTION TO MINERAL PROCESSING AND LABORATORY (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.

MNGN404. TUNNELING (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 (I) The course deals with the rock mechanics aspect of design of mine layouts developed in both underground and surface. Underground mining sections includes design of coal and hard rock pillars, mine layout design for tabular and massive ore bodies, assessment of caving characteristics of 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: MNGN321 or equivalent. 3 hours lecture; 3 semester hours.

MNGN406. DESIGN AND SUPPORT OF UNDERGROUND EXCAVATIONS Design of underground excavations and support. Analysis of stress and rock mass deformations around excavations using analytical and numerical methods. Collections, preparation, and evaluation of in situ and laboratory data for excavation design. Use of rock mass rating systems for site characterization and excavation design. Study of support types and selection of support for underground excavations. Use of numerical models for design of shafts, tunnels and large chambers. Prerequisite: Instructor's consent. 3 hours lecture; 3 semester hours. Offered in odd years.

MNGN407. ROCK FRAGMENTATION (II) Theory and application of rock drilling, rock boring, explosives, blasting, and mechanical rock breakage. Design of blasting rounds,

applications to surface and underground excavation. Prerequisite: DCGN241 concurrent enrollment or instructors consent. 3 hours lecture; 3 semester hours.

MNGN408 UNDERGROUND DESIGN AND CONSTRUCTION (I) Soil and rock engineering applied to underground civil works. Tunneling and the construction of underground openings for power facilities, water conveyance, transportation, and waste disposal; design, excavation and support of underground openings. Emphasis on consulting practice, case studies, geotechnical design, and construction methods. Prerequisite: EGGN361 OR MNGN321, or Instructor's consent. 2 hours of lecture; 2 semester hours.

MNGN410. EXCAVATION PROJECT MANAGEMENT (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 or Instructor's consent, 2-hour lecture, 2 semester hours.

MNGN414. MINE PLANT DESIGN (I) Analysis of mine plant elements with emphasis on design. Materials handling, dewatering, hoisting, belt conveyor and other material handling systems for underground mines. Prerequisite: MNGN312, MNGN314 or Instructor's consent. 2 hours lecture, 3 hours lab; 3 semester hour.

MNGN418. ADVANCED ROCK MECHANICS Analytical and numerical modeling analysis of stresses and displacements induced around engineering excavations in rock. In-situ stress. Rock failure criteria. Complete load deformation behavior of rocks. Measurement and monitoring techniques in rock mechanics. Principles of design of excavation in rocks. Analytical, numerical modeling and empirical design methods. Probabilistic and deterministic approaches to rock engineering designs. Excavation design examples for shafts, tunnels, large chambers and mine pillars. Seismic loading of structures in rock. Phenomenon of rock burst and its alleviation. Prerequisite: MNGN321 or Instructor's consent. 3 hours lecture; 3 semester hours.

MNGN421. DESIGN OF UNDERGROUND EXCAVATIONS (II) Design of underground openings in competent and broken ground using rock mechanics principles. Rock bolting design and other ground support methods. Coal, evaporite, metallic and nonmetallic deposits included. Prerequisite: MNGN321, concurrent enrollment or Instructor's consent. 3 hours lecture; 3 semester hours.

MNGN422/522. FLOTATION 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 (I) Experiments to accompany the lectures in MNGN422. Co-requisite: MNGN421 or Instructor's consent.. 3 hours lab; 1 semester hour.

MNGN424. MINE VENTILATION (II) Fundamentals of mine ventilation, including control of gas, dust, temperature, and humidity; ventilation network analysis and design of systems. Prerequisite: EGGN351, EGGN371 and MNGN314 or Instructor's consent. 2 hours lecture, 3 hours lab; 3 semester hours.

MNGN427. MINE VALUATION (II) Course emphasis is on the business aspects of mining. Topics include time valuation of money and interest formulas, cash flow, investment criteria, tax considerations, risk and sensitivity analysis, escalation and inflation and cost of capital. Calculation procedures are illustrated by case studies. Computer programs are used. Prerequisite: Senior in Mining, graduate status or Instructor's consent. 2 hours lecture; 2 semester hours.

MNGN428. MINING ENGINEERING EVALUATION AND DESIGN REPORT I (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. Prerequisitie: EPIC251. 3 hours lab; 1 semester hour.

MNGN429. MINING ENGINEERING EVALUATION AND DESIGN REPORT II (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: MNGN427, 428. 3 hours lab; 2 semester hours.

MNGN431. MINING AND METALLURGICAL ENVIRONMENT This course covers studies of the interface between mining and metallurgical process engineering and environmental engineering areas. Wastes, effluents and their point sources in mining and metallurgical processes such as mineral concentration, value extraction and process metallurgy are studied in context. Fundamentals of unit operations and unit processes with those applicable to waste and effluent control, disposal and materials recycling are covered. Engineering design and engineering cost components are also included for some examples chosen. The ratio of fundamentals applications coverage is about 1:1. Prerequisite: Instructor's consent. 3 hours lecture; 3 semester hours.

MNGN433. MINE SYSTEMS ANALYSIS I (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 Projects to accompany the lectures in MNGN422. Prerequisite: MNGN422 or Instructor's consent. 3 hours lab; 1 semester hour.

MNGN436. UNDERGROUND COAL MINE DESIGN (II) Design of an underground coal mine based on an actual coal reserve. This course shall utilize all previous course material in the actual design of an underground coal mine. Ventilation, materials handling, electrical transmission and distribution, fluid mechanics, equipment selection and application, mine plant design. Information from all basic mining survey courses will be used. Prerequisite: MNGN316, MNGN321, MNGN414, EGGN329 and MNGN381 or MNGN384. Concurrent enrollment with the Instructor's consent permitted. 3 hours lecture, 3 hours lab; 3 semester hours.

MNGN438. GEOSTATISTICS (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 (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 This course gives students in engineering and applied sciences the opportunity to acquire the fundamental concepts of explosives engineering and science applications as they apply to industry and real life examples. Students will expand upon their MNGN333 knowledge and develop a more advanced knowledge base including an understanding of the subject as it applies to their specific project interests. Assignments, quizzes, concept modeling and their project development and presentation will demonstrate student's progress. Prerequisite: none. 3 hours lecture, 3 semester hours.

MNGN445/545. ROCK SLOPE ENGINEERING Introduction to the analysis and design of slopes excavated in rock. Rock mass classification and strength determinations, geological structural parameters, properties of fracture sets, data collection techniques, hydrological factors, methods of analysis of slope stability, wedge intersections, monitoring and maintenance of final pit slopes, classification of slides. Deterministic and probabilistic approaches in slope design. Remedial measures. Laboratory and field exercise in slope design. Collection of data and specimens in the field for deterring physical properties required for slope design. Application of numerical modeling and analytical techniques to slope stability determinations for hard rock and soft rock environments. Prerequisite: Instructor's consent. 3 hours lecture. 3 semester hours.

MNGN452/552. SOLUTION MINING AND PROCESSING OF ORES (II) Theory and application of advanced methods of extracting and processing of minerals, underground or in situ, to recover solutions and concentrates of value-materials, by minimization of the traditional surface processing and disposal of tailings to minimize environmental impacts. Prerequisite: Senior or graduate status; Instructor's consent. 3 hours lecture, 3 semester hours. Offered in spring.

MNGN460. INDUSTRIAL MINERALS PRODUCTION (II) This course describes the engineering principles and practices associated with quarry mining operations related to the cement and aggregates industries. The course will cover resource definition, quarry planning and design, extraction, and processing of material for cement and aggregate production. Permitting issues and reclamation, particle sizing and environmental practices, will be studied in depth. Prerequisite: MNGN312, MNGN322, MNGN323, or Instructor's consent. 3 hours lecture; 3 semester hours. Offered in spring.

MNGN482. MINE MANAGEMENT (II) Basic principles of successful mine management including supervision skills, administrative policies, industrial and human relations, improvement engineering, risk management, conflict resolution and external affairs. Prerequisite: Senior or graduate status or Instructor's consent. 2 hours lecture and 1 hour case study presentation / discussion per week; 3 semester hours.

MNGN497. SUMMER PROGRAMS

MNGN498. SPECIAL TOPICS IN MINING ENGINEERING (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's consent. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MNGN499. INDEPENDENT STUDY (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

RAMONA M. GRAVES, Professor and Department Head
HOSSEIN KAZEMI, Chesebro' Distinguished Professor
ERDAL OZKAN, Professor
AZRA TUTUNCU, Harry D. Campbell Chair and Professor
YU-SHU WU, CMG Chair and Professor
ALFRED W. EUSTES III, Associate Professor
JENNIFER L. MISKIMINS, Associate Professor
MANIKA PRASAD, Associate Professor
TODD HOFFMAN, Assistant Professor
XIAOLONG YIN, Assistant Professor
LINDA BATTALORA, Teaching Associate Professor
MARK G. MILLER, Teaching Associate Professor
M.W. SCOGGINS, Research Professor and CSM President
BILLY J. MITCHELL, Professor Emeritus
CRAIG W. VAN KIRK, Professor Emeritus
RICHARD CHRISTIANSEN, Associate Professor Emeritus

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, and the University of Adelaide, Adelaide, Australia. 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.

New laboratory and computer equipment added during the past few years total more than $3 million. The department has state-of-the-art laboratories in a wide range of technical areas, including the following undergraduate labs:

Computer Laboratory

This computer laboratory is available for general use and classroom instruction. It is continuously open for student use. Software includes more than $5.0 million in donated industry software used by oil and gas companies and research labs around the world.

Drilling Simulator Laboratory

Rare on university campuses, this lab contains a computer controlled, full-scale, drilling rig simulator. It includes drilling controls that can be used to simulate onshore and offshore drilling operations and well control situations. This lab also has three small scale drilling rig simulators, identical to those used in industrial well control training facilities.

Reservoir Characterization Laboratory

Rock properties are measured that affect economic development of reservoir resources of oil and gas. Measured properties include permeability, porosity, and relative permeability. "Hands on" experiences with simple and sophisticated equipment are provided.

Drilling Field Laboratory

Modern equipment found on drilling rigs world-wide enables students to evaluate and design fluid systems required in drilling operations.

Fluids Characterization Laboratory

A variety of properties of fluids from oil and gas reservoirs are measured for realistic conditions of elevated temperature and pressure. This laboratory accentuates principles studied in lectures.

Petroleum Engineering Summer Sessions

Two summer sessions, one after the completion of the sophomore year and one after the junior year, are important

parts of the educational experience. The first is a two-week session designed to introduce the student to the petroleum industry. Various career opportunities are highlighted as well as showing petroleum field and office operations and geology. In addition, students are indoctrinated in health, safety, and environmental awareness. Petroleum Engineering, a truly unique and exciting engineering discipline, can be experienced by visiting petroleum operations. Historically, the areas visited have included Europe, Alaska, Canada, the U.S. Gulf Coast, California, the Midcontinent, the Northeast US, and the Rocky Mountain Region.

The second two-week session, after the junior year, is an in-depth study of the Rangely Oil Field and surrounding geology in Western Colorado. The Rangely Oil Field is the largest oil field in the Rocky Mountain region and has undergone primary, secondary, and enhanced recovery processes. Field work in the area provide the setting for understanding the complexity of geologic systems and the environmental and safety issues in the context of reservoir development and management.

Other Opportunities

It is recommended that all students considering majoring or minoring in Petroleum Engineering sign up for the elective course PEGN 102, 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 for course offerings).

The program leading to the degree Bachelor of Science in Petroleum 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 Petroleum Engineering)

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 lifelong 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.

In addition to contributing toward achieving the educational objectives described in the CSM Graduate Profile and the ABET Accreditation Criteria, individuals interested in the Petroleum Engineering program educational objectives are encouraged to contact faculty, visit the CSM campus, or visit our website: www.mines.edu. The Petroleum Engineering program educational objectives can also be found posted in the hallway outside the department office. The specific educational objectives are outlined below:

1. **Broad education as evidenced by:**
   CSM design and system courses
   Effective communication
   Skills necessary for diverse and international professional career
   Recognition of need and ability to engage in lifelong learning
2. **Solid foundation in engineering principles and practices as shown by:**
   Society of Petroleum Engineers' ABET Program Criteria
   Strong petroleum engineering faculty with diverse backgrounds
   Technical seminars, field trips, and field sessions
3. **Applied problem solving skills as demonstrated by:**
   Designing and conducting experiments
   Analyzing and interpreting data
   Problem solving skills in engineering practice
   Working real world problems
4. **An understanding of ethical, social, environmental, and professional responsibilities by:**
   Following established Department and Colorado School of Mines honor codes
   Integrating ethical and environmental issues into real world problems
   Awareness of health and safety issues
5. **Multidisciplinary team skills as displayed by:**
   Integrating information and data from multiple sources
   Critical team skills

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 recov-

ery, 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, 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.

The program has state-of-the-art 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 outcrops 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 in the Denver metropolitan region or near campus.

Degree Requirements (Petroleum Engineering)

Sophomore Year Fall Semester	lec.	lab.	sem.hrs.
EBGN201 Principles of Economics	3		3
EPICS251 - 268 (choose one)	3		3
DCGN241 Statics	3		3
MATH213 Calculus for Scientists & Engn'rs III	4		4
PHGN200 Physics II	3.5	3	4.5
PAGN201 Physical Education III		2	0.5
Total			18
Sophomore Year Spring Semester	lec.	lab.	sem.hrs.
DCGN209 Introduction to Thermodynamics	3		3
EGGN320 Mechanics of Materials	3		3
PEGN251 Fluid Mechanics	3		3
PEGN308 Res. Rock Properties	2	3	3
MATH225 Differential Equations	3		3
SYGN200 Human Systems	3		3
Total			18
Summer Session	lec.	lab.	sem.hrs.
PEGN315 Summer Field Session I	2		2
Total			2
Junior Year Fall Semester	lec.	lab.	sem.hrs.
GEOL315 Sedimentology & Stratigraphy	2	3	3
PEGN305 Computational Methods	2		2
PEGN310 Reservoir Fluid Properties	2		2
PEGN311 Drilling Engineering	3	3	4
PEGN419 Well Log Anal. & Formation Eval.	2	3	3
LAIS/EBGN H&SS GenEd Restricted Elective I	3	3	
PAGN202 Physical Education IV	2	0	.5
Total			17.5
Junior Year Spring Semester	lec.	lab.	sem.hrs.
GEOL308 Intro. Applied Structural Geology	2	3	3
PEGN438 Geostatistics	2	3	3
PEGN361 Well Completions	3		3
PEGN411 Mechanics of Petrol. Production	3		3
LAIS/EBGN H&SS GenEd Restricted Elective II	3		3
Free Elective	3		3
Total			18
Summer Session	lec.	lab.	sem.hrs.
PEGN316 Summer Field Session II	2		2
Total			2
Senior Year Fall Semester	lec.	lab.	sem.hrs.
PEGN481 Petroleum Seminar	2		2
PEGN423 Petroleum Reservoir Eng. I	3		3
PEGN413 Gas Meas. & Formation Evaluation		6	2
PEGN414 Well Test Analysis and Design	3		3
PEGN422 Econ. & Eval. Oil & Gas Projects	3		3
Free Elective	3		3
Total			16
Senior Year Spring Semester	lec.	lab.	sem.hrs.
PEGN424 Petroleum Reservoir Eng. II	3		3
PEGN426 Stimulation	3		3
PEGN439 Multidisciplinary Design	2	3	3
LAIS/EBGN H&SS GenEd Restricted Elective III	3		3
Free Elective	3		3
Total			15
Degree Total			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.

Description of Courses

Freshman Year

PEGN102. INTRODUCTION TO PETROLEUM INDUSTRY (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 (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 semester hours. Repeatable for credit under different titles.

PEGN199. INDEPENDENT STUDY (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 semester hours. Repeatable for credit under different titles.

Sophomore Year

PEGN251. FLUID MECHANICS (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 PEGN 308. Students cannot receive credit for both PEGN 251 Fluid Mechanics and EGGN351 Fluid Mechanics. Prerequisite: MATH213. Corequisite: PEGN308. Prerequisite or Corequisite: DCGN209 and DCGN241. 3 hours lecture; 3 semester hours.

PEGN298. SPECIAL TOPICS IN PETROLEUM ENGINEERING (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 semester hours. Repeatable for credit under different titles.

PEGN299. INDEPENDENT STUDY (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 semester hours. Repeatable for credit under different titles.

PEGN308. RESERVOIR ROCK PROPERTIES (II) (WI) Introduction 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). Corequisite: PEGN251. Prerequisite or Corequisite DCGN241. 2 hours lecture, 3 hours lab; 3 semester hours.

Junior Year

PEGN305 COMPUTATIONAL METHODS IN PETROLEUM ENGINEERING (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. 2 hours lecture; 2 semester hours.

PEGN310. RESERVOIR FLUID PROPERTIES (I) Properties of fluids encountered in petroleum engineering. Phase behavior, density, viscosity, interfacial tension, and composition of oil, gas, and brine systems. Interpreting lab data for engineering applications. Flash calculations with k-values and equation of state. Introduction to reservoir simulation software. Prerequisites: DCGN209 and PEGN308. 2 hours lecture; 2 semester hours.

PEGN311. DRILLING ENGINEERING (I) Study of drilling operations, fluid design, hydraulics, drilling contracts, rig selection, rotary system, well control, bit selection, drill string design, directional drilling, and casing seat selection. Prerequisites: PEGN251, PEGN315, and DCGN241. 3 hours lecture, 3 hours lab; 4 semester hours.

PEGN315. SUMMER FIELD SESSION I (S) This two-week 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 (S) This two-week 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 incorporat-

ing both surface and subsurface data are used extensively. Prerequisites: PEGN315, PEGN411, PEGN419, GEOL308, and GEOL315. 2 semester hours.

PEGN340. COOPERATIVE EDUCATION (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 (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. Prerequisite: EPIC151 or consent of instructor. 3 hours lecture; 3 semester hours.

PEGN361. COMPLETION ENGINEERING (II) (WI) This class is a continuation from drilling in PEGN311 into completion operations. Topics include casing design, cement planning, completion techniques and equipment, tubing design, wellhead selection, and sand control, and perforation procedures. This course is designed as a writing intensive course (WI). Prerequisites: PEGN311 and EPIC251, Prerequisite or Corequisite: EGGN320. 3 hours lecture; 3 semester hours.

PEGN398. SPECIAL TOPICS IN PETROLEUM ENGINEERING (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 semester hours. Repeatable for credit under different titles.

PEGN399. INDEPENDENT STUDY (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 semester hours. Repeatable for credit under different titles.

PEGN411. MECHANICS OF PETROLEUM PRODUCTION (II) Nodal analysis for pipe and formation deliverability including single and multiphase flow. Natural flow and design of artificial lift methods including gas lift, sucker rod pumps, electrical submersible pumps, and hydraulic pumps. Prerequisites: PEGN 251, PEGN308, PEGN310, and PEGN311. 3 hours lecture; 3 semester hours.

PEGN419/GPGN419. WELL LOG ANALYSIS AND FORMATION EVALUATION (I) An introduction to well logging methods, including the relationship between measured properties and reservoir properties. Analysis of log suites for reservoir size and content. Graphical and analytical methods will be developed to allow the student to better visualize the reservoir, its contents, and its potential for production. Use of the computer as a tool to handle data, create graphs and log traces, and make computations of reservoir parameters is required. Prerequisite: PEGN308. Corequisites: PEGN310 and GEOL315. 2 hours lecture, 3 hours lab; 3 semester hours.

Senior Year

PEGN413. GAS MEASUREMENT AND FORMATION EVALUATION LAB (I) (WI) This lab investigates the properties of a gas such as vapor pressure, dew point pressure, and field methods of measuring gas volumes. The application of well logging and formation evaluation concepts are also investigated. This course is designated as a writing intensive course (WI). Prerequisites: PEGN308 and PEGN310. Corequisite: PEGN423. 6 hours lab; 2 semester hours.

PEGN414. WELL TEST ANALYSIS AND DESIGN (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. Superposition, active and interference tests. Well test design. Prerequisites: MATH225 and PEGN419. 3 hours lecture; 3 semester hours.

PEGN422. ECONOMICS AND EVALUATION OF OIL AND GAS PROJECTS (I) Project economics for oil and gas projects under conditions of certainty and uncertainty. Topics include time value of money concepts, discount rate assumptions, measures of project profitability, costs, taxes, expected value concept, decision trees, gambler's ruin, and Monte Carlo simulation techniques. Prerequisite: PEGN438/MNGN438. 3 hours lecture; 3 semester hours.

PEGN423. PETROLEUM RESERVOIR ENGINEERING I (I) Data requirements for reservoir engineering studies. Material balance calculations for normal gas, retrograde gas condensate, solution-gas and gas-cap reservoirs with or without water drive. Primary reservoir performance. Forecasting future recoveries by incremental material balance. Prerequisites: PEGN316, PEGN419 and MACS315 (MACS315 only for non PE majors). 3 hours lecture; 3 semester hours.

PEGN424. PETROLEUM RESERVOIR ENGINEERING II (II) Reservoir engineering aspects of supplemental recovery processes. Introduction to liquid-liquid displacement processes, gas-liquid displacement processes, and thermal recovery processes. Introduction to numerical reservoir simulation, history matching and forecasting. Prerequisite: PEGN423. 3 hours lecture; 3 semester hours.

PEGN426. WELL COMPLETIONS AND STIMULATION (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. Prerequisites: PEGN361 and PEGN411. 3 hours lecture; 3 semester hours.

PEGN428. ADVANCED DRILLING ENGINEERING (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. Prerequisites: PEGN311 and EGN361. 3 hours lecture; 3 semester hours.

PEGN438/MNGN438. GEOSTATISTICS (I & II) Introduction to elementary probability theory and its applications in engineering and sciences; discrete and continuous probability distributions; parameter estimation; hypothesis testing; linear regression; spatial correlations and geostatistics with emphasis on applications in earth sciences and engineering. Prerequisite: MATH112. 2 hours lecture; 3 hours lab; 3 semester hours.

PEGN439/GEGN439/GPGN439. MULTIDISCIPLINARY PETROLEUM DESIGN (II) This is a multidisciplinary 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 are assigned. Several written and oral presentations are made throughout the semester. Project economics including risk analysis are an integral part of the course. Prerequisites: PE Majors: GEOL308, PEGN316, PEGN422, PEGN423 and PEGN414. Corequisites: PEGN424 and PEGN426; Prerequisites GE Majors: GEOL308 or GEOL309, GEGN438, GEGN316 and EPIC264. Prerequisites GP Majors: GPGN302, GPGN303 and EPIC268. 2 hours lecture, 3 hours lab; 3 semester hours.

PEGN450. ENERGY ENGINEERING (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 (I) (WI) Written and oral presentations by each student on current energy topics. This course is designated as a writing intensive course (WI). Prerequisite: Consent of instructor. 2 hours lecture; 2 semester hours.

PEGN497. SUMMER PROGRAMS

PEGN498. SPECIAL TOPICS IN PETROLEUM ENGINEERING (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 semester hours. Repeatable for credit under different titles.

PEGN499. INDEPENDENT STUDY (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 semester hours. Repeatable for credit under different titles.

Physics

THOMAS E. FURTAK, Professor and Department Head
REUBEN T. COLLINS, Professor
UWE GREIFE, Professor
FRANK V. KOWALSKI, Professor
MARK T. LUSK, Professor
JOHN A. SCALES, Professor
JEFF A. SQUIER, Professor
P. CRAIG TAYLOR, Professor
LINCOLN D. CARR, Associate Professor
CHARLES G. DURFEE, III, Associate Professor
TIMOTHY R. OHNO, Associate Professor
FREDERIC SARAZIN, Associate Professor
ERIC S. TOBERER, Assistant Professor
LAWRENCE R. WIENCKE, Associate Professor
DAVID M. WOOD, Associate Professor
ZHIGANG WU, Assistant Professor
TODD G. RUSKELL, Teaching Professor
CHARLES A. STONE, Teaching Professor
MATTHEW M. YOUNG, Teaching Professor
ALEX T. FLOURNOY, Teaching Associate Professor
PATRICK B. KOHL, Teaching Associate Professor
H. VINCENT KUO, Teaching Associate Professor
JOHN U. TREFNY, Professor Emeritus and President Emeritus
F. EDWARD CECIL, University Professor Emeritus
JAMES T. BROWN, Professor Emeritus
JOHN A. DESANTO, Professor Emeritus
JAMES A. McNEIL, University Professor Emeritus
FRANKLIN D. SCHOWENGERDT, Professor Emeritus
DON L. WILLIAMSON, Professor Emeritus
F. RICHARD YEATTS, Professor Emeritus
WILLIAM B. LAW, Associate Professor Emeritus
ARTHUR Y. SAKAKURA, Associate Professor Emeritus
JOSEPH D. BEACH, Research Associate Professor
JAMES E. BERNARD, Research Associate Professor
M. SCOTT BRADLEY, Research Assistant Professor
MARK W. COFFEY, Research Professor
P. DAVID FLAMMER, Research Assistant Professor
ALBERTO FRANCESCHETTI, Research Professor
DAVID S. GINLEY, Research Professor
FREDRICK E. GRAY, Research Assistant Professor
RUSSELL E. HOLLINGSWORTH, Research Professor
G. MARTIN HUDSON, Research Professor
JONATHAN L. MACE, Research Professor
DANA C. OLSON, Research Assistant Professor
VOICU A. POPESCU, Research Assistant Professor
ZEEV SHAYER, Research Professor
STEVE J. SMITH, Research Assistant Professor
PAULS STRADINS, Research Professor
ADELE C. TAMBOLI, Research Assistant Professor
QI WANG, Research Professor
JOHN M. YARBROUGH, Research Assistant Professor
XIUWEN ZHANG, Research Assistant Professor

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. Approximately 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 and the ABET Accreditation Criteria, the physics department embraces the broad institutional educational objectives as summarized in the Graduate Profile. The additional engineering physics program-specific educational objectives are listed below.

All engineering physics graduates must have the factual knowledge and other thinking skills necessary to con-

struct an appropriate understanding of physical phenomena in an applied context.

All engineering physics graduates must have the ability to communicate effectively.

Throughout their careers engineering physics graduates should be able to function effectively and responsibly in society.

Combined Baccalaureate / Masters and Baccalaureate / Doctoral Degree Programs

The Physics Department, independently, and in collaboration with the Department of Metallurgical and Materials Engineering, the Engineering Division, the Department of Mathematical and Computer Sciences, and the Nuclear Science and Engineering Program offers five-year programs in which students obtain an undergraduate degree in Engineering Physics as well as a Masters Degree in Applied Physics, an Engineering discipline, or Mathematics. There are four engineering tracks, three physics tracks, and one mathematics track. The first two lead to a Masters degree in Engineering with a mechanical or electrical specialty. Students in the third track receive a Masters of Metallurgical and Materials Engineering with an electronic materials emphasis. Students in the fourth track receive a Masters degree in Nuclear Engineering. The Applied Physics tracks are in the areas of condensed matter, applied optics, and applied nuclear physics. The Mathematics track emphasizes applied mathematics and computational science and results in a Masters degree in Mathematical and Computer Sciences. The programs emphasize a strong background in fundamentals of science, in addition to practical experience within an applied physics, engineering, or mathematics discipline. Many of the undergraduate electives of students involved in each track are specified. For this reason, students are expected to apply to the program during the first semester of their sophomore year (in special cases late entry can be approved by the program mentors). A 3.0 grade point average must be maintained to guarantee admission into the engineering and physics graduate programs. A 3.3 grade point average must be maintained to guarantee admission into the mathematics graduate program.

Students in the engineering tracks must complete a report or case study during the fifth year. Students in the physics and mathematics tracks must complete a master's thesis. Students in the nuclear engineering program can choose between thesis and non-thesis options. The case study or thesis should begin during the senior year as part of the Senior Design experience. Participants must identify an engineering or physics advisor as appropriate prior to their senior year who will assist in choosing an appropriate project and help coordinate the senior design project with the case study or thesis completed in the fifth 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.

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 sem. hrs. minimum (includes 3 semester hours of PHGN100 or 200)

Minor: 18 sem. hrs. minimum (includes 3 semester hours of PHGN100 or 200)

Two courses (one year) of modern physics:
PHGN300/310 Modern Physics I 3 sem. hrs. and
PHGN320 Modern Physics II 4 sem. hrs.

One course:
PHGN341 Thermal Physics 3 sem. hrs. or
PHGN350 Mechanics 4 sem. hrs. or
PHGN361 Electromagnetism 3 sem. hrs.

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.

Degree Requirements (Engineering Physics)

Sophomore Year Fall Semester	**lec.**	**lab.**	**sem.hrs.**
MATH213 Calculus for Scientists & Engn'rs III	4		4
PHGN200 Physics II	2	4	4.5
EPIC251 Design II	3		3
SYGN200 Human Systems	3		3
PAGN201 Physical Education III	2		0.5
Total			15

Sophomore Year Spring Semester	**lec.**	**lab.**	**sem.hrs.**
MATH225 Differential Equations	3		3
MATH332 Linear Algebra	3		3
DCGN210 Introduction to Thermodynamics	3		3
PHGN300/310 Physics III-Modern Physics I	3		3
PHGN215 Analog Electronics	3	3	4
PAGN202 Physical Education IV	2		0.5
Total			16.5

Summer Session	**lec.**	**lab.**	**sem.hrs.**
PHGN384 Summer Field Session (6 weeks)			6
Total			6

Junior Year Fall Semester	lec.	lab.	sem.hrs.
PHGN315 Advanced Physics Lab I (WI)	1	3	2
PHGN311 Introduction to Math. Physics	3		3
LAIS/EBGN H&SS GenEd Restricted Elective I	3		3
PHGN317 Digital Circuits	2	3	3
PHGN350 Intermediate Mechanics	4		4
Total			15

Junior Year Spring Semester	lec.	lab.	sem.hrs.
PHGN361 Intermediate Electromagnetism	3		3
PHGN320 Modern Physics II	4		4
PHGN326 Advanced Physics Lab II (WI)	1	3	2
PHGN341 Thermal Physics	3		3
EBGN201 Principles of Economics	3		3
Total			15

Senior Year Fall Semester	lec.	lab.	sem.hrs.
PHGN471 Senior Design Principles I (WI)	0.5		0.5
PHGN481 Senior Design Practice I (WI)		6	2.5
PHGN462 Electromag. Waves & Opt. Physics	3		3
LAIS/EBGN H&SS GenEd Restricted Elective II	3		3
Free Elective I	3		3
Free Elective II	3		3
Total			15

Senior Year Spring Semester	lec.	lab.	sem.hrs.
PHGN472 Senior Design Principles II (WI)	0.5		0.5
PHGN482 Senior Design Practice II (WI)		6	2.5
LAIS/EBGN H&SS GenEd Restricted Elective III	3		3
Engineering Science Elective	3		3
Free Elective III	3		3
Free Elective IV	3		3
Total			15

Degree Total			130.5

Description of Courses

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

PHGN198. SPECIAL TOPICS (I, II) Pilot course or special topics course. Prerequisite: Consent of Department. Credit to be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

PHGN199. INDEPENDENT STUDY (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.

Sophomore Year

PHGN200. PHYSICS II-ELECTROMAGNETISM AND OPTICS (I, II, S) Continuation of PHGN100. Introduction to the fundamental laws and concepts of electricity and magnetism, electromagnetic devices, electromagnetic behavior of materials, applications to simple circuits, electromagnetic radiation, and an introduction to optical phenomena. Prerequisite: Grade of C or better in PHGN100, concurrent enrollment in MATH213/223. 2 hours lecture; 4 hours studio; 4.5 semester hours. Approved for Colorado Guaranteed General Education transfer. Equivalency for GT-SC1.

PHGN215. ANALOG ELECTRONICS (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 (I, II) Pilot course or special topics course. Prerequisite: Consent of Department. Credit to be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

PHGN299. INDEPENDENT STUDY (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.

Junior Year

PHGN300. PHYSICS III-MODERN PHYSICS I (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 or consent of instructor. 3 hours lecture; 3 semester hours.

PHGN310. HONORS PHYSICS III-MODERN PHYSICS (II) The third course in introductory physics with in depth discussion on special relativity, wave-particle duality, the Schroedinger equation, electrons in solids, quantum tunneling, nuclear structure and transmutations. Registration is strongly recommended for declared physics majors and those

considering majoring or minoring in physics. Prerequisite: PHGN200; Concurrent enrollment in MATH225 or consent of instructor. 3 hours lecture; 3 semester hours.

PHGN311. INTRODUCTION TO MATHEMATICAL PHYSICS 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 or consent of instructor. 3 hours lecture; 3 semester hours.

PHGN315. ADVANCED PHYSICS LAB I (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 or consent of instructor. 1 hour lecture, 3 hours lab; 2 semester hours.

PHGN317. SEMICONDUCTOR CIRCUITS- DIGITAL (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 (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: PHGN300/310 and PHGN311. 4 hours lecture; 4 semester hours.

PHGN324. INTRODUCTION TO ASTRONOMY AND ASTROPHYSICS (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 (II) (WI) Continuation of PHGN315. A writing-intensive course which expands laboratory experiments to include nuclear and solid state physics. Prerequisite: PHGN315. 1 hour lecture, 3 hours lab; 2 semester hours.

PHGN333/BELS333. INTRODUCTION TO BIOPHYSICS (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: PHGN 200 and BELS301/ESGN301, or permission of the instructor, 3 hours lecture, 3 semester hours.

PHGN340. COOPERATIVE EDUCATION (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 (II) An introduction to statistical physics from the quantum mechanical point of view. The microcanonical and canonical ensembles. Heat, work and the laws of thermodynamics. Thermodynamic potentials; Maxwell relations; phase transformations. Elementary kinetic theory. An introduction to quantum statistics. Prerequisite: DCGN209 or 210 and PHGN311. 3 hours lecture; 3 semester hours.

PHGN350. INTERMEDIATE MECHANICS (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. Co-requisite: PHGN311. 4 hours lecture; 4 semester hours.

PHGN361. INTERMEDIATE ELECTROMAGNETISM (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. APPARATUS DESIGN (S) Introduction to the design of engineering physics apparatus. Concentrated individual participation in the design of machined and fabricated system components, vacuum systems, electronics and computer interfacing systems. Supplementary lectures on safety and laboratory techniques. Visits to regional research facilities and industrial plants. Prerequisite: PHGN300/310, PHGN215. Available in 4 or 6 credit hour blocks in the summer session usually following the sophomore year. The machine shop component also may be available in a 2-hour block during the academic year. Total of 6 credit hours required for the Engineering Physics option. Repeatable for credit to a maximum of 6 hours.

PHGN398. SPECIAL TOPICS (I, II) Pilot course or special topics course. Prerequisites: Consent of department. Credit to

be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

PHGN399. INDEPENDENT STUDY (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.

Senior Year

PHGN401. THEORETICAL PHYSICS SEMINAR (I,II). Students will attend the weekly theoretical physics seminar. Students will be responsible for presentation and discussion. Corequisite: PHGN300/310. 1 hour lecture; 1 semester hour.

PHGN419. PRINCIPLES OF SOLAR ENERGY SYSTEMS. 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 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.

PHGN424. ASTROPHYSICS 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.

PHGN435/ChEN435/ChEN535/PHGN535/MLGN535. INTERDISCIPLINARY MICROELECTRONICS PROCESSING LABORATORY Application of science and engineering principles to the design, fabrication, and testing of microelectronic devices. Emphasis on specific unit operations and the interrelation among processing steps. Prerequisites: Senior standing in PHGN, CHGN, MTGN, or EGGN. Consent of instructor. 1.5 hours lecture, 4 hours lab; 3 semester hours.

PHGN440/MLGN502. SOLID STATE PHYSICS 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/MLGN522. SOLID STATE PHYSICS APPLICATIONS AND PHENOMENA Continuation of PHGN440/MLGN502 with an emphasis on applications of the principles of solid state physics to practical properties of materials including: optical properties, superconductivity, dielectric properties, magnetism, noncrystalline structure, and interfaces. (Graduate students in physics may register only for PHGN441.) Prerequisite: PHGN440 or MLGN502, or equivalent by instructor's permission. 3 hours lecture; 3 semester hours.

PHGN450. COMPUTATIONAL PHYSICS 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; PHGN311. 3 hours lecture; 3 semester hours.

PHGN462. ELECTROMAGNETIC WAVES AND OPTICAL PHYSICS (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 Provides students with a comprehensive working knowledge of optical system design that is sufficient to address optical problems found in their respective disciplines. Topics include paraxial optics, imaging, aberration analysis, use of commercial ray tracing and optimization, diffraction, linear systems and optical transfer functions, detectors and optical system examples. Prerequisite: PHGN462 or consent of instructor. 3 hours lecture; 3 semester hours.

PHGN471. SENIOR DESIGN PRINCIPLES (I) (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. Prerequisite: PHGN384 and PHGN326. Co-requisite: PHGN481. 1 hour lecture in 7 class sessions; 0.5 semester hours.

PHGN472. SENIOR DESIGN PRINCIPLES (II) (WI) Continuation of PHGN471. Prerequisite: PHGN384 and PHGN326. Co-requisite: PHGN482. 1 hour lecture in 7 class sessions; 0.5 semester hours.

PHGN480. LASER PHYSICS (I) Theory and application of the following: Gaussian beams, optical cavities and wave guides, atomic radiation, detection of radiation, laser oscillation, nonlinear optics and ultrafast pulses. Prerequisite: PHGN320. Co-requisite: PHGN462. 3 hours lecture; 3 semester hours.

PHGN481. SENIOR DESIGN PRACTICE (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 (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 (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 (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

PHGN498. SPECIAL TOPICS (I, II) Pilot course or special topics course. Prerequisites: Consent of instructor. Credit to be determined by instructor, maximum of 6 credit hours. Repeatable for credit under different titles.

PHGN499. INDEPENDENT STUDY (I, II) Individual research or special problem projects supervised by a faculty member, student and instructor agree on a subject matter, content, deliverables, 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.

Bioengineering and Life Sciences (BELS)

Minors and Areas of Special Interest Only
JAMES F. ELY, Professor and BELS Director
JOEL M. BACH, Associate Professor and BELS Assistant Director

Department of Chemistry and Geochemistry
DANIEL KNAUSS, Professor and Department Head
KENT J. VOORHEES, Professor
JAMES F. RANVILLE, Associate Professor
KIM R. WILLIAMS, Associate Professor
DAVID T. WU, Associate Professor
MATTHEW C. POSEWITZ, Assistant Professor

Department of Chemical and Biological Engineering
DAVID W. M. MARR, Professor and Department Head
TRACY Q. GARDNER, Teaching Associate Professor and Assistant Department Head
JAMES F. ELY, Professor
ANNETTE L. BUNGE, Professor Emerita
JOHN R. DORGAN, Professor
C. MARK MAUPIN, Assistant Professor
KEITH B. NEEVES, Assistant Professor
AMADEU SUM, Assistant Professor
NING WU, Assistant Professor
HUGH KING, Teaching Professor
CYNTHIA NORRGRAN, Teaching Associate Professor
PAUL OGG, Teaching Associate Professor
JOHN PERSICHETTI, Teaching Associate Professor
JUDITH Y. SCHOONMAKER, Teaching Associate Professor

Division of Engineering
JOEL M. BACH, Associate Professor
WILLIAM A. HOFF, Associate Professor
ANTHONY J. PETRELLA, Assistant Professor
ANNE SILVERMAN, Assistant Professor

Division of Environmental Science and Engineering
JOHN MCCRAY, Professor and Director
RONALD R. H. COHEN, Associate Professor
LINDA A. FIGUEROA, Associate Professor
JUNKO MUNAKATA MARR, Associate Professor
JOHN R. SPEAR, Assistant Professor

Department of Geology and Geological Engineering
JOHN D. HUMPHREY, Associate Professor and Head
MURRAY W. HITZMAN, Professor: Charles Franklin Fogarty Distinguished Chair in Economic Geology

Division of Liberal Arts and International Studies
CARL MITCHAM, Professor
TINA L. GIANQUITTO, Associate Professor
JASON DELBORNE, Assistant Professor
SANDRA WOODSON, Teaching Associate Professor

Department of Mathematical and Computer Sciences
DINESH MEHTA, Professor
MAHADEVAN GANESH, Professor
WILLIAM C. NAVIDI, Professor

Department of Metallurgical and Materials Engineering
IVAR E. REIMANIS, Professor
REED AYERS, Assistant Professor
HONGUIN LIANG, Assistant Professor

Department of Physics
THOMAS E. FURTAK, Professor and Department Head
JEFF SQUIER, Professor

Programs Offered:

Minor in Bioengineering and Life Sciences
Area of Special Interest in Bioengineering and Life Sciences

Program Description

The interdisciplinary program in Bioengineering and Life Sciences (BELS) is administered by the Chemical and Biological Engineering Department. Participating departments (listed above) are represented on the Curriculum and Research Committee, which is responsible for the delivery and new course development for the program.

The mission of the BELS program is to offer Minors and Areas of Special Interest (ASI) at the undergraduate level, and support areas of specialization at the graduate level, as well as to enable research opportunities for CSM students in bioengineering and the life sciences.

Bioengineering and the Life Sciences (BELS) are becoming increasingly significant in fulfilling the role and mission of the Colorado School of Mines. Many intellectual frontiers within the fields of environment, energy, materials, and their associated fields of science and engineering , are being driven by advances in the biosciences and the application of engineering to living processes.

Program Requirements:

Minor in Bioengineering and Life Sciences:

The Minor in BELS requires a minimum of 18 semester hours of acceptable coursework, as outlined under the Required Curriculum section that follows.

The Area of Special Interest (ASI) in BELS requires a minimum of 12 semester hours of acceptable coursework, as outlined under the Required Curriculum section that follows.

Enrollments in the BELS Minor and ASI are approved by the Director or Associate Director, who monitor progress and completion.

Required Curriculum:

Both the Minor and the ASI require one core course (3 semester hours). The minor requires at least 6 additional credit hours from the Basic Life Science course list, and additional BELS-approved courses to make up a total of at least 18 credit hours. The ASI requires at least 3 additional credit hours from the Life Science course list, and additional BELS-approved courses to make up a total of at least 12 credit hours.

Core Course:
BELS301 General Biology I

Basic Life Science courses:
BELS303 General Biology II
BELS311 General Biology I Laboratory
BELS313 General Biology II Laboratory
BELS321 Introduction to Genetics
BELS402 Cell Biology and Physiology
BELS404 Anatomy and Physiology
BELS405 Anatomy and Physiology Laboratory
CHGN428 Biochemistry I
CHGN462/CHGC562/ESGN580 Microbiology & the Environment
CHGN563/CHGC563/ESGN582 Environmental Microbiology Lab

BELS-approved Elective courses (including, but not limited to):
BELS320/LAIS320 Introduction to Ethics
BELS333/PHGN333 Introduction to Biophysics
BELS350 Honors Undergraduate Research
BELS351 Honors Undergraduate Research
BELS398 Special Topics in Bioengineering and Life Sciences
BELS415/ChEN415 Polymer Science and Technology
BELS432/CHEN432 Transport Phenomena in Biological Systems
BELS450 Honors Undergraduate Research
BELS451 Honors Undergraduate Research
BELS325/EGGN325 Intro to Biomedical Engineering
BELS425/EGGN425 Musculoskeletal Biomechanics
BELS427/EGGN427 Prosthetic and Implant Engineering
BELS428/EGGN428 Computational Biomechanics
BELS430/EGGN430 Biomedical Instrumentation
BELS433/MATH433 Mathematical Biology
BELS453/EGGN453 Wastewater Engineering
BELS470/CHEN470 Intro to Microfluidics
BELS498 Special Topics in Bioengineering and Life Sciences
BELS525/ EGGN Musculoskeletal Biomechanics
BELS527/EGGN527 Prosthetic and Implant Engineering
BELS528/EGGN528 Computational Biomechanics
BELS530/EGGN530 Biomedical Instrumentation
BELS541/ESGN541 Biochemical Treatment Processes
CHGN422 Polymer Chemistry Laboratory
CHGN508 Analytical Spectroscopy
MLGN523 Applied Surface & Solution Chem.
ESGN401 Fundamentals of Ecology
BELS544/ESGN544 Aquatic Toxicology
BELS545/ESGN545 Environmental Toxicology
BELS596/ESGN596 Molecular Environmental Biotechnology
ESGN586 Microbiology of Engineered Environmental Systems
*CHGN221 Organic Chemistry I
*CHGN222 Organic Chemistry II
BELS570/MTGN570/MLGN570 Intro to Biocompatibility

Premedical Students

While medical college admissions requirements vary, most require a minimum of:

two semesters of General Chemistry with lab
two semesters of Organic Chemistry with lab
two semesters of Calculus
two semesters of Calculus-based Physics
two semesters of English Literature and Composition
two semesters of General Biology with lab.

CSM currently offers all of these requirements. CSM also has a premedical student society. See http://stulife.mines.edu/premed for more information.

*Note: Only 3 hours of Organic Chemistry course credit may be applied toward the BELS minor or ASI. General

rules for Minor Programs and Areas of Special Interest are on page 50 & 51 of this bulletin, Note, however, that due to the interdisciplinary nature of the BELS minor and ASI programs, there is no restriction on the number of credit hours that may be taken in the student's degree grantling department, provided that the course carries a BELS course number and is not required by the degree program for graduation.

Description of Courses

BELS101 BIOLOGICAL AND ENVIRONMENTAL SYSTEMS (I,II) This course presents the basic principles and properties of biological and environmental systems. It considers the chemistry of life and the structure and function of cells and organisms. Concepts related to physiology, energetics, and genetics are introduced. The fundamentals of environmental science are presented and we consider how organisms interact with each other and with their environment and discuss the possibilities and problems of these interactions. Basic engineering principles of thermodynamics, kinetics, mass balance, transport phenomena and material science are presented and applied to biological systems. 4 hours lecture; 4 semester hours

BELS301. GENERAL BIOLOGY I (I, II) This is the first semester of an introductory course in Biology. Emphasis is placed on the methods of science; structural, molecular, and energetic basis of cellular activities; genetic variability and evolution; diversity and life processes in plants and animals; and, principles of ecology. Prerequisite: None. 3 hours lecture; 3 semester hours.

BELS311. GENERAL BIOLOGY I LABORATORY(I, II) This Course provides students with laboratory exercises that complement lectures given in BELS301, the first semester introductory course in Biology. Emphasis is placed on the methods of science; structural, molecular, and energetic basis of cellular activities; genetic variability and evolution; diversity and life processes in plants and animals; and, principles of ecology. Co-requisite or Prerequisite: EGGN/BELS301 or equivalent. 3 hours lab; 1 semester hour.

BELS303. GENERAL BIOLOGY II (I, II) This is the continuation of General Biology I. Emphasis is placed on an examination of organisms as the products of evolution. The diversity of life forms will be explored. Special attention will be given to the vertebrate body (organs, tissues, and systems) and how it functions. Prerequisite: General Biology I, or equivalent. 3 hours lecture; 3 semester hours.

BELS313. GENERAL BIOLOGY II LABORATORY (I, II) This Course provides students with laboratory exercises that complement lectures given in BELS303, the second semester introductory course in Biology. Emphasis is placed on an examination of organisms as the products of evolution. The diversity of life forms will be explored. Special attention will be given to the vertebrate body (organs, tissues and systems) and how it functions. Co-requisite or Prerequisite: BELS303 or equivalent. 3 hours lab; 1 semester hour.

BELS320/LAIS320 INTRODUCTION TO ETHICS A general introduction to ethics that explores its analytic and historical traditions. Reference will commonly be made to one or more significant texts by such moral philosophers as Plato, Aristotle, Augustine, Thomas Aquinas, Kant, John Stuart Mill, and others. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

BELS321. INTRO TO GENETICS (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 lab; 4 semester hours.

BELS325/EGGN325. INTRO TO BIOMEDICAL ENGINEERING (I) The application of engineering principles and techniques to the human body presents many unique challenges. Biomedical Engineering is a diverse, seemingly all-encompassing field that includes such areas as biomechanics, bioinstrumentation, medical imaging, and rehabilitation. This course is intended to provide an introduction to, and overview of, Biomedical Engineering. 3 hours lecture; 3 semester hours.

BELS333/PHGN333. INTRODUCTION TO BIOPHYSICS 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: PHGN 200 and BELS301, or permission of the instructor. 3 hours lecture; 3 semester hours.

BELS350. HONORS UNDERGRADUATE RESEARCH (I) Scholarly research of an independent nature. Prerequisite: junior standing, consent of instructor. 1 to 3 semester hours.

BELS351. HONORS UNDERGRADUATE RESEARCH (II) Scholarly research of an independent nature. Prerequisite: junior standing, consent of instructor. 1 to 3 semester hours.

BELS398. SPECIAL TOPICS IN BIOENGINEERING AND LIFE SCIENCES 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.

BELS402. CELL BIOLOGY AND PHYSIOLOGY (II) An introduction to the morphological, biochemical, and biophysical properties of cells and their significance in the life processes. Prerequisite: General Biology I, or equivalent. 3 hours lecture; 3 semester hours.

BELS404. ANATOMY AND PHYSIOLOGY (II) This course will cover the basics of human anatomy and physiology. We will discuss the gross and microscopic anatomy and the physiology of the major organ systems. Where possible we will integrate discussions of disease processes and introduce reliant biomedical engineering concepts. Prerequisite: General Biology I or consent of instructor. 3 hours lecture; 3 semester hours.

BELS405. ANATOMY AND PHYSIOLOGY LAB (II) In this course we explore the basic concepts of human anatomy and physiology using simulations of the physiology and a virtual human dissector program. These are supplemented as needed with animations, pictures and movies of cadaver dissection to provide the student with a practical experience discovering principles and structures associated with the anatomy and physiology. Corequisite: BELS404. 3 lab hours, 1 semester hour.

BELS415/ChEN415. POLYMER SCIENCE AND TECHNOLOGY Chemistry and thermodynamics of polymers and polymer solutions. Reaction engineering of polymerization. Characterization techniques based on solution properties. Materials science of polymers in varying physical states. Processing operations for polymeric materials and use in separations. Prerequisite: CHGN211, MATH225, ChEN357, or consent of instructor. 3 hours lecture; 3 semester hours.

BELS425/EGGN425. MUSCULOSKELETAL BIOMECHANICS (II) This course is intended to provide engineering students with an introduction to musculoskeletal biomechanics. At the end of the semester, students should have a working knowledge of the special considerations necessary to apply engineering principles to the human body. The course will focus on the biomechanics of injury since understanding injury will require developing an understanding of normal biomechanics. Prerequisites: DCGN421 Statics, EGGN320 Mechanics of Materials, EGGN325/BELS325 Introduction to Biomedical Engineering (or instructor permission). 3 hours lecture; 3 semester hours.

BELS427/EGGN427. PROSTHETIC AND IMPLANT ENGINEERING (I) Prosthetics and implants for the musculoskeletal and other systems of the human body are becoming increasingly sophisticated. From simple joint replacements to myoelectric limb replacements and functional electrical stimulation, the engineering opportunities continue to expand. This course builds on musculoskeletal biomechanics and other BELS courses to provide engineering students with an introduction to prosthetics and implants for the musculoskeletal system. At the end of the semester, students should have a working knowledge of the challenges and special considerations necessary to apply engineering principles to augmentation or replacement in the musculoskeletal system. Prerequisites: Musculoskeletal Biomechanics (EGGN/BELS425 or EGGN/BELS525) 3 hours lecture; 3 semester hours.

BELS428/EGGN428. COMPUTATIONAL BIOMECHANICS (I) Computational Biomechanics provides and introduction to the application of computer simulation to solve some fundamental problems in biomechanics and bioengineering. Musculoskeletal mechanics, medical image reconstruction, hard and soft tissue modeling, joint mechanics, and inter-subject variability will be considered. An emphasis will be placed on understanding the limitations of the computer model as a predictive tool and the need for rigorous verification and validation of computational techniques. Clinical application of biomechanical modeling tools is highlighted and impact on patient quality of life is demonstrated. Prerequisites: EGGN413 Computer Aided Engineering, EGGN325/BELS325 Introduction to Biomedical Engineering. 3 hours lecture; 3 semester hours.

BELS430/EGGN430. BIOMEDICAL INSTRUMENTATION (I) The acquisition, processing, and interpretation of biological signals presents many unique challenges to the Biomedical Engineer. This course is intended to provide students with an introduction to, and appreciation for, many of these challenges. At the end of the semester, students should have a working knowledge of the special considerations necessary to gathering and analyzing biological signal data. Prerequisites: EGGN250 MEL I, DCGN381 Introduction to Electrical Circuits, Electronics, and Power, EGGN325/BELS425 Introduction to Biomedical Engineering (or permission of instructor). 3 hours lecture; 3 semester hours.

BELS432/CHEN432. TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS (II) 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. Prerequisite: CHEN430 or equivalent. 3 hours lecture, 3 semester hours.

BELS433/MATH433. MATHEMATICAL BIOLOGY (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. 3 hours lecture; 3 semester hours.

BELS450. HONORS UNDERGRADUATE RESEARCH (I) Scholarly research of an independent nature. Prerequisite: senior standing, consent of instructor. 1 to 3 semester hours.

BELS45I. HONORS UNDERGRADUATE RESEARCH (II) Scholarly research of an independent nature. Prerequisite: senior standing, consent of instructor. 1 to 3 semester hours.

BELS453/EGGN453. WASTEWATER ENGINEERING (I) The goal of this course is to familiarize students with the fundamental phenomena involved in wastewater treatment processes (theory) and the engineering approaches used in designing such processes (design). This course will focus on the physical, chemical and biological processes applied to liquid wastes of municipal origin. Treatment objectives will be discussed as the driving force for wastewater treatment. Prerequisite: ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

BELS470/CHEN470. (I) INTRODUCTION TO MICROFLUIDICS This course introduces the basic principles and applications of microfluidic systems. Concepts related to microscale fluid mechanics, transport, physics, and biology are presented. To gain familiarity with small-scale systems, students are provided with the opportunity to design, fabricate, and test a simple microfluidic device. Prerequisites: CHEN307 (or equivalent) and DCGN210 (or equivalent) or permission of instructor. 3 semester hours.

BELS497. SUMMER PROGRAMS

BELS498. SPECIAL TOPICS IN BIOENGINEERING AND LIFE SCIENCES 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.

BELS525/EGGN525. MUSCULOSKELETAL BIOMECHANICS (II) This course is intended to provide graduate engineering students with an introduction to musculoskeletal biomechanics. At the end of the semester, students should have a working knowledge of the special considerations necessary to apply engineering principles to the human body. The course will focus on the biomechanics of injury since understanding injury will require developing an understanding of normal biomechanics. Prerequisites: DCGN241 Statics, EGGN320 Mechanics of Materials, EGGN325/BELS325 Introduction to Biomedical Engineering (or instructor permission). 3 hours lecture; 3 semester hours.

BELS527/EGGN527. PROSTHETIC AND IMPLANT ENGINEERING (I) Prosthetics and implants for the musculoskeletal and other systems of the human body are becoming increasingly sophisticated. From simple joint replacements to myoelectric limb replacements and functional electrical stimulation, the engineering opportunities continue to expand. This course builds on musculoskeletal biomechanics and other BELS courses to provide engineering students with an introduction to prosthetics and implants for the musculoskeletal system. At the end of the semester, students should have a working knowledge of the challenges and special considerations necessary to apply engineering principles to augmentation or replacement in the musculoskeletal system. Prerequisites: Musculoskeletal Biomechanics (EGGN/BELS425 or EGGN/BELS525) 3 hours lecture; 3 semester hours.

EGGN528. COMPUTATIONAL BIOMECHANICS (I) Computational Biomechanics provides and introduction to the application of computer simulation to solve some fundamental problems in biomechanics and bioengineering. Musculoskeletal mechanics, medical image reconstruction, hard and soft tissue modeling, joint mechanics, and inter-subject variability will be considered. An emphasis will be placed on understanding the limitations of the computer model as a predictive tool and the need for rigorous verification and validation of computational techniques. Clinical application of biomechanical modeling tools is highlighted and impact on patient quality of life is demonstrated. Prerequisites: EGGN413 Computer Aided Engineering, EGGN325/BELS325 Introduction to Biomedical Engineering. 3 hours lecture; 3 semester hours.

BELS530/EGGN530. BIOMEDICAL INSTRUMENTATION (I) The acquisition, processing, and interpretation of biological signals presents many unique challenges to the Biomedical Engineer. This course is intended to provide students with the knowledge to understand, appreciate, and address these challenges. At the end of the semester, students should have a working knowledge of the special considerations necessary to gathering and analyzing biological signal data. Prerequisites: EGGN250 MEL I, EGGN381 Introduction to Electrical Circuits, Electronics, and Power, EGGN325/BELS325 Introduction to Biomedical Engineering (or permission of instructor). 3 hours lecture; 3 semester hours.

BELS541/ESGN541. BIOCHEMICAL TREATMENT PROCESSES The analysis and design of biochemical processes used to transform pollutants are investigated in this course. Suspended growth, attached growth, and porous media systems will be analyzed. Common biochemical operations used for water, wastewater, and sludge treatment will be discussed. Biochemical systems for organic oxidation and fermentation and inorganic oxidation and reduction will be presented. Prerequisites: ESGN504 or consent of the instructor. 3 hours lecture; 3 semester hours.

BELS570/MTGN570/MLGN570. INTRO TO BIOCOMPATIBILITY Material biocompatibility is a function of tissue/implant mechanics, implant morphology and surface chemistry. The interaction of the physiologic environment with a material is present at each of these levels, with sub-

jects including material mechanical/structural matching to surrounding tissues, tissue responses to materials (inflammation, immune response), anabolic cellular responses and tissue engineering of new tissues on scaffold materials. This course is intended for senior level undergraduates and first year graduate students. Prerequisites: BELS301 or equivalent, or consent of instructor. 3 hours lecture; 3 semester hours.

CHGN422. INTRO TO POLYMER CHEMISTRY LABORATORY (I) Prerequisites: CHGN221. 3 hours lab; 1 semester hour.

CHGN428. BIOCHEMISTRY I (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: CHGN221 or consent of instructor. 3 hours lecture; 3 semester hours.

CHGN462/CHGC562/ESGN580. MICROBIOLOGY & THE ENVIRONMENT This course will cover the basic fundamentals of microbiology, such as structure and function of procaryotic versus eucaryotic cells; viruses; classification of microorganisms; microbial metabolism, energetics, genetics, growth and diversity, microbial interactions with plants, animals, and other microbes. Additional topics covered will include various aspects of environmental microbiology such as global biogeochemical cycles, bioleaching, bioremediation, and wastewater treatment. Prerequisite: Consent of instructor 3 hours lecture; 3 semester hours. Offered in alternate years.

CHGN508. ANALYTICAL SPECTROSCOPY (II) Detailed study of classical and modern spectroscopic methods; emphasis on instrumentation and application to analytical chemistry problems. Topics include: UV-visible spectroscopy, infrared spectroscopy, fluorescence and phosphorescence, Raman spectroscopy, arc and spark emission spectroscopy, flame methods, nephelometry and turbidimetry, reflectance methods, Fourier transform methods in spectroscopy, photoacoustic spectroscopy, rapid-scanning spectroscopy. Prerequisite: Consent of instructor. 3 hours lecture; 3 semester hours. Offered alternate years.

MLGN532. APPLIED SURFACE & SOLUTION CHEMISTRY. (I) Solution and surface chemistry of importance in mineral and metallurgical operations. Prerequisite: Consent of department. 3 semester hours. (Fall of even years only.)

BELS544/ESGN544. AQUATIC TOXICOLOGY (II) An introduction to assessing the effects of toxic substances on aquatic organisms, communities, and ecosystems. Topics include general toxicological principles, water quality standards, quantitative structure-activity relationships, single species and community-level toxicity measures, regulatory issues, and career opportunities. The course includes hands-on experience with toxicity testing and subsequent data reduction. Prerequisite: none. 2.5 hours lecture, 1 hour lab; 3 semester hours.

BELS545/ESGN545. ENVIRONMENTAL TOXICOLOGY (II) Introduction to general concepts of ecology, biochemistry, and toxicology. The introductory material will provide a foundation for understanding why, and to what extent, a variety of products and by-products of advanced industrialized societies are toxic. Classes of substances to be examined include metals, coal, petroleum products, organic compounds, pesticides, radioactive materials, and others. Prerequisite: none. 3 hours lecture; 3 semester hours.

BELS596/ESGN596. MOLECULAR ENVIRONMENTAL BIOTECHNOLOGY (l) Applications of recombinant DNA technology to the development of enzymes and organisms used for environmentally friendly industrial purposes. Topics include genetic engineering technology, biocatalysis of industrial processes by extremozymes, dye synthesis, biodegradation of aromatic compounds and chlorinated solvents, biosynthesis of polymers and fuels, and agricultural biotechnology. Prerequisite: introductory microbiology and organic chemistry or consent of the instructor. 3 hours lecture; 3 semester hours.

CHGN563/ESGN582. MICROBIOLOGY AND THE ENVIRONMENT LAB. (I) An introduction to the microorganisms of major geochemical importance, as well as those of primary importance in water pollution and waste treatment. Microbes and sedimentation, microbial leaching of metals from ores, acid mine water pollution, and the microbial ecology of marine and freshwater habitats are covered. Prerequisite: Consent of instructor. 1 hour lecture, 3 hours lab; 2 semester hours. Offered alternate years.

ESGN401. FUNDAMENTALS OF ECOLOGY (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.

ESGN586. MICROBIOLOGY OF ENGINEERED ENVIRONMENTAL SYSTEMS (l) Applications of microbial physiological processes to engineered and human-impacted systems for the purpose of achieving environmentally desirable results. Topics include microbial identification and enumeration, biofilms in engineered systems, industrial fermentations and respirations, biodegradation and bioremediation of organic and inorganic contaminants, wastewater microbiology, renewable energy generation, and agricultural biotechnology. Prerequisite: CHGC562 or equivalent, or enrollment in an ESE program. 3 hours lecture; 3 semester hours.

CHGN221. ORGANIC CHEMISTRY I (I) Structure, properties, and reactions of the important classes of organic compounds, introduction to reaction mechanisms. Laboratory exercises including synthesis, product purification and characterization. Prerequisite: CHGN122. 3 hours lecture; 3 hours lab; 4 semester hours.

CHGN222. ORGANIC CHEMISTRY II (II) Continuation of CHGN221. Prerequisite: CHGN221. 3 hours lecture; 3 hours lab; 4 semester hours.

Energy Minor

Minor and Area of Special Interest Only
TIMOTHY R. OHNO, Associate Professor of Physics and Director

Department of Chemical Engineering
ANDREW M. HERRING, Associate Professor
JOHN M. PERSICHETTI, Teaching Associate Professor

Division of Economics and Business
RODERICK G. EGGERT, Professor and Division Director
CAROL DAHL, Professor
DANIEL KAFFINE, Assistant Professor

Division of Environmental Science and Engineering
LINDA FIGUEROA, Associate Professor

Division of Engineering
P. K. SEN, Professor
MARCELO SIMOES, Associate Professor
NEAL SULLIVAN, Assistant Professor
KATHRYN JOHNSON, Assistant Professor

Department of Geology and Geological Engineering
JOHN CURTIS, Professor
MURRAY W. HITZMAN, Professor, Charles F. Fogarty Professor of Economic Geology

Department of Geophysics
ROEL SNIEDER, Keck Foundation Professor of Basic Exploration Science

Department of Mining Engineering
MASAMI NAKAGAWA, Professor

Department of Metallurgical and Materials Engineering
JEFFREY C. KING, Assistant Professor

Department of Petroleum Engineering
RAMONA M. GRAVES, Professor and Interim Department Head
DWAYNE BOURGOYNE, Assistant Professor
LINDA BATTALORA, Teaching Associate Professor

Department of Physics
JOSEPH BEACH Jr. Research Associate Professor
REUBEN COLLINS, Professor
CHARLES STONE, Teaching Professor
P. CRAIG TAYLOR, Professor
ERIC TOBERER, Assistant Professor

Division of Liberal Arts and International Studies
CARL MITCHAM, Professor
JASON A. DELBORNE, Assistant Professor
JOHN HEILBRUNN, Associate Professor
JENNIFER SCHNEIDER, Assistant Professor

Programs Offered:

Minor in Energy
Area of Special Interest in Energy

Program Educational Objectives

The discovery, production, and use of energy in modern societies has profound and far-reaching economic, political, and environmental effects. As energy is one of CSM's core statutory missions, it is appropriate that CSM offer a program of study that not only addresses the scientific and technical aspects of energy production and use but its broader social

impacts as well. The Energy Minor program is intended to provide engineering students with a deeper understanding of the complex role energy technology plays in modern societies by meeting the following learning objectives:

1. Students will gain a broad understanding of the scientific, engineering, environmental, economic and social aspects of the production, delivery, and utilization of energy as it relates to the support of current and future civilization both regional and worldwide.

2. Students will develop depth or breadth in their scientific and engineering understanding of energy technology.

3. Students will be able to apply their knowledge of energy science and technology to societal problems requiring economic, scientific, and technical analysis and innovation, while working in a multidisciplinary environment and be able to communicate effectively the outcomes of their analyses in written and oral form.

Program Requirements:

Minor in Energy:

The Minor in Energy requires a minimum of 18 credit hours of acceptable course work. There are three curricular tracks: Fossil Energy, Renewable Energy, and General. All Energy Minors must take Introduction to Energy, ENGY200, and Energy Economics, EBGN330/ENGY330, and Energy and Society, ENGY490. In addition to the required courses, students in the Fossil Energy track must take ENGY310, Fossil Energy, and two approved fossil energy-related electives. In addition to the required courses, students in the Renewable Energy track must take ENGY320, Renewable Energy, and two approved renewable energy-related electives. In addition to the required courses, students in the General track must take at least two of the energy topic survey courses, ENGY310, Fossil Energy, ENGY320, Renewable Energy, and ENGY340, Nuclear Energy, ENGY350, Introduction to Geothermal Energy and one additional energy-related elective from any category. Up to 3 hours of coursework may be taken in the student's degree-granting department.

The Area of Special Interest in Energy requires a minimum of 12 credit hours of acceptable course work: ENGY200, EBGN330/ENGY330 and two additional courses selected from the Energy-related courses listed below.

Introductory Courses (6 sem. hrs.)
- ENGY200 Introduction to Energy 3 sem. hrs.
- EBGN330 / ENGY330 Energy Economics, 3 sem. hrs.

Energy-related Courses: Fossil Energy Track (9 sem. hrs.)
- ENGY310: Fossil Energy, 3 sem. hrs.
- CHEN408: Natural Gas Processing, 3 sem. hrs.
- CHEN409: Petroleum Processes, 3 sem. hrs.
- GEGN308: Instroductory Applied Structural Geology, 3 sem.hrs.
- GEGN438: Petroleum Geology I, 3 sem. hrs.
- PEGN251: Fluid Mechanics, 3 sem. hrs.
- PEGN305: Computational Methods in Petroleum Engineering, 2 sem. hrs.
- PEGN308: Reservoir Rock Properties, 3 sem. hrs.
- PEGN311: Drilling Engineering, 4 sem. hrs.
- PEGN361: Completion Engineering, 3 sem. hrs.
- PEGN411: Mechanics of Petroleum Production, 3 sem. hrs.
- PEGN419: Well Log Analysis and Formation Evaluation, 3 sem. hrs.
- PEGN422: Economics and Evaluation of Oil and Gas Projects, 3 sem. hrs.
- PEGN438/MNGN438: Geostatistics, 3 sem. hrs.

Energy-related Courses: Renewable Energy Track (9 sem. hrs.)
- ENGY320: Renewable Energy, 3 sem. hrs.
- MTGN469: Fuel Cell Science and Technology, 3 sem. hrs.
- EGGN486: Practical Design of Small Renewable Energy Systems, 3 sem. hrs.
- PHGN419: Principles of Solar Energy Systems, 3 sem. hrs.

General Track (9 sem. hrs.)
Required courses (2 of 4 survey):
- ENGY310: Fossil Energy, 3 sem. hrs.
- ENGY320: Renewable Energy, 3 sem. hrs.
- ENGY340: Nuclear Energy, 3 sem. hrs.
- ENGY350. Introduction to Geothermal Energy; 3 sem. Hrs.

Elective courses: one additional course chosen from either the Fossil Energy or Renewable Energy tracks or from the following additional energy-related courses:
- EGGN389: Fundamentals of Electric Machinery I, 3 sem. hrs.
- EGGN403: Thermodynamics II, 3 sem. hrs.
- EGGN589. Design And Control Of Wind Energy Systems, 3 sem. hrs.
- EBGN 340 Energy and Environmental Policy, 3 sem. hrs.
- LAIS 419: Media & the Environment, 3 sem. hrs.
- LAIS 423: Advanced Science Communication, 3 sem. hrs.
- LAIS 477: Engineering & Sustainable Community Development, 3 sem. hrs.
- LAIS 489: Nuclear Power & Public Policy, 3 sem. hrs.
- LAIS 498: Rhetoric, Energy & Public Policy, 3 sem. hrs.
- LAIS 486: Science & Technology Policy, 3 sem. hrs.

Policy course (3 sem. hrs., required for all Energy minors):
- ENGY490 / LAIS490: Energy and Society, 3 sem. hrs.

Description of Courses:

ENGY200. Introduction to Energy. Survey of human-produced energy technologies including steam, hydro, fossil (petroleum, coal, and unconventionals), geothermal, wind, solar, biofuels, nuclear, and fuel cells. Current and possible future energy transmission and efficiency. Evaluation of different energy sources in terms of a feasibility matrix of technical,

economic, environmental, and political aspects. Prerequisites: PHGN100, SYGN101, BELS101 or BELS301. 3 hours lecture; 3 semester hours.

ENGY310. Fossil Energy (I). Students will learn about conventional coal, oil, and gas energy sources across the full course of exploitation, from their geologic origin, through discovery, extraction, processing, processing, marketing, and finally to their end-use in society. Students will be introduced to the key technical concepts of flow through rock, the geothermal temperature and pressure gradients, hydrostatics, and structural statics as needed to understand the key technical challenges of mining, drilling, and production. Students will then be introduced to unconventional (emerging) fossil-based resources, noting the key drivers and hurdles associated with their development. Students will learn to quantify the societal cost and benefits of each fossil resource across the full course of exploitation and in a final project will propose or evaluate a national or global fossil energy strategy, supporting their arguments with quantitative technical analysis. Prerequisite: ENGY200. 3 hours lecture; 3 semester hours.

ENGY320. Renewable Energy (I). Survey of renewable sources of energy. The basic science behind renewable forms of energy production, technologies for renewable energy storage, distribution, and utilization, production of alternative fuels, intermittency, natural resource utilization, efficiency and cost analysis and environmental impact. Prerequisite ENGY200. 3 hours lecture, 3 semester hours.

ENGY330/EBGN330. Energy Economics (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. Prerequisites: EBGN201 or EBGN311. 3 hours lecture; 3 semester hours.

ENGY340. Nuclear Energy (II). Survey of nuclear energy and the nuclear fuel cycle including the basic principles of nuclear fission and an introduction to basic nuclear reactor design and operation. Nuclear fuel, uranium resources, distribution, and fuel fabrication, conversion and breeding. Nuclear safety, nuclear waste, nuclear weapons and proliferation as well economic, environmental and political impacts of nuclear energy. Prerequisite: ENGY200. 3 hours lecture; 3 semester hours.

ENGY350. INTRODUCTION TO GEOTHERMAL ENERGY (II) Geothermal energy resources and their utilization, based on geoscience and engineering perspectives. Geoscience topics include worldwide 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.Prerequisite: ENGY200. 3 hours lecture, 3 semester hours.

ENGY/LAIS490. ENERGY AND SOCIETY (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. Prerequisites: EBGN330; ENGY200; one of the following: ENGY310, ENGY320, or ENGY340; and one additional energy minor course, or consent of instructor. 3 lecture hours, 3 semester hours.

Humanitarian Engineering Minor

Certificate Minor, Minor and Area of Special Interest
DAVID R. MUNOZ, Associate Professor of Engineering and Director

Division of Engineering
JOAN GOSINK, Professor Emerita
NING LU, Professor
KEVIN MOORE, Professor
JOEL M. BACH, Associate Professor
PANOS KIOUSIS, Associate Professor
DAVID R. MUNOZ, Associate Professor
MARCELO SIMOES, Associate Professor
CATHERINE A. SKOKAN, Associate Professor
KATHRYN JOHNSON, Clare Boothe Luce Assistant Professor
JOSEPH P. CROCKER, Teaching Professor
SANAA ABDEL-AZIM, Teaching Associate Professor
CARA COAD, Teaching Associate Professor

Division of Environmental Science and Engineering
LINDA FIGUROA, Associate Professor
JUNKO MUNAKATA-MARR, Associate Professor

Department of Geology and Geological Engineering
JOHN D. HUMPHREY, Associate Professor and Head of Department

Department of Geophysics
ROEL SCHNIEDER, Professor

Department of Mathematics and Computer Sciences
BARBARA MOSKAL, Professor

Department of Metallurgical and Materials Engineering
JEFFREY C. KING, Assistant Professor

Department of Physics
F. EDWARD CECIL, Professor Emeritus

Division of Liberal Arts and International Studies
BARBARA OLDS, Professor Emerita
CARL MITCHAM, Professor
ARTHUR SACKS, Professor
TINA L. GIANQUITTO, Associate Professor
JON LEYDENS, Associate Professor
JUAN C. LUCENA, Associate Professor
JENNIFER SCHNEIDER, Assistant Professor
JAMES D. STRAKER, Assistant Professor
SANDY WOODSON, Teaching Professor

EPICS
ROBERT KNECHT, Teaching Professor
MARTIN SPANN, Teaching Assistant Professor

Staff
DAVID FROSSARD, CCIT Staff
KAY GODEL-GENGENBACH, Director, International Programs
GINNY LEE, CCIT Staff

Programs Offered:

- Certificate Minor in Humanitarian Engineering (27 credit hours)
- Minor in Humanitarian Engineering (18 credit hours)
- Area of Special Interest in Humanitarian Engineering (12 credit hours)
- Minor in Humanitarian Studies (for non-engineering majors) (18 credit hours)
- Area of Special Interest in Humanitarian Studies (12 credit hours)

Program Educational Objectives

The Humanitarian Engineering and Humanitarian Studies Minors (HE & HS) are designed to prepare students to better understand the complexities of and develop a strong appreciation for society, culture, and environment in sustainable humanitarian engineering design projects. Humanitarian engineering projects are intended to provide fundamental needs (food, water, shelter, and clothing), or higher-level needs when these are specifically requested by the local people. The preparatory courses are offered through the Division of Liberal Arts and International Studies (LAIS) with additional technical electives offered by engineering departments across campus. Interested students are encouraged to investigate the many options previously listed and described in more detail below that range from a 12 credit hour area of special interest (ASI) to a 27-credit hour certificate minor in Humanitarian Engineering.

Program Requirements:

1. NATURE AND HUMAN VALUES (GATEWAY COURSE)

This is part of all CSM degree programs but the credit hours are not included as a part of the HE minor. Transfer students must show an equivalent course.

2. HUMANITARIAN ENGINEERING MINOR (TOTAL: 18 credit hours)

Take the Following (HE Core):
LAIS/BELS 320 Ethics (required)

Take two (6 credits) of the Following (HE Core):
LAIS 375 Engineering Cultures
LAIS 402 Writing Proposals for a Better World
LAIS 412 Literature and the Environment
LAIS 475 Engineering Cultures in the Developing World
LAIS477/577 Engineering and Sustainable Community Development (strongly recommended)

Take two (6 credits) from Global Studies track:
LAIS 220 Introduction to Philosophy*
LAIS 221 Introduction to Religion*
LAIS 301 Explorations in Comparative Literature
LAIS 309 Literature and Society*
LAIS 325 Cultural Anthropology*
LAIS 335 International Political Economy of Latin America*
LAIS 337 International Political Economy of Asia
LAIS 339 International Political Economy of the Middle East
LAIS 341 International Political Economy of Africa
EBGN 342 Economic Development
LAIS 345 International Political Economy
LAIS 411 Literatures of the African World

LAIS 412 Literature and the Environment*
LAIS 421 Environmental Philosophy
LAIS 435 Latin American Development
LAIS 436 Hemispheric Integration of the Americas
LAIS 437 Asian Development*
LAIS 439 Mid-East Development*
LAIS 441 African Development
LAIS 442 Natural Resources and War in Africa*
LAIS 444 Social Question in Europe
LAIS 446 Globalization*
LAIS 448 Global Environmental Issues
LAIS 449 Cultural Dynamics of Global Development
LAIS 452 Corruption and Development*
LAIS 453 Ethnic Conflict in the Global Perspective
LAIS 466 War in the Global Perspective
LAIS 485 Constitutional Law and Politics
LAIS 486 Science & Technology Policy*
LAIS 487 Environmental Politics and Policy
LAIS 488 Water Politics and Policy

OR

Foreign Language Courses (6 university level credits)
McBride Courses (6 credits)
Economics and Business Courses form the following :
EBGN 310 Environmental and Resource Economics,
EBGN 321 Engineering Economics,
EBGN 330 Energy Economics

Take one (3 credit hours) from the following Technical Electives:

EGGN 447/547 Timber and Masonry Construction
EGGN 486 Practical Design of Small Renewable Energy Systems
EGGN 490 Sustainable Engineering Design
EGGN 498 Groundwater Mapping
EGGN 536 Understanding Landslides

Any Biomedical Engineering Course

EGGN 325 Introduction to Biomedical Engineering,
EGGN425 Musculoskeletal Biomechanics,
EGGN 427 Prosthetic and Implant Engineering and
EGGN430 Bioinstrumentation
ESGN460 Onsite Water Reclamation and Reuse
ESGN/EGGN353, 354 Fund. Env. Sci. and Engr I and II
EGGN453 Waste Water Engineering
ESGN/EGGN454 Water Supply Engineering

3. CO-CURRICULAR ACTIVITIES

Co-curricular activities associated with the Humanitarian Engineering Program will include public lectures on campus and student clubs such as Engineers without Borders, Earthworks, Blue Key, Rotaract and Circle K.

4. MULTIDISCIPLINARY ENGINEERING LABS (MEL) (3 credit hours)

MEL will be adding labs with HE enhancements.

5. SENIOR DESIGN (6 credit hours)

Senior design projects will preferably include students working directly with the population lacking some basic human need. Ideally, the local people will be involved with the development of the project objectives.

6. INTERNSHIP within and/or COMMUNITY SERVICE

Strongly recommended and not necessarily for credit. The project is secured through McBride (if student is Honors student), EWB, Rotoract, Circle K, Career Center, or some other nonprofit or non-governmental organization (NGO). This project must be discussed with the Director of Humanitarian Engineering prior to its occurrence.

FIVE OPTIONS FOR CSM STUDENTS:

A. Area of Special Interest (ASI) in Humanitarian Studies (12 credit hours): Mainly for students not enrolled in the Engineering Division and/or students not earning ABET accredited engineering degrees. Nine credits must be from the HE core in LAIS, with three more from associated LAIS or EB courses.

B. Minor is Humanitarian Studies (18 credit hours) Mainly for students not enrolled in one of the ABET accredited Engineering programs on campus. Nine credits must be from the HE core in LAIS, with nine more credits from associated LAIS or EB courses.

C. Area of Special Interest (ASI) in Humanitarian Engineering (12 credit hours):
Mainly for students not enrolled in the Engineering Division but from an ABET accredited engineering program on campus wishing to deepen their knowledge in human development issues. Nine credits must be from the HE core in LAIS, with three more from LAIS, EB or associated HE technical elective courses.

D. Minor in Humanitarian Engineering (18 credit hours): For those students enrolled in any CSM engineering degree program. Take 1. and 2. from the list above.

E. Certificate Minor in Humanitarian Engineering (27+ credit hours):
For students enrolled in the Engineering Division or who can incorporate a strong humanitarian component to their senior design project. Will include the minor (D.) plus program requirements 4, 5, and 6 above.

Description of Courses:

EBGN310. ENVIRONMENTAL AND RESOURCE ECONOMICS (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.

EBGN321/CHEN421. ENGINEERING ECONOMICS (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. 3 hours lecture; 3 semester hours.

EBGN330. ENERGY ECONOMICS (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.

EBGN342. ECONOMIC DEVELOPMENT (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.

EGGN325/BELS325. INTRODUCTION TO BIOMEDICAL ENGINEERING (I) The application of engineering principles and techniques to the human body presents many unique challenges. The discipline of Biomedical Engineering has evolved over the past 50 years to address these challenges. Biomedical Engineering is a diverse, seemingly all-encompassing field that includes such areas as biomechanics, biomaterials, bioinstrumentation, medical imaging, rehabilitation. This course is intended to provide an introduction to, and overview of, Biomedical Engineering. At the end of the semester, students should have a working knowledge of the special considerations necessary to apply various engineering principles to the human body. Prerequisites: None.3 hours lecture; 3 semester hours.

EGGN353/ESGN353. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I (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: CHGN124, PHGN100 and MATH213, or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN354/ESGN354. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II (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: CHGN124, PHGN100 and MATH213, or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN425/BELS425. MUSCULOSKELETAL BIOMECHANICS (II) This course is intended to provide engineering students with an introduction to musculoskeletal biomechanics. At the end of the semester, students should have a working knowledge of the special considerations necessary to apply engineering principles 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: DCGN241, EGGN320, EGGN325/BELS325, or instructor permission. 3 hours lecture; 3 semester hours.

EGGN427/BELS427. PROSTHETIC AND IMPLANT ENGINEERING (I) Prosthetics and implants for the musculoskeletal and other systems of the human body are becoming increasingly sophisticated. From simple joint replacements to myoelectric limb replacements and functional electrical stimulation, the engineering opportunities continue to expand. This course builds on musculoskeletal biomechanics and other BELS courses to provide engineering students with an introduction to prosthetics and implants for the musculoskeletal system. At the end of the semester, students should have a working knowledge of the challenges and special considerations necessary to apply engineering principles to augmentation or replacement in the musculoskeletal system. Prerequisites: EGGN/BELS325 or EGGN/BELS525. 3 hours lecture; 3 semester hours.

EGGN430/BELS430. BIOMEDICAL INSTRUMENTATION (I) The acquisition, processing, and interpretation of biological signals present many unique challenges to the Biomedical Engineer. This course is intended to provide students with an introduction to, and appreciation for, many of these challenges. At the end of the semester, students should have a working knowledge of the special considerations necessary to gathering and analyzing biological signal data. EGGN250, DCGN381, EGGN325/BELS325, or instructor permission. 3 hours lecture; 3 semester hours.

EGGN447. TIMBER AND MASONRY DESIGN (II) The course develops the theory and design methods required for the use of timber and masonry as structural materials. The design of walls, beams, columns, beam-columns, shear walls, and structural systems are covered for each material. Gravity, wind, snow, and seismic loads are calculated and utilized for design. Prerequisite: EGGN320 or equivalent. 3 hours lecture: 3 semester hours. Spring semester, odd years.

EGGN453/ESGN453. WASTEWATER ENGINEERING (I) The goal of this course is to familiarize students with the fundamental phenomena involved in wastewater treatment processes (theory) and the engineering approaches used in designing such processes (design). This course will focus on

the physical, chemical and biological processes applied to liquid wastes of municipal origin. Treatment objectives will be discussed as the driving force for wastewater treatment. Prerequisite: EGGN/ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN454/ESGN454. WATER SUPPLY ENGINEERING (I) Water supply availability and quality. Theory and design of conventional potable water treatment unit processes. Design of distribution systems. Also includes regulatory analysis under the Safe Drinking Water Act (SDWA). Prerequisite: EGGN/ESGN353, or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN486. PRACTICAL DESIGN OF SMALL RENEWABLE ENERGY SYSTEMS (Taught on Demand) This course provides the fundamentals to understand and analyze renewable energy powered electric circuits. It covers practical topics related to the design of alternative energy based systems. It is assumed the students will have some basic and broad knowledge of the principles of electrical machines, thermodynamics, electronics, and fundamentals of electric power systems. One of the main objectives of this course is to focus on the interdisciplinary aspects of integration of the alternative sources of energy, including hydropower, wind power, photovoltaic, and energy storage for those systems. Power electronic systems will be discussed and how those electronic systems can be used for stand-alone and grid-connected electrical energy applications. Prerequisite: EGGN382 or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN490 SUSTAINABLE ENGINEERING DESIGN (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 thrugh 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 strongly recommended; 3 hours lecture, 3 semester hours.

EGGN536. HILLSLOPE HYDROLOGY AND STABILITY (I) Introduction of shallow landslide occurrence and socio-economic dynamics. Roles of unsaturated flow and stress in shallow landslides. Slope stability analysis based on unsaturated effective stress conceptualization. Computer modeling of unsaturated flow and stress distributions in hillslope. Prediction of precipitation induced shallow landslides. Prerequisite: EGGN461. 3 hours lecture; 3 semester hours.

ESGN460. ONSITE WATER RECLAMATION AND REUSE. 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: ESGN/EGGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

LAIS220. INTRODUCTION TO PHILOSOPHY 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 corequisite: SYGN200. 3 hours lecture; 3 credit hours.

LAIS221. INTRODUCTION TO RELIGIONS This course has two focuses. We will look at selected religions emphasizing their popular, institutional, and contemplative forms; these will be four or five of the most common religions: Hinduism, Buddhism, Judaism, Christianity, and/or Islam. The second point of the course focuses on how the Humanities and Social Sciences work.We will use methods from various disciplines to study religion-history of religions and religious thought, sociology, anthropology and ethnography, art history, study of myth, philosophy, analysis of religious texts and artifacts (both contemporary and historical), analysis of material culture and the role it plays in religion, and other disciplines and methodologies. We will look at the question of objectivity; is it possible to be objective? We will approach this methodological question using the concept "standpoint." For selected readings, films, and your own writings, we will analyze what the "standpoint" is. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LAIS309. LITERATURE AND SOCIETY Before the emergence of sociology as a distinct field of study, literary artists had long been investigating the seemingly infinite complexity of human societies, seeking to comprehend the forces shaping collective identities, socio-cultural transformations, technological innovations, and political conflicts. Designed

to enrich recognition and understanding of the complex interplay of artistic creativity and social inquiry over time, this course compares influential literary and social-scientific responses to the Enlightenment, the Industrial Revolution, and other dynamic junctures integral to the forging of "modernity" and the volatile world we inhabit today. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours lecture; 3 semester hours.

LAIS320/BELS320. ETHICS 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 corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LAIS325. CULTURAL ANTHROPOLOGY A study of the social behavior and cultural development of humans. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LAIS335. INTERNATIONAL POLITICAL ECONOMY OF LATIN AMERICA 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 corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LAIS337. INTERNATIONAL POLITICAL ECONOMY OF ASIA 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 corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LAIS339. INTERNATIONAL POLITICAL ECONOMY OF THE MIDDLE EAST 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 corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LAIS341. INTERNATIONAL POLITICAL ECONOMY OF AFRICA 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 corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LAIS345. INTERNATIONAL POLITICAL ECONOMY 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 o the regional level, and between region-states and region-markets on the global level. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LAIS375. ENGINEERING CULTURES 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 present-day Russia, Europe, Southeast Asia, and Latin America. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LAIS402.WRITING PROPOSALS FOR A BETTER-WORLD This course develops the student's writing and higher-order thinking skills and helps meet the needs of underserved populations, particularly via funding proposals written for nonprofit organizations. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS411. MODERN AFRICAN LITERATURE This course examines African writers' depictions of varied material and symbolic transformations wrought by twentieth-century colonialism and decolonization, and their differential impacts upon individual lives and collective histories around the continent. Fiction and poetry representing Anglophone, Francophone, Arabic, and indigenous language traditions will constitute the bulk of the reading. Alongside their intrinsic artistic values, these texts illuminate religious, ritual, and popular cultural practices massively important to social groups in countries ranging from Nigeria, Guinea, Sierra Leone, Liberia, and Ivory Coast to Sudan, Uganda, Rwanda, and Zimbabwe. Primary soci-historical themes will include generational consciousness, ethnicity, gender relations, the dramatic grown of cities, and forms of collective violence stirred by actions and inactions of colonial and postcolonial governments. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS412. LITERATURE AND THE ENVIRONMENT 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. Read-

ings include texts that celebrate the natural world, those that indict the careless use of land and resources, and those that predict and depict the consequensces of that carelessness. Additionally, we investigate philosophical, legal, and policy frameworks that shape approaches to environmental issues. Prerequesite: LAIS100. Prerequisite or corequisite SYGN200. 3 hours lecture, 3 semester hours.

LAIS421 ENVIRONMENTAL PHILOSOPHY A critical examination of environmental ethics and the philosophical theories on which they depend. Topics may include preservation/conservation, animal welfare, deep ecology, the land ethic, eco-feminism, environmental justice, sustainability, or non-western approaches. This class may also include analyses of select, contemporary environmental issues. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS435/LAIS535. LATIN AMERICAN DEVELOPMENT A senior 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 corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS436/LAIS536. HEMISPHERIC INTEGRATION IN THE AMERICAS This international political economy seminar is designed to accompany the endeavor now under way in the Americas to create a free trade area for the entire Western Hemisphere. Integrating this hemisphere, however, is not just restricted to the mechanics of facilitating trade but also engages a host of other economic, political, social, cultural, and environmental issues, which will also be treated in this course. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS437/LAIS537. ASIAN DEVELOPMENT 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 corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS439. MIDDLE EAST DEVELOPMENT This international political economy seminar analyzes economic, political and social dynamics that affect the progress and direction of states, markets, and peoples of the region. It examines the development of the Middle East from agrarian to post-industrial societies; economic, political and cultural transformations since World War II; contemporary security issues that both divide and unite the region; and the effects of globalization processes on economies and societies in the Middle East. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS441. AFRICAN DEVELOPMENT This course provides a broad overview of the political economy of Africa. Its goal is to give students an understanding of the possibilities of African development and the impediments that currently block its economic growth. Despite substantial natural resources, mineral reserves, and human capital, most African countries remain mired in poverty. The struggles that have arisen on the continent have fostered thinking about the curse of natural resources where countries with oil or diamonds are beset with political instability and warfare. Readings give first an introduction to the continent followed by a focus on the specific issues that confront African development today. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester.

LAIS442. NATURAL RESOURCES AND WAR IN AFRICA 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 corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS444. THE SOCIAL QUESTION IN EUROPE Between 1850 and 1960 the "proletariat" - the industrial working class - threatened the stability of bourgeois Europe. What were their grievances, and how were they resolved? Similarly, today large, unassimilated immigrant populations pose growing challenges to European societies. What are the main tensions, and how might they be addressed? Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS446/LAIS546. GLOBALIZATION 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 corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS448. GLOBAL ENVIRONMENTAL ISSUES Critical examination of interactions between development and the environment and the human dimensions of global change; social, political, economic, and cultural responses to the man-

agement and preservation of natural resources and ecosystems on a global scale. Exploration of the meaning and implications of "Stewardship of the Earth" and "Sustainable Development." Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS449. CULTURAL DYNAMICS OF GLOBAL DEVELOPMENT Role of cultures and nuances in world development; cultural relationship between the developed North and the developing South, specifically between the U.S. and the Third World. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS452/LAIS552. CORRUPTION AND DEVELOPMENT This course addresses the problem of corruption and its impact on development. Readings are multidisciplinary 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. Prereqisite: LAIS100. Prerequeiste or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS453. ETHNIC CONFLICT IN GLOBAL PERSPECTIVE Many scholars used to believe that with modernization, racial, religious, and cultural antagonisms would weaken as individuals developed more rational outlooks and gave primacy to their economic concerns. Yet, with the waning of global ideological conflict of the left-right nature, conflict based on cultural and "civilization" differences have come to the fore in both developing and developed countries. This course will examine ethnic conflict, broadly conceived, in a variety of contexts. Case studies will include the civil war in Yugoslavia, the LA riots, the antagonism between the Chinese and "indigenous' groups in Southeast, the so-called war between the West and Islam, and ethnic relations in the U.S. We will consider ethnic contention in both institutionalized, political processes, such as the politics of affirmative action, as well as in non-institutionalized, extra-legal settings, such as ethnic riots, pogroms, and genocide. We will end by asking what can be done to mitigate ethnic conflict and what might be the future of ethnic group identification. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar. 3 semester hours.

LAIS466. WAR IN GLOBAL PERSPECTIVE This course examines selected military conflicts from the Greeks and the Romans to recent wars in Kosovo, Afghanistan, and Iraq, with considerable attention given to the two world wars. The course is not battles-oriented; rather, using an historical lens, it focuses on the causes that lie behind the battles themselves. Prerequisite: LAIS100. Prerequisite or co-requisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS475. ENGINEERING CULTURES IN THE DEVELOPING WORLD 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 corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS477/577. ENGINEERING AND SUSTAINABLE COMMUNITY DEVELOPMENT An introduction to the relationship between engineering and sustainable community development (SCD) from historical, political, ethical, cultural, and practical perspectives. Students will study and analyze different dimensions of sustainability, community, and "helping," and the role that engineering might play in each. Will include critical explorations of strengths and limitations of dominant methods in engineering problem solving, design and research for working in SCD. Through case-studies, students will learn to analyze and evaluate projects in SCD and develop criteria for their evaluation. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS485. CONSTITUTIONAL LAW AND POLITICS 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 corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS486/LAIS586. SCIENCE AND TECHNOLOGY POLICY 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 corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS487/LAIS587. ENVIRONMENTAL POLITICS AND POLICY 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 corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LAIS488/LAIS588. WATER POLITICS AND POLICY 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. Prerequisite: LAIS100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

Materials Science

(Interdisciplinary Program)

This graduate interdisciplinary Materials Science Program is administered jointly by the Departments of Chemical Engineering, Chemistry and Geochemistry, Metallurgical and Materials Engineering, Engineering Physics and the Division of Engineering. Each department is represented on both the Governing Board and the Graduate Affairs Committee which are responsible for the operation of the program.

Consult the Graduate Bulletin for details on the program and course listings.

Guy T. McBride, Jr. Honors Program in Public Affairs

(Interdisciplinary Program)

DR. KENNETH A. OSGOOD, Program Director and Associate Professor of Liberal Arts & International Studies

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 science and technology. Students will gain the knowledge, skills, and values to anticipate, analyze, and evaluate the social, cultural, ethical, and environmental implications of their future professional judgments and activities, and as responsible citizens in global, national, and local contexts. The seminars are designed to offer coherent perspectives across the curriculum, allowing for a maximum degree of discussion and debate on complex topics. Themes, approaches and perspectives from the humanities and the social sciences are integrated with science and engineering perspectives to develop in students habits of thought necessary for a comprehensive understanding of societal and cultural issues that enhance critical thinking, social responsibility, and enlightened leadership.

Program Description

The McBride Honors Program is administered by the Division of Liberal Arts and International Studies.

As of fall 2011, the new 21 credit hour curriculum of the McBride Honors Program in Public Affairs has been modified for all students admitted as freshmen in spring 2011 and starting the Program as sophomores in the fall term.

McBride students who began the Program prior to fall 2011 will continue with the 24-credit hour curriculum that is designated separately below.

The Program is delivered primarily in an interdisciplinary seminar format, with the intent of providing a coherent, interconnected curriculum which maximizes discussion and debate and student engagement. Seminars are designed and taught by teams of faculty members from the humanities, social sciences, life sciences and physical sciences, and engineering. The curriculum of the McBride Honors Program includes the following features and educational experiences:

- Student-centered seminars guided by faculty moderators from various disciplines.
- An interdisciplinary approach that integrates domestic and global perspectives into the curriculum.
- One-to-one long-lasting intellectual relationships and camaraderie among students and between faculty and students.
- The Development and practice of oral/written communication, argumentation, and listening skills.
- The opportunity to travel to Washington, DC and /or countries abroad as part of the McBride curriculum.
- The opportunity to engage in a public affairs or policy related internship

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), which usually comes during the summer following the junior year. Because engineers and scientists will continue to assume significant responsibilities as leaders in public and private sectors, it is essential that CSM students be prepared for more than their traditional first jobs. Leadership and management demand an understanding of the accelerating pace of change that marks the social, political, economic, and environmental currents of society and a commitment to social and environmental responsibility. Regardless of their career goals, however, this same understanding is demanded of an educated person in the contemporary world. While the seminars in the Program are designed to nourish such an understanding, these Practicum experiences allow students to see firsthand the kinds of challenges that they will face in their professional and personal lives.

Foreign study is also possible either through CSM-sponsored trips or through individual plans arranged in consultation with the Director and CSM's Office of International Programs. The cost for any foreign study is the responsibility of the student.

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 public affairs and public policy, 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 through an essay and an interview with faculty members.

Once admitted into the Program, a McBride student commits to:

- completing the McBride curriculum as stated in the Bulletin, deviating from this course of study only with permission from the Program Administration;
- 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 of the world and the Earth;
- accepting and behaving according to the rules established for the Washington Policy and/or international study trips to ensure the safety of peers, maximize the educational experience of the group, and maintain CSM's high reputation;
- understanding that the McBride faculty are committed to provide the best education to help students become thoughtful and responsible persons, citizens, and professionals; and
- upholding the highest standards of ethical conduct and the CSM Honor Code, particularly those related to academic honesty and respect for peers, instructors, and Program administrators.

Although the educational experiences in the McBride Honors Program are rigorous and demand a high degree of dedication from the students, McBride graduates have gained positions of their choice in industry, business, government, and within non-governmental organizations, or in other professions more easily than others, and have been successful in winning admission to high-quality graduate, law, medicine and other professional schools.

Admission

Interested students who will begin the Program in the fall of their sophomore year should apply to the McBride Program by the deadline set by the Program, by filling out an application, submitting an essay, and securing a letter of recommendation (see website for details: http://mcbride.mines.edu/). Applicants will be interviewed by a team of Honors faculty and students. Once a finalist accepts the responsibilities of being a member of the Program (see above), s/he begins taking Honors courses as prescribed by the Program.

Note: Students must complete LAIS100 Nature and Human Values prior to enrolling in the first course, HNRS200 Public Affairs: Global Responsibility & Sustainability.

H & SS Core Curriculum Requirements

Students completing the McBride Honors Program are required to complete LAIS100, "Nature and Human Values," and EBGN201, "Principles of Economics." McBride students are exempt from completing SYGN200, "Human Systems."

Transfer and Graduation Policies

The McBride Program accepts applications from transfer students as follows:

Transfer students must complete and submit an application and participate in the interview process with all other applicants under the timeframe set by the Program. All transfer students should expect to take the entire McBride curriculum in residence. Only under very special circumstances will the Director consider a petition by a transfer student 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 upon admission.. Students who meet this GPA requirement will be formally admitted to the Program and allowed to enroll in the first McBride course at the appropriate time. 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 will be withdrawn from the Program.
- If a student's CSM *semester GPA* falls below the required minimum, the student will receive a formal letter from the Director noting that his or her semester GPA does not meet McBride standards. The student will be strongly encouraged to meet with the Director to review strategies for academic success.

- 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. Those students will receive a formal letter from the Director informing them that they are on academic probation and are required to meet with the Director. Students must meet with the Director or another faculty member regularly through the semester of academic probation. . If the required minimum GPA has not been met at the end of the probationary semester, or in any subsequent semester, the student will be withdrawn from the Program.
- The minimum *cumulative GPA* and the minimum *Honors GPA* at the time of graduation are required in order to receive the "Minor in the McBride Honors Program in Public Affairs." Graduating seniors who fall below these minima will receive a "Minor in Public Affairs" without the Honors designation if they choose to complete the Public Affairs minor instead of transferring their credits to the Division of Liberal Arts and International Studies.
- If students wish to appeal their withdrawal from the McBride Honors Program, they must write a letter of appeal to the Director, who will review the student's case and consult with McBride faculty colleagues.

Curriculum

The Curriculum Effective for Students Beginning Fall 2011

Curriculum Effective Fall 2011

Sophomore Year

HNRS200	Public Affairs: Global Responsibility & Sustainability (Fall)
HNRS210	Comparative Ethics & Politics (Spring)

Junior Year

HNRS300	U.S. Public Policy Analysis (Fall)
HNRS310	International Science & Technology Policy (Spring)

Senior Year

HNRS400	Field Research (Summer) [Students who do not register for HNRS400 but under take other work in summer must complete HNRS405 in semester eight, in addition to HNRS410]
HNRS405	McBride Practicum (Fall)
HNRS410	Leadership & Power (Fall)
HNRS420	Synthesis Seminar (Spring)
Total:	21 credit hours

The Curriculum Effective for Students Who Began 2010 or Earlier

Curriculum Effective Fall 2010 & Earlier

Freshman Year

HNRS101	Paradoxes of the Human Condition (Spring)

Sophomore Year

HNRS201	Cultural Anthropology: A Study of Diverse Cultures (Fall)
HNRS202	Comparative Political & Economic Systems (Spring)

Junior Year

HNRS301	International Political Economy (Fall)
HNRS302	Technology & Socio-Economic Change (Fall)
HNRS311	U.S. Public Policy: Domestic & Foreign (Spring)
HNRS312	Foreign Area Study (Spring)

Senior Year

HNRS402	McBride Practicum (Summer)
HNRS401	McBride Practicum: Internship (Fall)
HNRS411	Study of Leadership & Power (Fall
HNRS412	Conflict Resolution (Fall)
HNRS420	Science, Technology & Ethics (Spring)
Total:	24 credit hours

Description of Courses

For Students Starting the Program in Fall 2011

HNRS200. PUBLIC AFFAIRS: GLOBAL RESPONSIBILITY AND SUSTAINABILITY (I) An introduction to issues and cultural problems and the “public affairs” and “public policy” circumstances faces by scientists, engineers, and economists as they confront issues of global responsibility and sustainability in their professional and personal lives. The seminar focuses on culture and its core role in relationships among science, engineering, technology and the environment as interactive systems. Prerequisites: Admission to McBride Honors Program and completion of LAIS100. 3 hours seminar; 3 semester hours.

HNRS210. COMPARATIVE ETHICS AND POLITICS (II) Ethics and politics interact and diverge in subtle and overt ways. This seminar will introduce students to major schools of thought and important thinkers from a variety of time periods and perspectives. Upon completion, students will be able to articulate and critically evaluate a selection of major ethical and political systems, and understand how these systems have impacted the trajectory and growth in the physical and applied sciences, particularly with regard to issues related to global responsibility and sustainability. Prerequisite: HNRS200. 3 hours seminar; 3 semester hours.

HNRS300. U.S. PUBLIC POLICY ANALYSIS (I) This seminar offers a microeconomic approach that explores rationales for public policy and develops tools for policy analysis especially in terms of the U.S. with attention to science and technology policies which are especially relevant to issues of global responsibility and sustainability. It includes perspectives from social sciences other than economics. Prerequisites: EBGN201, HNRS200, and HNRS210. 3 hours seminar, 3 semester hours.

HNRS310. INTERNATIONAL SCIENCE & TECHNOLOGY POLICY (II) This course builds on HNRS300 by bringing a global perspective to policy-making and policies that relate to science and technology especially with relevance to global responsibility and sustainability. The student will learn about the international organizations that affect science and technology worldwide and compare the politics of science, engineering, and economics in one or more countries with those in the United States. Those who travel abroad for their summer Field Research will go to one of the countries evaluated in this class; those who travel to Washington, D.C. will investigate further the domestic perspectives examined in this course. Prerequisite: HNRS300. 3 hours seminar, 3 semester hours.

HNRS400. FIELD RESEARCH (S) An extended period, typically of three weeks duration, in a field location (either in the United States or abroad or in both settings) visiting and analyzing the work and policies of government agencies, international organizations, and non-governmental agencies in relation to central themes of focus in the McBride Program. This seminar builds upon the background and study undertaken in HNRS310. Prerequisite: HNRS310. 3 semester hours.

HNRS405 MCBRIDE PRACTICUM (I) Individualized study under special circumstances and with approval of the Program, a McBride student may enroll in an individualized study of project which substitutes for or enhances the regularly-scheduled McBride curriculum seminars. This option – for 3 semester credits – may be used in lieu of HNRS400 in conjunction with an approved study abroad, summer internship, or a research experience for undergraduates (REU) to develop and prepare a faculty-guided major research paper in the following semester that integrates the experience with the goals, objectives, and focus of the Honors Program in Public Affairs. Credit will not be granted for both HNRS 400 and HNRS 405. Prerequisite: HNRS310: International Science & Technology Policy.

HNRS410. LEADERSHIP AND POWER (II) This seminar builds on summer field study and the other McBride seminars by examining leadership and its relation to power. It explores the potential leadership roles of applied scientists, engineers, and economists in their professional lives as well as in their other roles as members of various communities contributing to global responsibility and sustainability. Students will gain knowledge and understanding about the subject of the seminar and enhance their skills in leadership, communication, conflict management, and examine a theoretical range of approaches and real world case studies to the same. Prerequisite: HNRS310. 3 hours seminar, 3 semester hours.

HNRS420. SYNTHESIS SEMINAR As the culmination of the Program, this seminar will build upon the previous required seminars and will examine in detail one or more themes related to applied science, engineering, and global responsibility, and sustainability for more in-depth analysis and critical reflection. The particular theme or themes will be influenced by student experience and learning in the previous semesters and the prominence of relevant issues in public affairs. The aim will be to engage participants; in the most current scholarship related to these themes, leading to a scholarly deliverable in the form of a conference presentation or publication. Prerequisite: HNRS410. 3 hours seminar; 3 semester hours.

Description of Courses

For Students Who Began in Fall 2010 or Earlier

HNRS101. PARADOXES OF THE HUMAN CONDITION Study of the paradoxes of the human condition as expressed in significant texts, classics, literature, moral philosophy, and history; drama and music, both classical and contemporary, biography, and fiction. Prerequisite: Freshman status in the McBride Honors Program, 3 hours seminar, 3 semester hours.

HNRS201. CULTURAL ANTHROPOLOGY: A STUDY OF DIVERSE CULTURES A study of cultures within the United States and abroad and the behavior of people. The seminar will emphasize the roles of languages, religions, moral values, and legal and economic systems in the cultures selected for inquiry. Prerequisite: HNRS101 or consent of the Program Director. 3 hours seminar; 3 semester hours.

HNRS202. COMPARATIVE POLITICAL AND ECONOMIC SYSTEMS This course constitutes a comparative study of the interrelationships between political and economic systems in theory and practice. Totalitarianism, authoritarianism, democracy, anarchy, socialism, and communism will be examined in their historical and theoretical contexts and compared with baseline concepts of what constitutes a political system. Economics will be studied from a historical/developmental approach, examining classical and neo-classical economics and theories of major western economists, including Smith, Marx, and Keynes. Specific nation or area case studies will be used to integrate concepts and to explore possible new global conditions which define the roles of governments and other institutions in the development, planning, and control of economic activities and social policy. Prerequisite: HNRS201 or permission of the Program Director. 3 hours seminar; 3 semester hours.

HNRS301. INTERNATIONAL POLITICAL ECONOMY International political economy is the study of the dynamic relationships between nation-states and the global marketplace. Topics include: international and world politics, money and international finance, international trade, multinational and global corporations, global development, transition economies and societies, and developing economies and societies. Prerequisite: HNRS202 or permission of Program Director. 3 hours seminar; 3 semester hours.

HNRS302. TECHNOLOGY AND SOCIO-ECONOMIC CHANGE A critical analysis of the interactions among science, technology, and American values and institutions. The seminar will study the role of technology in American society and will debate the implications of technology transfer from developed to developing nations. Students will learn to relate technological issues to socio-economic and religious aspects of society and explore the moral and social consequences of technological innovations. Prerequisite: HNRS202 or permission of the Program Director. 3 hours seminar; 3 semester hours.

HNRS311. U.S. PUBLIC POLICY: DOMESTIC AND FOREIGN Detailed examination of United States public policy, using a case study approach to guide students to understand the various aspects of policy making and the participants in the process. As an outcome of this seminar, students will have the ability to engage in informed, critical analysis of public policy, and will understand the process and how they may become involved in it. Students should expect to spend spring break in Washington, D.C., as part of this seminar. Prerequisite: HNRS301 or HNRS302 or permission of the Program Director. 3 hours seminar; 3 semester hours.

HNRS312 FOREIGN AREA STUDY A survey of current public policy issues of a selected country or region, based on a broad survey of history and culture as well as contemporary social, technological, economic and political trends. The areas that might be studied in a three year rotation; Far East (China and Taiwan or Hong Kong, Indonesia and/or Malaysia), Latin America (Brazil or Chile), Middle East/Africa (Turkey or South Africa). Students taking this seminar in preparation for a McBride sponsored trip abroad might be able to take a brief intensive language course before departure. Prerequisite: HNRS301 or HNRS302 or permission of the Program Director. 3 hours seminar; 3 semester hours.

HNRS398. SPECIAL TOPICS IN THE MCBRIDE HONORS PROGRAM IN PUBLIC AFFAIRS FOR ENGINEERS 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.

HNRS401. MCBRIDE PRACTICUM: INTERNSHIP An off-campus practicum which may include an internship in a company, government agency, or public service organization (domestic or foreign), or foreign study as a part of a McBride group or individually. The practicum must have prior approval of the Program Director. All students completing a practicum are expected to keep an extensive journal and write a professional report detailing, analyzing, and evaluating their experiences. Prerequisite: HNRS311. 3 hours seminar; 3 semester hours.

HNRS402. MCBRIDE PRACTICUM: FOREIGN AREA STUDY FIELD TRIP After completing the HNRS312 Foreign Area Study seminar, students travel to the selected country or region. Students will gain first hand experience interacting and communicating with people from another culture. Students will complete a written research and analysis report using historic cultural, technological, political, or an economic theme. Prerequisite: HNRS312 or permission of the Program Director. 3 hours seminar, 3 semester hours.

HNRS411. STUDY OF LEADERSHIP AND POWER An intellectual examination into the nature of leadership and power. Focuses on understanding and interpreting the leadership role, both its potential and its limitations, in various historical, literary, political, socio-economic, and cultural contexts. Exemplary leaders and their antitypes are analyzed. Characteristics of leaders are related to their cultural and temporal context. This course will ask questions regarding the morality of power and its uses. Leadership in technical and non-technical environments will be compared and contrasted. Additionally, power and empowerment, and the complications of becoming or of confronting a leader are scrutinized. Prerequisite: HNRS311 or HNRS312 or permission of the Program Director. 3 hours seminar; 3 semester hours.

HNRS412. CONFLICT RESOLUTION An in-depth look at creative, non-violent, non-litigious, win-win ways to handle conflicts in personal, business, environmental and governmental settings. The class will learn concepts, theories and methods of conflict resolution, study past and present cases, and observe on-going conflict resolution efforts in the Denver area. Prerequisite: HNRS311 or HNRS312 or permission of the Program Director. 3 hour seminar. 3 semester hours.

HNRS420. SCIENCE, TECHNOLOGY, AND ETHICS A comprehensive inquiry into ethical and moral issues raised by modern science and technology. Issues covered include: the contention that science is value neutral; the particular sorts of ethical problems faced by engineers in their public and political roles in deciding uses of materials and energy; the personal problems faced in the development of a career in science and technology; the moral dilemmas inherent in using natural forms and energies for human purposes; and the technologically dominated modern civilization. The seminar will consist of readings and discussion of ethical issues in plays, works of fiction, and films. Prerequisite: HNRS411 or HNRS412 or permission of the Program Director. 3 hours seminar; 3 semester hours.

HNRS498. SPECIAL TOPICS IN THE MCBRIDE HONORS PROGRAM IN PUBLIC AFFAIRS 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 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.

Military Science

(Army ROTC-AROTC)

The Department of Military Science offers programs leading to an officer's commission in the active Army, Army Reserve, or National Guard in conjunction with an undergraduate or graduate degree. Military science courses are designed to supplement a regular degree program by offering practical leadership and management experience. The Military Science Program at the Colorado School of Mines (CSM) is offered in conjunction with the University of Colorado at Boulder (CU-B). Students attend classes at the Colorado School of Mines in Golden.

Four-Year Program

The four-year program consists of two phases: the basic course (freshman and sophomore years) and the advanced course (junior and senior years).

Basic course

The basic course offers a 2- or 3-credit course each semester, covering Army history and organization as well as military leadership and management. Laboratory sessions provide the opportunity to apply leadership skills while learning basic military skills. Enrollment in the basic course incurs no military obligation except for Army scholarship recipients.

Advanced course

The advanced course covers leadership, tactics and unit operations, training techniques, military law, and professional ethics, and includes a leadership practicum each semester. A 33-day summer advanced camp at Fort Lewis, Washington, provides challenging leadership training and is a prerequisite for commissioning. Advanced course students must have completed the basic course and obtain permission from the Professor of Military Science (PMS).

Two-Year Program

The two-year program consists of the advanced course, preceded by attending the Leaders Training course (a four-week summer ROTC basic course at Ft. Knox, Kentucky). Veterans, or Active Army Reserve/Army National Guard Soldiers, or students who have participated in three years of Junior ROTC or Civil Air Patrol, may be eligible to enroll in the advanced course without attendance at basic camp or completion of the basic course. Advanced course students must obtain permission from the Professor of Military Science (PMS) at 303-492-6495.

Scholarship Programs

Four-year college scholarships are available to high school seniors, who apply before December 1 of their senior year. Competition for two- and three- year scholarships is open to all university students, regardless of academic major and whether or not they are currently enrolled in ROTC. Scholarship students receive full tuition and mandatory labo-

ratory fees, a book allowance, and an allowance of $300-$500 per month during the academic year. Students interested in the scholarship program should contact the AROTC Enrollment and Scholarship Officer at 303-492-3549 no later than the beginning of the spring semester to apply for the following academic year.

Simultaneous Membership Program

Students currently in the Army Reserves or Army National Guard and entering either the second year of the basic course or the advanced course may participate in the Simultaneous Membership Program (SMP). Students participating in this program will receive $450 to $500 monthly stipend plus their unit pay at the E-5 grade. SMP participants may be eligible for Army Reserve or Army National Guard tuition assistance benefits.

Leadership Laboratories

Leadership labs provide cadets with practical leadership experience and performance-oriented, hands-on instruction outside the classroom.. Diagnostic evaluations of cadets in leadership roles are frequently administered. Leadership labs are compulsory for enrolled cadets. Physical training is conducted three times a week with the purpose of developing muscular strength, endurance, and cardio-respiratory endurance.

Veterans

Veterans who have served on active duty or in the Army Reserve/National Guard are also eligible for the ROTC program. Although veterans are not required to take the Basic Course, they are encouraged to do so. A minimum of 60 credit hours are required prior to enrolling in the Advanced Course.

Registration and Credits

Army ROTC serves as elective credit in most departments. Elective course credit toward your degree for AROTC classes will be determined by your individual academic advisor. Students who wish to register for Army ROTC classes do so through the normal course registration process at CSM. AROTC classes begin with the MSGN prefix.

For more information about AROTC, contact the Army ROTC Enrollment and Scholarship Officer at 303-492-3549 or 303-492-6495, or the department on campus directly at 303-273-3380. The department is located in the Military Science building, 1232 West Campus Road. You can also go to http://www.colorado.edu/AROTC. For information about ROTC at CSM, call 303-273-3398 or 303-273-3380.

Military Science Minor

Army ROTC cadets desiring to receive a minor in Military Science must complete at least 18 hours of Military Science courses as follows:

1. At least two courses from the following (4 hours):

   MSGN103. ADVENTURES IN LEADERSHIP I
   MSGN104. ADVENTURES IN LEADERSHIP II
   MSGN198. SPECIAL TOPICS IN MILITARY SCIENCE
   MSGN199. INDEPENDENT STUDY
   MSGN203. MSGN203. METHODS OF LEADERSHIP AND MANAGEMENT I
   MSGN204. METHODS OF LEADERSHIP AND MANAGEMENT II
   MSGN298. SPECIAL TOPICS IN MILITARY SCIENCE (I, II)
   MSGN299. INDEPENDENT STUDY (I, II)

2. All fourteen hours contained in the following courses:

   MSGN301. MSGN301. MILITARY OPERATIONS AND TRAINING I (I)
   MSGN302. MILITARY OPERATIONS AND TRAINING II (II)
   MSGN303. LEADERSHIP LABORATORY (I)
   MSGN304. LEADERSHIP LABORATORY (II)
   MSGN401. OFFICER LEADERSHIP AND DEVELOPMENT I (I)
   MSGN402. OFFICER LEADERSHIP AND DEVELOPMENT II (II)
   MSGN403. LEADERSHIP LABORATORY (I)
   MSGN404. LEADERSHIP LABORATORY (II)

Description of Courses

Freshman Year

*Indicates courses that may be used to satisfy PAGN semester requirements.

*MSGN103. ADVENTURES IN LEADERSHIP I (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, team-building 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 (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 (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: Consent of instructor. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MSGN199. INDEPENDENT STUDY (I, II). Individual research or special problem projects supervised by a faculty member. Student and instructor will agree on subject matter, content, and credit hours. Prerequisite: Consent of instructor. "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Sophomore Year

*MSGN203. MSGN203. METHODS OF LEADERSHIP AND MANAGEMENT I (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 (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 (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: Consent of instructor. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MSGN299. INDEPENDENT STUDY (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: Consent of instructor. "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Junior Year

MSGN301. MSGN301. MILITARY OPERATIONS AND TRAINING I (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 (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 (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 (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)

LEADERSHIP DEVELOPMENT AND ASSESSMENT COURSE (LDAC) (Fort Lewis, WA) A 34 day LDAC is required for completion of the AROTC program. LDAC should be attended between the junior and senior year. The emphasis at LDAC is placed on the development of individual leadership initiative and self-confidence. Students are rated on their performance in various positions of leadership during the LDAC period. The U.S. Army reimburses students for travel to and from LDAC. In addition, students receive approximately $600.00 pay while attending LDAC. Prerequisite: Enrollment in the AROTC LDAC and completion of MSGN301 through 304.

MSGN398. SPECIAL TOPICS IN MILITARY SCIENCE (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: Consent of instructor. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MSGN399. INDEPENDENT STUDY (I, II). Individual research or special problem projects supervised by a faculty member. Student and instructor will agree on subject matter, content, and credit hours. Prerequisite: Consent of instructor. "Independent Study" form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

Senior Year

MSGN401. OFFICER LEADERSHIP AND DEVELOPMENT I (I) Examines management and leadership concepts and techniques associated with planning and executing military training and operations at company and higher echelons. Includes analyses of professional ethics and values, effective training principles and procedures, subordinate counseling, and effective staff officer briefing techniques. Also investigates other subjects such as counter terrorism, modern peacekeeping missions, and the impact of the information revolution on the art of land warfare. Conducted both in and out of classroom setting and with multiple practical leadership opportunities to organize cadet training and activities. Prerequisite: Consent of the Professor of Military Science. Lab Fee. 3 hours lecture; 3 semester hours. (Fall)

MSGN402. OFFICER LEADERSHIP AND DEVELOPMENT II (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 (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 (II) Continued leadership development by serving in the command and staff positions in the Cadet Battalion. Cadets take a large role in determining the goals and direction of the cadet organization, under supervision of the cadre. Cadets are required to plan and organize cadet outings and much of the training of underclassmen. Lab Fee. Prerequisite: Consent of department. Lab Fee. 2 hours lab, 3 hours PT, and 80 hours field training; .5 semester hour. (Spring)

MSGN497. SPECIAL STUDIES IN LEADERSHIPAND SMALL GROUP DYNAMICS I (I) The course is specifically geared to the unique leadership challenges faced by individuals involved in CSM student government and other campus leadership positions. Instruction emphasis is on forces and dynamics which shape and define leader/manager's job in the campus environment. Prerequisite: Currently appointed or elected leader of a recognized student organization or consent of the department head. 1 hour lecture and 5 hours lab; 3 semester hours.

MSGN498. SPECIAL TOPICS IN MILITARY SCIENCE (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: Consent of instructor. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

MSGN499. INDEPENDENT STUDY (I, II). Individual research or special problem projects supervised by a faculty member. Student and instructor will agree on subject matter, content, and credit hours. Prerequisite: Consent of instructor. "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 (CU-B).

Four-Year Program

The four-year program consists of two phases: the general military course (freshman and sophomore years) and the professional officer course (junior and senior years). This program is designed for incoming freshmen or any student with four years remaining until degree completion. It consists of three parts: the General Military Course (GMC) for lower division (normally freshmen and sophomore) students;

the Professional Officer Course (POC) for upper division students (normally juniors and seniors); and Leadership Laboratory (LLAB-attended by all cadets). Completion of a four-week summer training course is required prior to commissioning.

Leadership Lab

All AFROTC cadets must attend Leadership Lab (2 hours per week). The laboratory involves a study of Air Force customs and courtesies, drill and ceremonies, career opportunities, and the life and work of an Air Force officer.

General Military Course (GMC)

The basic course covers Air Force history and organization as well as military leadership and management. Laboratory sessions provide the opportunity to apply leadership skills while learning basic military skills. Enrollment in the basic course incurs no military obligation except for Air Force scholarship recipients.

Professional Officer Course (POC)

The advanced course covers military officership, leadership and unit operations, training techniques, military law, and professional ethics, and includes a leadership practicum each semester. A Field Training encampment provides challenging leadership training and is a prerequisite for commissioning. Advanced course students must have completed the basic course and obtain permission from the Professor of Aerospace Studies (PAS) to enroll in the POC.

Three-Year Program

The three-year program consists of the first two years of GMC courses taken concurrently in one year. The student then attends a Field Training encampment, and completes two years of advanced POC courses.

Scholarship Programs

Four-year college scholarships are available to high school seniors, who apply before December 1 of their senior year. Competition for two- and three- year scholarships is open to all university students, regardless of academic major and whether or not they are currently enrolled in ROTC. Scholarship students receive tuition assistance and mandatory laboratory fees, a book allowance, and a monthly stipend. Students interested in the scholarship program should contact the AFROTC Unit Admissions Officer at www.afrotc.colorado.edu 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.

Registration and Credits

Air Force ROTC serves as elective credit in most departments. Elective course credit toward your degree for AFROTC classes will be determined by your individual academic advisor. Students who wish to register for Air Force ROTC classes do so through the normal course registration process at CSM. AFROTC classes begin with the AFGN prefix. For more information about AFROTC, contact the Air Force ROTC Unit Admissions Officer at www.afrotc.colorado.edu , or the department on campus directly at 303-273-3380. The department is located in the Military Science building on West Campus Road. For information about CSM, call 303-273-3380.

Aerospace Studies Minor

Air Force ROTC cadets desiring to receive a minor in Aerospace Studies must complete at least 20 hours of Aerospace Studies courses as follows:

1.5 AFGN101. FOUNDATIONS OF THE UNITED STATES AIR FORCE (I)

1.5 AFGN102. FOUNDATIONS OF THE UNITED STATES AIR FORCE (II)

1.5 AFGN201. THE EVOLUTION OF USAF AIR AND SPACE POWER (I)

1.5 AFGN202. THE EVOLUTION OF USAF AIR AND SPACE POWER (II)

3.5 AFGN301. AIR FORCE LEADERHIP STUDIES (I)

3.5 AFGN302. AIR FORCE LEADERHIP STUDIES (II)

3.5 AFGN401. NATIONAL SECURITY AFFAIRS AND PREPARATION FOR ACTIVE DUTY (I)

3.5 AFGN402. NATIONAL SECURITY AFFAIRS AND PREPARATION FOR ACTIVE DUTY (II)

Other AFROTC Programs

Other programs are frequently available based on current Air Force needs. Contact a Det 105 representative at afrotc.colorado.edu.

Description of Courses

Freshman Year

AFGN101 and 102. FOUNDATIONS OF THE UNITED STATES AIR FORCE - 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.

Sophomore Year

AFGN201 and 202. THE EVOLUTION OF USAF AIR AND SPACE POWER - Two semesters, 1.5 hours per semester. This survey course covers 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 mis-

sions 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.

Junior Year

AFGN301 and 302. AIR FORCE LEADERHIP STUDIES - 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.

Senior Year

AFGN401 and 402. NATIONAL SECURITY AFFAIRS AND PREPARATION FOR ACTIVE DUTY - 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.

Physical Education and Athletics

TOM SPICER, Department Head and Athletic Director
DIXIE CIRILLO, Associate Athletic Director
BRANDON LEIMBACH, Associate Athletic Director
NOLAN SWETT, Instructor and Assistant Football Coach
STEPHANIE BEGLAY, Assistant Athletics Trainer
BOB BENSON, Instructor and Associate Head Football Coach
SATYEN BHATKA, Instructor and Assistant Football Coach
OSCAR BOES, Assistant Women's Cross Country Coach
SCOTT CAREY, Instructor and Assistant Football Coach
AMY HENKELMAN, Assistant Athletic Director and Director of Recreational Sports
JEFF DUGGAN, Sports Information Director
CLEMENT GRINSTEAD, Instructor and Assistant Football Coach
JOHN HOWARD, Director of Intramural and Club Sports
JOSH HUTCHENS, Head Wrestling Coach
GREG JENSEN, Assistant Athletics Trainer
JACOB POPE, Assistant Athletics Trainer
TYLER KIMBLE, Instructor, Head Golf Coach and Coordinator for Marketing and Promotions
FRANK KOHLENSTEIN, Instructor and Head Men's Soccer Coach
PAULA KRUEGER, Head Women's Basketball Coach
ADAM LONG, Instructor and Assistant Football Coach/Strength and Conditioning
JENNIFER McINTOSH, Head Athletic Trainer
GREG MULHOLLAND, Instructor and Assistant Men's Soccer Coach
JERRID OATES, Instructor and Head Baseball Coach
CHARLES O'DELL, Assistant Athletic Director
PRYOR ORSER, Head Men's Basketball Coach
HEATHER ROBERTS, Instructor and Assistant Volleyball Coach
BRAD SCHICK, Instructor and Assistant Men's Basketball Coach
ART SIEMERS, Instructor and Head Track & Field and Cross Country Coach
KATIE SIMONS, Assistant Sports Information Director
BRITTANY SIMPSON, Instructor and Assistant Women's Basketball Coach
JAMIE SKADELAND, Head Volleyball Coach
ROBERT STITT, Head Football Coach
ROBERT THOMPSON, Instructor and Director of Outdoor Recreation Center
KRISTIE HAWKINS, Instructor and Head Softball Coach
KEVIN FICKES, Instructor and Head Women's Soccer Coach
KATE CORTIS, Instructor and Assistant Women's Soccer Coach
NATE ROTHMAN, Head Swimming and Diving Coach
CAROLYN DENNEE, Administrative Assistant
DARREN TOWNSEND, Equipment Manager

The Department of Physical Education and Athletics offers a four-fold physical education and athletics program which includes (a) required physical education classes; (b) intercollegiate athletics; (c) intramural athletics and club sports; and (d) 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 scoreboard, netted backstop, press-box and lights for night games. Located west of Brooks Field and has seating accommodations for 500 spectators.

Softball Field

Newly constructed dugouts, batting cage, perimeter fencing, sound system and new irrigation system. Located west of Darden Field seating for 200 people.

Harry D. Campbell Field

Includes a synthetic surface named in honor of Harry D. Campbell, Class of 1939. This is equipped with lights and a steel-concrete grandstand and bleachers which seat 3,500 spectators.

Tennis Courts

The Department maintains four tennis courts.

Student Recreation Center

A three-level, 108,000 square foot facility that features an 8 lane, 25 yard swimming pool with 2 diving boards and a 14 person hot tub. There are men's and women's locker rooms, a 4,000 square foot climbing wall, a full service juice bar, an elevated jogging track, a 5,500 square foot fitness area, 2 multi-purpose rooms, a recreational gym and an arena that seats 3,000 for varsity athletic contests.

Swenson Intramural Complex

Two fields are available for intramural/recreation sports.

Stermole Track and Field Complex

Nine lane metric track with all field event components necessary to host NCAA, RMAC sanctioned events. Seating for 800 spectators.

CSM Soccer Stadium

Synthetic surface which provides opportunities for Men's and Women's NCAA, RMAC sanctioned events. Seating for 500 spectators.

Required Physical Education.

Each student at Colorado School of Mines is required to complete four Physical Education classes, beginning with the prerequisite classes of PAGN101 and PAGN102 continuing on to two additional 200 level courses. Four separate semesters of Physical Education is a graduation requirement. Exceptions: (1) a medical excuse verified by a physician; (2) veterans, honorably discharged from the armed forces; (3) new students entering CSM for the first time who are 26 years or older prior to the first day of class (4) students holding a bachelor's degree. Normally, it is fulfilled during the first two years of attendance. Transfer students should clear with the Admissions Offices regarding advanced standing in physical education. Participation in intercollegiate athletics may be substituted for required semesters and hours of physical education. ROTC students can waive the physical education requirement when a similar four-semester physical activity is required in their respective ROTC Programs.

Upper-class students who wish to continue taking physical education after completing graduation requirements may re-enroll in any of the regularly scheduled classes.

All students enrolled in physical education shall provide their own gym uniform, athletic shoes, and swimming suit. A non-refundable $10 fee is assessed for the required locker service.

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. One hour credit is given for a semester's participation in each sport.

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.

Description of Courses

All students are required to complete PAGN101 and PAGN102 before they will be allowed to register in higher level activity classes. The only exceptions to this requirement are students enrolled in intercollegiate athletics and ROTC. (See Required Physical Education.)

Freshman Year

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

PAGN102. PHYSICAL EDUCATION (II) (Required) Sections in physical fitness and team sports, relating to personal health and wellness activities. Prerequisite: PAGN101 or consent of the Department Head.

Sophomore, Junior, Senior Years

Students may select from several special activities listed below. Approved transfer credit may be substituted for the following classes:

PAGN201. PERSONAL WELLNESS provides an overview of the 5 Dimensions of Wellness: Physical, Social, Emotional, Intellectual and Spiritual. Students will take a proactive approach to developing strategies for optimum wellness including goal setting and application of wellness principles through assignments and group in-class work. Prerequisites: PAGN101 and PAGN102 or consent of Department Head. 2 hours lecturer; 1 semester hour. Repeatable for credit.

PAGN202 through PAGN280. (Students enrolling in these courses may be required to furnish their own equipment.) Classes will be offered on Monday and Wednesday for 50 minutes each day or on Tuesday or Thursday for 1.5 hours. Prerequisite: PAGN101 or PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour. Repeatable for credit.

PAGN202 INDOOR SOCCER
PAGN203 TECHNIQUES OF RELAXATION
PAGN205. BEGINNING KARATE
PAGN206 INTERMEDIATE/ADVANCED KARATE
PAGN207 TRAIL RUNNING
PAGN208 KAYAKING
PAGN209 AIKIDO
PAGN210 HIKING
PAGN211 BEGINNING SWIMMING
PAGN212 INTERMEDIATE SWIMMING
PAGN221 BEGINNING WEIGHT TRAINING
PAGN222 ADVANCED WEIGHT TRAINING
PAGN223 DISTANCE RUNNING
PAGN232 YOGA
PAGN235 AEROBICS
PAGN241 WOMEN'S WEIGHT TRAINING
PAGN242 WOMEN'S RAQUETBALL
PAGN251 GOLF
PAGN255 MOUNTAIN BIKING
PAGN257 INTRODUCATION TO ROCK CLIMBING
PAGN258 WOMEN'S ROCK CLIMBING
PAGN271 BEGINNING BADMINTON
PAGN272 ADVANCED BADMINTON
PAGN273 BEGINNING BASKETBALL
PAGN274 ADVANCED BASKETBALL
PAGN275 VOLLEYBALL
PAGN277 BEGINNING RACQUETBALL
PAGN279 HANDBALL
PAGN280 CLUB SPORTS

Intercollegiate Athletics

Instruction and practice in fundamentals and mechanics of the selected sport in preparation for collegiate competition. Satisfactory completion of any course fulfills one semester of physical education requirements.

PAGN151 VARSITY BASEBALL
PAGN153 VARSITY MEN'S BASKETBALL
PAGN154 VARSITY WOMEN'S BASKETBALL
PAGN157 VARSITY CROSS COUNTRY
PAGN159 VARSITY FOOTBALL
PAGN161 VARSITY GOLF
PAGN167 VARSITY MEN'S SOCCER
PAGN168 VARSITY WOMEN'S SOCCER
PAGN169 VARSITY SWIMMING AND DIVING
PAGN173 VARSITY TRACK AND FIELD
PAGN175 VARSITY WRESTLING
PAGN177 VARSITY VOLLEYBALL
PAGN179 VARSITY SOFTBALL

Prerequisite: Consent of department. 1 semester hour.

Space and Planetary Science and Engineering (SPSE)

Minors and Areas of Special Interest Only
JEFFREY C. ANDREWS-HANNA, Assistant Professor and SPSE Director
ANGEL ABBUD-MADRID, Associate Research Professor and SPSE Associate Director
THOMAS FURTAK, Professor and SPSE Program Advisor

Department of Chemical Engineering
ANGEL ABBUD-MADRID, Associate Research Professor and SPSE Associate Director
ROBERT D. KNECHT, Research Professor and Teaching Professor in EPICS
CYNTHIA NORRGRAN, Teaching Associate Professor

Department of Geology and Geological Engineering
JOEL G. DUNCAN, Teaching Professor

Department of Geophysics and Geophysical Engineering
JEFFREY C. ANDREWS-HANNA, Assistant Professor
WARREN HAMILTON, Distinguished Senior Scientist
GARY R. OLHOEFT, Professor

Department of Engineering
CHRISTOPHER DRYER, Assistant Research Professor

Department of Environmental Science and Engineering
JOHN R. SPEAR, Assistant Professor

Department of Physics
F. EDWARD CECIL, Professor Emeritus
THOMAS FURTAK, Professor and Department Head
UWE GREIFE, Professor

Programs Offered:

Area of Special Interest in Space and Planetary Science and Engineering

Programs Offered:

Area of Special Interest in Space and Planetary Science and Engineering

Program Description

Since the advent of the space age in the middle of the last century, the pace of human and robotic exploration of space has been ever increasing. This exploration is made possible by feats of engineering to allow long-term operation of robotic and human explorers in the harsh environment of space. The product of this exploration is a large and growing body of knowledge about our neighbors in the Solar System and our place in the universe. The mission of the Space and Planetary Science and Engineering (SPSE) program is to provide students with a pathway for studying extraterrestrial applications of science, engineering, and resource utilization through an Area of Special Interest. This ASI draws on courses from five CSM departments and programs, covering a broad spectrum of space and planetary topics including astronomy, planetary science, space exploration, and the design of missions and instruments.

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:
EPICS 251 Planetary EPICS Design II
EPICS 251 GIS EPICS Design II
EGGN 408 Introduction to Space Exploration
EGGN 491/492 Senior Design I and II
GEGN 469 Engineering Geology Design
GEOL 410 Planetary Geology
GPGN 438 Geophysics Project Design
GPGN/GEOL 470 Applications of Satellite Remote Sensing
GPGN 475 Planetary Geophysics
PHGN 324 Introduction to Astronomy and Astrophysics
PHGN 424 Astrophysics
PHGN 471/481 and 472/482 Senior Design Principles/Practice I & II

Underground Construction and Tunneling Minor

Department of Mining Engineering
KADRI DAGDELEN, Professor and Head of Department
CHRISTIAN FRENZEL, Associate Professor

Department of Geology and Geological Engineering
PAUL SANTI, Professor
JERRY HIGGINS, Associate Professor

Division of Engineering
VAUGHAN GRIFFITHS, Professor
MICHAEL MOONEY, Professor

Programs Offered:

Minor in Underground Construction and Tunneling (18 credit hours)

Program Educational Objectives

Underground Construction and Tunneling is a growing discipline involving knowledge in the fields of mining engineering, geological engineering and civil engineering. The Departments/Divisions of Mining Engineering, Geology & Geological Engineering and Engineering (Civil Engineering Specialty) offer an interdisciplinary minor course of study that would allow students from these departments to take a suite of courses requiring a minimum of 18 credit hours. Only three credit hours from the student's degree granting department/division may be used toward the minor. The remainder would be part of a student's free elective courses.

The minor program is delivered and managed by a committee consisting of members from the three departments/divisions. Curricular and advising matters are decided by this committee.

The objectives of the minor are to supplement an engineering background with a formal approach to subsurface engineering that includes site characterization, design and construction of underground infrastructures. Infrastructures could be water, storm water, highway or subway tunnels and subsurface underground facilities beneath major metropolitan cities. The formal approach includes courses in site investigation and geotechnical analysis, mining, structural and foundational design.

Curriculum

Several courses in each department or division were identified and categorized into the following three areas:

i) Site Investigation and Geotechnical Engineering

ii) Underground Mining Engineering

iii) Civil and Structural Engineering

The Minor Committee faculty members will sign Underground Construction and Tunneling minor forms in routine cases. For exceptions (e.g., course substitutions) the UC&T committee will make decisions. Students may obtain information on the minor from any of the three participating departments/divisions.

The Underground Construction & Tunneling minor consists of a minimum of 18 credit hours of a logical sequence of courses. Only three of the minimum 18 hours may be taken in the student's degree-granting department.

Program Requirements:

Required Courses:

MNGN321 – 3 Introduction to Rock Mechanics
MNGN404 – 3 Tunneling
MNGN408 – 3 Underground Design and Construction
GEGN466 – 3 Groundwater Engineering
or GEGN467 – 4 Groundwater Engineering
GEOL308 – 3 Introductory Applied Structural Geology
or GEOL309 – 4 Structural Geology and Tectonics
or GEOL311 – 3 Structural Geology for Mining Engineers
EGGN342 – 3 Structural Theory
EGGN361 – 3 Soil Mechanics
EGGN445 – 3 Design of Reinforced Concrete Structures

Electives:

GEGN468 – 4 Engineering Geology and Geotechnics
GEGN469 – 3 Engineering Geology Design
GEGN470 – 3 Groundwater Engineering Design
GEGN473 – 3 Geological Engineering Site Investigation
MNGN314 – 3 Underground Mine Design
MNGN333 – 3 Explosives Engineering
MNGN406 – 3 Design and Support of Underground Excavations
MNGN410 – 2 Excavation Project Management
MNGN418 – 3 Advanced Rock Mechanics
MNGN424 – 3 Mine Ventilation
EGGN422 – 3 Advanced Mechanics of Materials
EGGN441 – 3 Advanced Structural Analysis
EGGN444 – 3 Design of Steel Structures
EGGN460 – 3 Numerical Methods for Engineers
EGGN464 – 3 Foundations

Section 6 - Research Centers and Institutes

8th Continent Project

The 8th Continent Project is a comprehensive effort to integrate space technology and resources into the global economy. It includes a chamber of commerce, business incubator, funding network and research center. The Project is organizing "Space 2.0" - the emerging generation of entrepreneurial space-related business ventures - to apply space technology to a variety of multidisciplinary challenges, from global warming to resource and energy development to biotechnology.

Advanced Coatings and Surface Engineering Laboratory

The Advanced Coating and Surface Engineering Laboratory (ACSEL) is a multi-disciplinary laboratory that serves as a focal point for industry- driven research and education in advanced thin films and coating systems, surface engineering, tribology, electronic, optical and magnetic thin films and devices. The laboratory is supported by a combination of government funding agencies (NSF, DOE, DOD) and an industrial consortium that holds annual workshops designed to maximize interaction between participants, evaluate the research conducted by graduate students and faculty, and provide direction and guidance for future activities. ACSEL provides opportunities for CSM faculty and graduate students to visit and work in sponsor facilities, participate in technical meetings with sponsors, and for CSM graduates to gain employment with sponsors.

Advanced Control of Energy and Power Systems

The Advanced Control of Energy and Power Systems Center (ACEPS), based in the Engineering Division, features a unique partnership consisting of industry, the Department of Energy (DOE), the Electric Power Research Institute (EPRI), Colorado School of Mines (CSM) and twelve other universities. The mission of ACEPS is to conduct fundamental and applied research supporting the technical advancement of the electric utility industry, their customers, and component suppliers in the field of electric power systems and power electronics. Special emphasis is placed on advanced/intelligent control and power quality in the generation, transmission, distribution, and utilization.

Center research projects focus on the development of an intelligent energy system that will employ advanced power electronics, enhanced computer and communications systems, renewable energy applications and distributed generation. Examples include development of intelligent substations, impact of highly varying loads, power quality, electrical equipment life assessment, and intelligent automatic generation control for transient loads.

Advanced Mineralogy Research Center

The Advanced Mineralogy Research Center (AMRC), is an Independent Center dedicated to the characterization of a broad array of materials in mining, energy, environmental, and planetary applications. The focus of the Center is to provide improved understanding of geological and mineralogical materials in order to better predict their management, development, and the effective recovery of resources. The AMRC utilizes scanning-electron-microscopy-based quantitative mineralogy techniques with high-speed, image-analysis capabilities. Particles and solid materials from the micron-scale to hand sample size are analyzed to determine the distribution of minerals, ores, fabrics, textures, porosity, fracture distribution, alteration, and other attributes critical to understanding the material properties and behavior. The AMRC encourages interdisciplinary research, particularly in new and developing areas such as geomet, oil shale and unconventional energy resources, environmental materials characterization, medical geology, and lunar materials science. The Center includes two sample preparation laboratories, an analytical laboratory, and work stations and hot-seats for visiting researchers. Short courses in applications and data management using image analysis and quantification software are given at the beginning of each semester, and further training is available onsite. Students, faculty, university and government researchers, and commercial partners provide projects in a range of applications with the common goal of solving problems related to mineral characterization.

Advanced Steel Processing and Products Research Center

The Advanced Steel Processing and Products Research Center (ASPPRC) at Colorado School of Mines was established in 1984. The Center is a unique partnership between industry, the National Science Foundation (NSF), and Colorado School of Mines, and is devoted to building excellence in research and education in the ferrous metallurgy branch of materials science and engineering. Objectives of ASPPRC are to perform research of direct benefit to the users and producers of steels, to educate graduate students within the context of research programs of major theoretical and practical interest to the steel-using and steel-producing industries, to stimulate undergraduate education in ferrous metallurgy, and to develop a forum to stimulate advances in the processing, quality and application of steel.

Research programs consist of several projects, each of which is a graduate student thesis. Small groups of students and faculty are involved in each of the research programs. Sponsor representatives are encouraged to participate on the graduate student committees.

The Center was established with a five-year grant of $575,000 from the National Science Foundation, and is now self-sufficient, primarily as a result of industry support.

Advanced Water Technology Center

The Advanced Water Technology Center (AQWATEC) was established in 2006 to support the advancement of the campus' thrust areas of water and renewable energy. Research activities at AQWATEC are directed to advance research and development of novel water treatment processes and hybrid systems to enable sustainable and energy efficient utilization of impaired water sources to provide potable and non-potable water supplies. Our focus areas include:

- To conduct world-class research on teaching and learning in engineering and science.
- Advanced natural systems for elimination of emerging contaminants from the environment
- Traditional and novel membrane separation processes for water purification, reuse and desalination including zero-liquid discharge
- Development of multiple-barrier hybrid processes to provide more efficient water treatment systems
- Predictive tools for process performance/reliability and water quality assessments
- Advanced concepts in decentralized water treatment facilities
- Development of more efficient water treatment systems for the industrial and renewable energy sector
- Treatment and management strategies for produced water from unconventional gas resources

AQWATEC operates two major on-campus facilities, a state-of-the-art water quality analysis laboratory and a high-bay facility for laboratory- and pilot-scale research. The center also jointly operates a state-of-the-art surface water pilot plant at Golden's Water Treatment Plant and supports the Rocky Mountain Onsite & Small Flow Program by operating advanced pilot-scale system for onsite wastewater treatment. AQWATEC faculty currently sustain a research funding base of over $6.6M via active grants and contracts from AwwaRF, WERF, WRF, NSF, Cal DWR, U.S. Bureau of Reclamation, U.S. Department of Energy, NREL, and private industry.

Center for Assessment in Science, Technology, Engineering and Mathematics (CA:STEM)

The mission of the Center for Assessment (CA) in Science, Technology, Engineering and Mathematics (STEM) at the Colorado School of Mines (CSM) is to improve the methodologies used in the assessment of educational interventions in the STEM disciplines. CA:STEM's role is to bring together experts in quantitative research, qualitative research, and STEM content with the purpose of improving the evaluation of educational research projects and the validity of the interpretations made based on the results of those projects. CA:STEM also provides a training ground for undergraduate students, graduate students and researchers who are interested in assessment and evaluation. The primary goals of CA:STEM are:

- To conduct research in the assessment of STEM disciplines at all levels, kindergarten through graduate education.
- To provide evaluation experts for educational research projects (kindergarten through graduate education) conducted both in CSM and across the nation.
- To train undergraduate and graduate students in both qualitative and quantitative research techniques for the evaluation of educational research projects in the STEM disciplines.

Center for Automation, Robotics and Distributed Intelligence

The mission of the Center for Automation, Robotics and Distributed Intelligence (CARDI) is to engage in interdisciplinary research encompassing the fields of control systems, robotics and automation, and distributed systems and networking. Focus areas include the theory of adaptive and nonlinear control, intelligent and learning control systems, system identification and fault detection, computer vision and image processing, wireless communication networks, intelligent autonomous robotic systems, machine learning and artificial intelligence, network communication protocols and simulation and modeling of computer networks. Applications of CARDI research can be found in renewable energy and power systems, materials processing, sensor and control networks, bio-engineering and medicine, data mining and activity recognition, defense and homeland security, smart structures, intelligent geo-systems, and environmental monitoring. CARDI research concentrates on problems which are not amenable to traditional solutions within a single discipline, but rather require a multi-disciplinary systems approach to integrate technologies.

Established in 1994, CARDI includes faculty from the Division of Engineering and the Department of Mathematical and Computer Science. Research is sponsored by industry, federal agencies, state agencies, and joint government-industry initiatives. Interaction with industry enables CARDI to identify technical needs that require research, to cooperatively develop solutions, and to generate innovative mechanisms for the technology transfer. Enthusiastic and motivated students are encouraged to join CARDI for education and research in the area of automation, robotics, and distributed systems.

Center for Earth Materials, Mechanics, and Characterization

CEMMC is a multidisciplinary research center intended to promote research in a variety of areas including rock mechanics, earth systems, and nontraditional characterization. The Center does not limit its focus to either "hard" or "soft" rock applications but instead fosters research in both arenas and encourages interdisciplinary communication between the associated disciplines. The Colorado School of Mines is a world leader in multidisciplinary integration and therefore presents a unique atmosphere to promote the success of such research. Faculty and students from the Departments of Petroleum Engineering, Geophysical Engineering, Physics, Geology and Geological Engineering, Engineering, and Mining Engineering are involved in CEMMC. In addition to traditional topics in these disciplines, the center cultivates research in nontraditional characterization such as arctic ice coring, extraterrestrial space boring, and laser/rock destruction for multiple applications. CEMMC was established in 2003.

Center for Engineering Education

The Center serves as a focal point for engineering and science education research conducted by CSM faculty. Successfully educating tomorrow's engineers and scientists requires that we look at student learning as a system. The principles of cognitive psychology and educational psychology provide the best explanation of how this learning system works. Education will be most effective when education research, informed by the principles of cognitive and educational psychology are applied to design and application of classroom teaching techniques and curricular materials.

The primary goals of the Center for Engineering Education are:

- To conduct world-class research on teaching and learning in engineering and science.
- To use the results of that research by continually improving instruction at the Colorado School of Mines to better support the learning process of our students.
- To support the educational needs of science and engineering instructors at the pre-college, college, graduate and professional development levels.

Center for Environmental Risk Assessment

The mission of the Center for Environmental Risk Assessment (CERA) at CSM is to unify and enhance environmental risk assessment research and educational activities at CSM. By bringing diverse, inter-disciplinary expertise to bear on problems in environmental risk assessment, CERA facilitates the development of significantly improved, scientifically based approaches for estimating human and ecological risks and for using the results of such assessments. Education and research programs within CERA integrate faculty and students from the departments of Chemical Engineering, Environmental Sciences and Engineering, Chemistry and Geochemistry, Mathematics and Computer Science, and Geology and Geological Engineering.

Center for Experimental Study of Subsurface Environmental Processes

The Center for Experimental Study of Subsurface Environmental Processes (CESEP) emphasizes the multi-disciplinary nature of subsurface remediation technologies by integrating the fundamental sciences of chemistry, biology, geology, hydrology and physics with applied geotechnical, civil and environmental engineering. With this emphasis, the focus for CESEP is to enhance environmental quality through innovative research of subsurface remediation techniques for the clean-up of environmental contaminants leading to improved methodology and decision-making.

Center for Intelligent Biomedical Devices and Musculoskeletal Systems

The multi-institutional Center for Intelligent Biomedical Devices and Musculoskeletal systems (IBDMS) integrates programs and expertise from CSM and the University of Colorado at Denver and Health Sciences Center. Established at CSM as a National Science Foundation (NSF) Industry/University Cooperative Research Center, IBDMS is also supported by industry, State, and Federal organizations.

IBDMS has become an international center for the development of Computer Assisted Surgery, Advanced Orthopaedic Applications, Sports Medicine, Occupational Biomechanics, and Biomaterials. Through the efforts of this center, new major and minor programs in bioengineering and biotechnology have been established at both the CSM graduate and undergraduate levels.

IBDMS seeks to establish educational programs in addition to short- and long-term basic and applied research efforts that would enhance the competitive position of Colorado and U.S. bio-industry in the international markets. IBDMS focuses the work of diverse engineering, materials and medicine disciplines. Its graduates are a new generation of students with an integrated engineering and medicine systems view, with increasing opportunities available in the biosciences.

Center for Research on Hydrates and Other Solids

Since 1975, the Center for Research on Hydrates and Other Solids has performed both fundamental and applied research on natural gas hydrates, curious ice-like compounds composed of water and hydrocarbon gases. Gas hydrates, which generally form at cold temperatures and high pressures, present both a major challenge and major opportunity in energy production. Gas hydrates can plug deep sea and arctic gas and oil pipelines, and preventing hydrate formation is a major design and operational challenge. On the other hand, naturally occurring gas hydrates could potentially pro-

vide the world's largest resource of natural gas. Recently, researchers at the center have also found that hydrates can be used as a hydrogen storage material for potential use in fuel cell applications.

With active participation of faculty, graduate, and undergraduate students, the center provides a unique combination of expertise that has enabled CSM to achieve international prominence in gas hydrate research. CSM participants interact on an on-going basis with sponsors and other collaborators, including frequent visits to their facilities both in the US and abroad. For students, this interaction often continues beyond graduation, with opportunities for employment at sponsoring industries. More information can be found at the center website, http://hydrates.mines.edu/

Center for Solar and Electronic Materials

The Center for Solar and Electronic Materials (CSEM) was established in 1995 to focus, support, and extend growing activity in electronic materials for solar applications, in electronic and microelectronic technologies, and in related optical technologies. In addition to photovoltaics, CSEM supports research into advanced optics, novel optical devices, thin film materials, polymeric devices, micro fluidic devices, nanoscale science and nanofabrication, novel characterization, electronic materials processing, process simulation, and systems issues associated with electronic materials and devices. Alternative energy technologies and sustainability are also areas of interest. CSEM facilitates interdisciplinary collaborations across the CSM campus, fosters interactions with national laboratories, industries, public utilities, local state and federal government, and other universities, and operates in close coordination with the National Science Foundation sponsored Renewable Energy Materials Research Science and Engineering Center. The Center coordinates grant applications by its members to collective funding opportunities, manages a joint-use laboratory with a broad range of characterization and processing tools, purchases joint-use tools based on member needs and maintains a virtural computational lab. In fulfilling its research and educational mission, CSEM draws from expertise in the departments of Physics, Chemical Engineering, Metallurgical and Materials Engineering, Chemistry and Geochemistry, and from the Division of Engineering.

CSEM also serves to guide and strengthen the curriculum in electronic materials and related areas. CSEM members develop and teach relevant courses. CSEM also emphasizes training through research experiences for both graduate and undergraduate students. Graduate students in the above-mentioned departments as well as the materials science program can pursue research on center-related projects. Undergraduates are involved through engineering design courses and summer research experiences. Close proximity to the National Renewable Energy Lab and several local photovoltaic companies provides a unique opportunity for students to work with industry and government labs as they solve real world problems. External contacts also provide guidance in targeting the educational curriculum toward the needs of the electronic materials industry.

Center for Space Resources (CSR)

The Center for Space Resources is dedicated to the human and robotic exploration of space and to the utilization of what we learn to the improvement of our society. These objectives are pursued by developing technologies for space resource prospecting, drilling, excavation, extraction, materials processing and manufacturing in space, and life-support systems on spacecraft and planetary habitats. While there are several practical applications of space exploration on Earth, the greatest achievement bringing benefits to humankind would be to develop commercial applications of space technology, including space and planetary resources, in space.

These applications will one day form the basis for new space industries that include the harvesting of solar energy outside Earth's atmosphere, the development of an in-space reusable transportation infrastructure carrying payloads from Earth to geostationary orbits, the Moon or Mars and back, servicing of satellites to extend their useful lifetimes and reduce the costs of space operations, processing of value-added materials in Earth orbit based on lunar material resources, and utilization of resources for in-situ planetary applications, such as energy, propellants, manufacturing, and habitat development.

These goals are pursued by a Consortium involving faculty and students from several departments, NASA and other government agencies, and industrial partners working together on space-related projects.

Center for Wave Phenomena

With sponsorship for its research by 25 companies in the worldwide oil exploration industry and several government agencies, this program, which includes faculty and students from the Departments of Geophysics, is engaged in a coordinated and integrated program of research in wave propagation, inverse problems and seismic data processing. Its methods have applications to seismic exploration and reservoir monitoring, global seismology, nondestructive testing and evaluation, and land-mine detection, among other areas. Extensive use is made of analytical methods as well as computational techniques. Methodology is developed through computer implementation, based on the philosophy that the ultimate test of an inverse method is its application to experimental data. Thus, the group starts from a physical problem, develops a mathematical model that adequately represents the physics, derives an approximate solution, generates a computer code to implement the method, performs tests on synthetic data, and finally, on field data.

Center for Welding, Joining and Coatings Research

The Center for Welding, Joining and Coatings Research (CWJCR) is an interdisciplinary organization with researchers and faculty from the Metallurgical and Materials Engineering Department, the Engineering Division, and the Mining Engineering Department. The goal of CWJCR is to promote graduate-level and undergraduate education and research, and to advance understanding of the metallurgical and processing aspects of welding, joining and coating processes. Current center activities include: education, research, conferences, short courses, seminars, information source and transfer, and industrial consortia. The Center receives significant support from industry, national laboratories and government entities.

The Center for Welding, Joining and Coatings Research strives to provide numerous opportunities that directly contribute to the student's professional growth. Some of the opportunities include:

- Direct involvement of graduate students in projects that constitute the Center's research program. Several undergraduate students are also selected per year to participate in ongoing CWJCR research projects.
- Interaction with internationally renowned visiting scholars.
- Industrial collaborations that provide equipment, materials and services.
- Research experience at industrial plants or national laboratories.
- Professional experience and exposure before nationally recognized organizations through student presentations of university research.
- Direct involvement in national welding, materials, and engineering professional societies.

Chevron Center of Research Excellence

The Chevron Center of Research Excellence (CoRE) is an industry-academic partnership between the Colorado School of Mines and Chevron that promotes the research, education, training, and recruiting objectives of both organizations. The current research focus is quantitative outcrop characterization using outcrops to document how sedimentary systems evolve through time and space in a variety of settings.

Colorado Center for Advanced Ceramics

The Colorado Center for Advanced Ceramics (CCAC) is developing the fundamental knowledge that is leading to important technological developments in advanced ceramics and composite materials. Established at CSM in April 1988 as a joint effort between CSM and the Coors Ceramics Company (now CoorsTek); the Center is dedicated to excellence in research and graduate education in high technology ceramic and composite materials. The goal of the Center is to translate advances in materials science into new and improved ceramic fabrication processes and ceramic and composite materials. Current research projects cover a broad spectrum of materials and phenomena including fuel cell, solar cell and battery materials; nano-scale powder preparation and mechanics; ceramic-metal composites; layered materials for ballistic applications; and mechanical behavior. Current projects are supported by both industry and government and several students are performing their research through collaboration with the National Renewable Energy Laboratory located in Golden. Each project involves research leading to a graduate thesis of a student. Significant international collaboration exists leading to student experiences abroad.

Colorado Energy Research Institute

Originally established in 1974 and reestablished in 2004, the Colorado Energy Research Institute (CERI) promotes research and educational activities through networking among all constituencies in Colorado, including government agencies, energy industries, and universities. CERI's mission is to serve as a state and regional resource on energy and energy-related minerals issues, provide energy status reports, sponsorship of symposia, demonstration programs, and reports on research results. CERI's activities enhance the development and promotion of energy and energy-related minerals education programs in the areas of energy development, utilization, and conservation, and provide a basis for informed energy-related state policies and actions. Currently CERI has started a sub center for oil shale research.

Colorado Fuel Cell Center

The Colorado Fuel Cell Center (CFCC) seeks to advance fuel-cell research, development, and commercialization and to promote business opportunities in Colorado. The CFCC was created in 2005 with funding from the Governor's Energy Office and co-funding from four partnering organizations. In July 2006 the CFCC was granted status as a Colorado School of Mines research center. The CFCC is managed by a faculty panel consisting of CSM faculty members using the facilities to perform research. The various scopes of the center are solid-oxide fuel cell (SOFC) development and testing, polymer-electrolyte membrane (PEM) development, fuel processing, modeling and simulation, advanced materials processing and evaluation, manufacturing technology development, and systems integration.

Colorado Institute for Energy, Materials and Computational Science

The Colorado Institute for Energy, Materials and Computational Science (CIEMACS) is an interdisciplinary research institute involving research active faculty and students from several academic departments at the Colorado School of Mines. These faculty and students have expertise in the chemistry, physics and engineering of energy conversion processes, including solid oxide and PEMS fuel cells, clean fuels, combustion experimentation and modeling, materials synthesis in flames, atomistic materials modeling and the development of optical measurement techniques for combustion systems and reactive flows.

Colorado Institute for Macromolecular Science and Engineering

The Colorado Institute for Macromolecular Science and Engineering (CIMSE) was established in 1999 by an interdisciplinary team of faculty from several CSM departments. It is sponsored by the National Science Foundation, the Environmental Protection Agency, and the Department of Energy.

The mission of the Institute is to enhance the training and research capabilities of CSM in the area of polymeric and other complex materials as well as to promote education in the areas of materials, energy, and the environment.

Fourteen CSM faculty members from eight departments are involved with the Institute's research. The research volume is more than $1 million and supports around 15 full-time graduate students in polymers, colloids and complex fluids. Current research projects include plastics from renewable resources, computer simulation of polymers, novel synthetic methods, and the development of new processing strategies from polymer materials.

CIMSE works to improve the educational experience of undergraduate and graduate students in polymers and complex fluids as well as maintain state-of-the-art lab facilities. Currently CSM has the largest polymeric materials effort in the State of Colorado. Materials are a dominant theme at CSM, and CIMSE will play an important role in ensuring that our students remain competitive in the workforce.

Colorado Renewable Energy Collaboratory

The Colorado Renewable Energy Collaboratory was created by the State of Colorado to advance multidisciplinary science, technology development and technology transfer on challenges related to renewable, reliable, secure, clean, and economically viable energy resources and technologies ("renewable energy"). Currently five centers have been created to explore initiatives in renewable energy:

- Colorado Center for Biorefining and Biofuels (C2B2)
- Center for Revolutionary Solar Photoconversion (CRSP)
- Collaborative Research and Education in Wind (CREW)
- Solar Technology Acceleration Center - Research Partnership (SolarTAC)
- Carbon Management Center (CMC)

Energy and Minerals Field Institute

The Energy and Minerals Field Institute is an educational activity serving Colorado School of Mines students and external audiences. The goal of the Institute is to provide better understanding of complex regional issues surrounding development of western energy and mineral resources by providing firsthand experience that cannot be duplicated in the classroom. The Institute conducts field programs for educators, the media, government officials, industry, and the financial community. The Institute also hosts conferences and seminars throughout the year dealing with issues specific to western resources development. Students involved in Institute programs are afforded a unique opportunity to learn about the technological, economic, environmental, and policy aspects of resource development.

Excavation Engineering and Earth Mechanics Institute

The Excavation Engineering and Earth Mechanics Institute (EMI), established in 1974, combines education and research for the development of improved excavation technology. By emphasizing a joint effort among research, academic, and industrial concerns, EMI contributes to the research, development and testing of new methods and equipment, thus facilitating the rapid application of economically feasible new technologies.

Current research projects are being conducted throughout the world in the areas of tunnel, raise and shaft boring, rock mechanics, micro-seismic detection, machine instrumentation and robotics, rock fragmentation and drilling, materials handling systems, innovative mining methods, and mine design and economics analysis relating to energy and non-fuel minerals development and production. EMI has been a pioneer in the development of special applications software and hardware systems and has amassed extensive databases and specialized computer programs. Outreach activities for the Institute include the offering of short courses to the industry, and sponsorship and participation in major international conferences in tunneling, shaft drilling, raise boring and mine mechanization.

The full-time team at EMI consists of scientists, engineers, and support staff. Graduate students pursue their thesis work on Institute projects, while undergraduate students are employed in research.

Golden Energy Computing Organization

The Golden Energy Computing Organization (GECO) is a partnership between Mines, the National Renewable Energy Laboratory, the National Center for Atmospheric Research and the National Science Foundation. It is dedicated to the use of high performance computing to advance research in the energy sciences. GECO has four main priority areas: pursuing renewable sources, locating and developing existing resources, advancing environmental stewardship, and designing new energy related materials. The center has acquired and maintains a Linux supercomputer, named Ra, which has 2144 computing cores and a peak performance of 23 teraflops. This is one of the most powerful computer resources in academe. It can do three-thousand calculations per second for each of the 6.6 billion people on the planet. A staff of full-time specialists works with researchers to install and optimize computing codes. The facility is open to all CSM faculty and students pursuing energy-related research.

International Ground Water Modeling Center

The International Ground Water Modeling Center (IGWMC) is an information, education, and research center for groundwater modeling established at Holcomb Research Institute in 1978, and relocated to the Colorado School of Mines in 1991. Its mission is to provide an international focal point for groundwater professionals, managers, and educators in advancing the use of computer models in ground-water resource protection and management. IGWMC operates a clearinghouse for ground-water modeling software; organizes conferences, short courses and seminars; and provides technical advice and assistance related to ground water modeling. In support of its information and training activities, IGWMC conducts a program of applied research and development in groundwater modeling.

Kroll Institute for Extractive Metallurgy

The Kroll Institute for Extractive Metallurgy (KIEM), a Center for Excellence in Extractive Metallurgy, was established at the Colorado School of Mines in 1974 using a bequest from William J. Kroll. Over the years, the Kroll Institute has provided support for a significant number of undergraduate and graduate students who have gone on to make important contributions to the mining, minerals and metals industries. The initial endowment has provided a great foundation for the development of a more comprehensive program to support industry needs.

The primary objectives of the Kroll Institute are to provide research expertise, well-trained engineers to industry, and research and educational opportunities to students, in the areas of minerals, metals and materials processing; extractive and chemical metallurgy; chemical processing of materials; and recycling and waste treatment and minimization.

Marathon Center of Excellence for Reservoir Studies

Marathon Center of Excellence for Reservoir Studies conducts collaborative research on timely topics of interest to the upstream segment of the petroleum industry and provides relevant technical service support, technology transfer, and training to the Center's sponsors. Research includes sponsorship of M.S. and Ph.D. graduate students, while technology transfer and training involve one-on-one training of practicing engineers and students from the sponsoring companies. The Center is a multi-disciplinary organization housed in the Petroleum Engineering Department. The Center activities call for the collaboration of the CSM faculty and graduate students in various engineering and earth sciences disciplines together with local world-class experts. The Center was initiated with a grant from Marathon Oil Company, in 2003 and has been serving the oil industry around the world. The current research topics include: modeling and evaluation of unconventional oil and gas resources, reservoir engineering aspects of horizontal and deviated wells, Non-Darcy flow effects in hydraulic fractures and naturally fractured reservoirs, streamline modeling in dual-porosity reservoirs, multi-scale simulation methods to capture the fine-scale heterogeneity effects in displacement processes, modeling of transient flow in hydraulically fractured horizontal wells, naturally fractured reservoirs containing multiple sets of intersecting fractures, numerical modeling of reservoirs containing sparse naturally fractured regions, improved modeling of matrix vertical flow in dual-porosity reservoirs, steam assisted gravity drainage (SAGD) for medium gravity foamy oil reservoirs.

Microintegrated Optics for Advanced Bioimaging and Control

Microintegrated Optics for Advanced Bioimaging and Control (MOABC) focuses on the integration of optics into microscale and microfluidics systems by reducing macroscale optics and electronics to an "optical lab-on-a-chip" compatible with the fluidics lab-on-a-chip paradigm. The center develops new fabrication techniques and new methods of biological measurement and manipulation based on microintegrated optics. Technology at the center is organized around three cores that tie strongly together with one another: spectroscopy, microscopy and manipulation. Our unique facilities enable the center to work closely with both academic and industrial collaborators to employ the developed technologies in useful and relevant applications.

The Nuclear Science and Engineering Center

The Nuclear Science and Engineering Center (NuSEC) is a new interdisciplinary research center whose main objective is to conduct research across all aspects of the nuclear fuel life cycle that includes: mineral exploration, extraction and processing; synthesis and processing of metal, oxide and ceramic fuels; nuclear power systems production, design and operation; fuel recycling, storage and waste remediation; and radiation damage, and the policy issues surrounding each of these activities.

NuSEC draws on substantial contributions from faculty across the Institution, which includes the Division of Engineering, the Division of Environmental Science and Engineering, the Department of Chemistry and Geochemistry, the Department of Geology and Geological Engineering, the Department of Mining Engineering, the Department of Physics, and the Department of Metallurgical and Materials Engineering. Faculty from the Division of Liberal Arts and International Studies provide key support in the areas of social license, policy and ethics.

Center for Oil Shale Technology and Research

The Center for Oil Shale Technology and Research (COSTAR) conducts investigations to advance the development of oil shale resources in the United States and around the world. Center projects include:

- Studies of rock physics and rock mechanics to understand how oil shale properties vary with temperature and how fractures will occur with heating
- Studies of geology, stratigraphy and climatology, to understand the conditions of formation of oil shale and provide the integrating framework for the Center's work
- Studies of geochemistry, to understand how best to characterize the productive potential of the resource, and to enhance geologic understanding of the formation of oil shale
- Development of a global database of oil shale information and support of the annual Oil Shale Symposium.

The founding Members of COSTAR include Total E&P USA, Shell E&P, and ExxonMobil Upstream Research Company.

Petroleum Exploration and Production Center

The Petroleum Exploration and Production Center (PEPC) is an interdisciplinary educational and research organization specializing in applied studies of petroleum reservoirs. The center integrates disciplines from within the Departments of Geology and Geological Engineering, Geophysics and Petroleum Engineering.

PEPC offers students and faculty the opportunity to participate in research areas including: improved techniques for exploration, drilling, completion, stimulation and reservoir evaluation techniques; characterization of stratigraphic architecture and flow behavior of petroleum reservoirs at multiple scales; evaluation of petroleum reserves and resources on a national and worldwide basis; and development and application of educational techniques to integrate the petroleum disciplines.

Renewable Energy Materials Research Science and Engineering Center

Meeting world energy needs is one of the most significant challenges we face in the coming century. The National Science Foundation sponsored Renewable Energy Materials Research Science and Engineering Center (REMRSEC) is focused on transformative materials advances and educational directions that greatly impact emerging renewable energy technologies. Established in 2008, the Center is organized around two research thrust areas. The first concentrates on harnessing unique properties of nanostructured materials to significantly enhance the performance of photovoltaic devices. The second explores ion transport in advanced composite membranes for renewable energy applications. The Center includes a seed grant program designed to stimulate innovative directions and to integrate into the center research portfolio those approaches that show promise. Center educational and outreach activities directly expose students to renewable energy concepts at a young age and prepare them, throughout their K-12 education and into college, for potential careers in this field. Activities include a Research Experience for Undergraduates (REU) summer program in renewable energy outreach to K-12 teachers to address renewable concepts, and renewable energy curriculum development. A diversity initiative seeks to broaden the participation of under represented groups in mathematics, science and engineering at all levels. The center also maintains a broad array of shared-use computational, characterization, deposition, and processing-related facilities. A strategic partnership with scientists and engineers at the National Renewable Energy Laboratory allows sharing of students, research associates, equipment and facilities between the two organizations. In addition, more than a dozen companies actively involved in alternative energy partner with the center. The REMRSEC collaborates with and integrates activities of other Centers active on the Colorado School of Mines campus including the Center for Solar and Electronic Materials (CSEM), the Colorado Fuel Cell Center (CFCC), the Colorado Renewable Energy Collaboratory (CREC) and the Golden Energy Computing Organization (GECO). It also collaborates internationally with leading universities and laboratories in the renewable energy field.

Reservoir Characterization Project

The Reservoir Characterization Project (RCP), established in 1985 at Colorado School of Mines, is an industry-sponsored research consortium. Its mission is to develop and apply 4-D, 9-C seismology and associated technologies for enhanced reservoir recovery. Each multi-year research phase focuses on a consortium partner's unique field location, where multicomponent seismic data are recorded, processed, and interpreted to define reservoir heterogeneity and architecture. Each field study has resulted in the development and advancement of new 3- and 4-D multicomponent acquisition, processing, and interpretation technology, which has led to additional hydrocarbon recovery. Research currently focuses on dynamic reservoir characterization, which enables monitoring of the reservoir production process.

The Reservoir Characterization Project promotes interdisciplinary research and education among industry and students in the fields of geophysics, geology and geological engineering, and petroleum engineering.

Unconventional Natural Gas Institute (UNGI)

The Colorado School of Mines has established the Unconventional Natural Gas Institute (UNGI) to support unconventional natural gas research and to partner with industry and government organizations in enhancing enhance existing Mines in-house expertise and communication between departments in Colorado School of Mines. Fourteen current CSM research centers, along with faculty from nine of the thirteen degree-granting departments are affiliated with UNGI.

Section 7 - Services

Arthur Lakes Library

JOANNE V. LERUD-HECK, Librarian and Library Director
LISA G. DUNN, Librarian
LAURA A. GUY, Librarian
LISA S. NICKUM, Associate Librarian
CHRISTOPHER THIRY, Associate Librarian
HEATHER L. WHITEHEAD, Associate Librarian
PATRICIA E. ANDERSEN, Assistant Librarian
CHRISTINE BAKER, Assistant Librarian
PAMELA M. BLOME, Assistant Librarian
LIA VELLA, Assistant Librarian
JULIE CARMEN, Research Librarian

Arthur Lakes Library is a regional information center for engineering, energy, minerals, materials, and associated engineering and science fields. The Library supports university education and research programs and is committed to meeting the information needs of the Mines community and all library users.

The Library has over 140,000 visitors a year and is a campus center for learning, study and research. Facilities include meeting space, a campus computer lab, and individual and group study space. We host many cultural events during the year, including concerts and art shows.

The librarians provide personalized help and instruction, and assist with research. The Library's collections include more than 500,000 books; thousands of print and electronic journals; hundreds of databases; one of the largest map collections in the West; an archive on Colorado School of Mines and western mining history; and several special collections. The Library is a selective U.S. and Colorado state depository with over 600,000 government publications.

The Library Catalog provides access to Library collections and your user account. Our databases allow users to find publications for classroom assignments, research or personal interest. Students and faculty can use most of the Library's electronic databases and publications from any computer on the campus network, including those in networked Mines residential facilities. Dial-up and Internet access are available out of network.

Arthur Lakes Library is a member of the Colorado Alliance. Students and faculty can use their library cards at other Alliance libraries, or can order materials directly using Prospector, our regional catalog. Materials can also be requested from anywhere in the world through interlibrary loan.

Computing, Communications, & Information Technologies (CCIT)

DEREK WILSON, CIO
PHIL ROMIG, III, CISO & Director, Computing & Networking Infrastructure
GINA BOICE, Director, Customer Services & Support
TIM KAISER, Director, High Performance and Research Computing
DAVID LEE, Director, Enterprise Systems
GEORGE FUNKEY, Director, Policy, Planning, and Integration Services

Campus Computing, Communications, & Information Technologies (CCIT) provides computing and networking services to meet the instructional, research, administrative, and networking infrastructure needs of the campus. CCIT manages and operates campus networks along with central academic and administrative computing systems, telecommunication systems, a high performance computing cluster for the energy sciences (see http://geco.mines.edu), and computer classrooms and workrooms in several locations on campus. CCIT's customer services and support group also provides direct support for most electronic classrooms, departmental laboratories and desktops throughout the campus.

Central computing accounts and services are available to registered students and current faculty and staff members. Information about hours, services, and the activation of new accounts is available on the web site at http://ccit.mines.edu/, directly from the Help Desk in the Computer Commons (in CTLM 156), or by calling (303) 273-3431.

Workrooms in several locations on campus contain networked PCs and workstations. Printers, scanners, digitizers, and other specialized resources are available for use in some of the locations.

In addition to central server and facilities operations, services supported for the campus community include e-mail, wired and wireless network operation and support, access to the commodity Internet, Internet 2, and National Lambda Rail, network security, volume and site licensing of software, on-line training modules, videoconferencing, student registration, billing, and other administrative applications, campus web sites and central systems administration and support. CCIT also manages and supports the central learning management system (Blackboard), printing, short-term equipment loan, and room scheduling for some general computer teaching classrooms.

All major campus buildings are connected to the computing network operated by CCIT and most areas of the campus are covered by the wireless network. All residence halls and the Mines Park housing complex are wired for network access and some fraternity and sorority houses are also directly connected to the network.

All users of Colorado School of Mines computing and networking resources are expected to comply with all policies related to the use of these resources. Policies are available via the web pages at http://ccit.mines.edu.

Copy Center

Located on the first floor of Guggenheim Hall, the Copy Center offers on-line binding, printed tabs, transparencies and halftones. Printing can be done on 8 ½" x11", 11"x14" and 11x17" paper sizes from odd-sized originals. Some of the other services offered are GBC and Velo Binding, folding, sorting and machine collating, reduction and enlargement, two sided copying, and color copying. We have a variety of paper colors, special resume paper and CSM watermark for thesis copying. These services are available to students, faculty, and staff. The Copy Center campus extension is 3202.

CSM Alumni Association

The Colorado School of Mines Alumni Association (CSMAA), established in 1895, serves the Colorado School of Mines and more than 23,000 proud members of the powerful and successful alumni community. While all alumni are included in the reach of the CSMAA, it is a membership-based, independent organization reliant upon membership funds for much of its budget. Other sources of funding include the School, Foundation, merchandise sales and revenue-sharing partnerships. For example, CSMAA administers the Colorado School of Mines license plate program for cars registered in Colorado.

General services and programs include:

- Mines magazine, a quarterly publication covering campus and alumni news;
- An online directory of all Mines alumni for networking purposes;
- Online job listings for alumni two years out of school;
- Access to the alumni network on LinkedIn;*
- Section activities that provide social and networking connections to the campus and Mines alumni around the world;
- Alumni gatherings (meetings, reunions, golf tournaments, educational programs and other special events) on and off campus;
- Alumni recognition awards;
- On-campus CSM library privileges for Colorado residents;

Benefits for current Colorado School of Mines students include:

- Legacy Grants for children or grandchildren of alumni when parent or grandparent has been a consistent member of CSMAA for previous five years;
- The Student Financial Assistance Program;
- Celebration of Alumni banquet for graduating students;
- The CSMAA Mentorship program, pairing students with alumni for professional development;*
- Invitations to social and networking events, i.e. Dinner and Dialogue, Leadership Development events, Holiday Party, sporting events
- Access to the alumni network on LinkedIn;*
- Access to the CSMAA social networking website, www.minesonline.net;
- Early notice, information and reminders about alumni-based scholarships;
- Exclusive opportunities to enter drawings for a CSMAA book scholarship;*
- CSM Bookstore discounts (excluding textbooks and Apple products);*
- Renter's insurance discount from Liberty Mutual;
- "Blaster Pack" – Mines marbles, an "M"-ulator t-shirt, membership card and more;*

Students can join the CSMAA at the student membership ("M"-ulator) level for exclusive benefits marked with an asterisk. For further information, call 303-273-3295, Fax 303-273-3583, e-mail csmaa@mines.edu, or write Mines Alumni Association, Coolbaugh House, P.O. Box 1410, Golden, CO 80402-1410.

Environmental Health and Safety

The Environmental Health and Safety (EHS) Department is located in Chauvenet Hall room 194. The Department provides a variety of services to students, staff and faculty members. Functions of the Department include: hazardous waste collection and disposal; chemical procurement and distribution; chemical spill response; assessment of air and water quality; fire safety; laboratory safety; industrial hygiene; radiation safety; biosafety; and recycling. Staff is available to consult on issues such as chemical exposure control, hazard identification, safety systems design, personal protective equipment, or regulatory compliance. Stop by our office or call 303 273-3316. The EHS telephone is monitored nights and weekends to respond to spills and environmental emergencies.

Green Center

Completed in 1971, the Cecil H. and Ida Green Graduate and Professional Center is named in honor of Dr. and Mrs. Green, major contributors to the funding of the building.

Bunker Memorial Auditorium, which seats 1,386, has a large stage that may be used for lectures, concerts, drama productions, or for any occasion when a large attendance is expected.

Friedhoff Hall contains a dance floor and an informal stage. Approximately 600 persons can be accommodated at tables for banquets or dinners. Auditorium seating can be arranged for up to 450 people.

Petroleum Hall and Metals Hall are lecture rooms seating 123 and 310, respectively. Each room has audio visual equipment. In addition, the Green Center houses the Department of Geophysics.

For more information visit www.greencenter.mines.edu.

LAIS Writing Center

Located on the third floor of Stratton Hall (phone: 303-273-3085), the LAIS Writing Center is a teaching facility providing all CSM students, faculty, and staff with an opportunity to enhance their writing abilities. The LAIS Writing Center faculty are experienced technical and professional writing instructors who are prepared to assist writers with everything from course assignments to scholarship and job applications. This service is free to CSM students, faculty, and staff and entails one-to-one tutoring and online resources (at http://www.mines.edu/academic/lais/wc/).

Off-Campus Study

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

Office of International Programs

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 is located at 1706 Illinois Street. For more specific information about study abroad and other international programs, contact OIP at 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:/OIP.mines.edu/studentabroad/schol.html).

Office of Technology Transfer

The purpose of the Office of Technology Transfer (OTT) is to reward innovation and entrepreneurial activity by students, faculty and staff, recognize the value, preserve ownership of CSM's intellectual property, and contribute to local and national the economic growth. OTT reports directly to the Vice President of Research and Technology Transfer and works closely with the school's offices of Legal Services and Research Administration to coordinate activities. With support from its external Advisory Board, OTT strives to:

(1) Initiate and stimulate entrepreneurship and development of mechanisms for effective investment of CSM's intellectual capital;

(2) Secure CSM's intellectual properties generated by faculty, students, and staff;

(3) Contribute to the economic growth of the community, state, and nation through facilitating technology transfer to the commercial sector;

(4) Retain and motivate faculty by rewarding entrepreneurship;

(5) Utilize OTT opportunities to advance high-quality faculty and students;

(6) Provide a return on investment on CSM inventions which is used to expand the school's research and education missions.

Public Relations

For information about the school's publications guidelines, including the use of Mines logos, and for media-related requests, contact Karen Gilbert, Public Relations Director, at 303-273-3541 or kgilbert@mines.edu.

Registrar

LARA MEDLEY, Registrar
DAHL GRAYCKOWSKI, Associate Registrar for Systems
DIANA ANGLIN, Associate Registrar for Operations
TABATHA GRAYCKOWSKI, Assistant Registrar for Graduation
MARGARET KENNEY, Reporting Specialist
NOLAN OLTJENBRUNS, Registration Specialist
JUDY WESTLEY, Records Specialist

The Office of the Registrar supports the academic mission of the Colorado School of Mines by providing service to our current and former students, faculty, staff, and administration. These services include maintaining and protecting the integrity and security of the official academic record, registration, degree verification, scheduling and reporting. Our office routinely reviews policy, makes recommendations for change, and coordinates the implementation of approved policy revisions.

The Office of the Registrar seeks to fulfill this mission through a commitment to high quality service provided in a professional, efficient and courteous manner. Our specific services include but are not limited to:

- Enrollment and degree verifications
- Transcripts
- Degree auditing and diplomas (undergraduate)
- Transfer credit entry and verification
- Veteran's Administration Certifying Official services
- Registration setup and execution
- Course and room scheduling
- Academic and enrollment reporting
- Residency for current students
- Grade collection, reporting and changes

Management of the Registrar's Office adheres to the guidelines on professional practices and ethical standards developed by the American Association of Collegiate Registrars and Admissions Officers (AACRAO). Our office also complies with the Family Educational Rights and Privacy Act of 1974 (FERPA), Colorado Department of Higher Education rules and policies, and the Colorado School of Mines policies on confidentiality and directory information.

The Registrar's Office is located in the Student Center, Room 31. Hours of operation are Monday/Tuesday/Thursday/Friday, 9am-5pm; Wednesday 10am-5pm. The office phone number is (303) 273-3200. The fax number is (303) 384-2253. Lara Medley represents Colorado School of Mines as the Registrar. She is normally available on a walk-in basis (when not in meetings) if a student or other client has an issue that needs special attention. Appointments are also welcomed.

Research Administration

The Office of Research Administration (ORA), under the Vice President for Finance and Administration, provides administrative support in proposal preparation and contract and grant administration, which includes negotiation, account set-up, and close out of expired agreements. Information on any of these areas of research and specific forms can be accessed on our web site at www.is.mines.edu/ora.

Office of Strategic Enterprises

NIGEL MIDDLETON, Senior Vice President

The mission of the Office of Strategic Enterprises (OSE) is to bring Mines' educational and intellectual resources to the world and enable professionals, corporate entities, and universities from around the globe to interact with Mines. The goal is a distinctive "anywhere, anytime" approach to learning in a fast-paced, changing world. Initiatives include executive and corporate training, non-degree courses, and summer intensives. Professionals needing continuing education can find short-term and part-time offerings, targeted training, off-campus programs and certificate courses. OSE also reaches out to prospective universities on different continents to initiate partnerships that could benefit from Mines' academic capabilities in resource or energy development. Advancing Mines' global mission in other countries, OSE increases opportunities for international researchers to study at Mines, and for Mines researchers to work at international facilities. The Office of Special Programs and Continuing Education (SPACE) reports to OSE and administers most of the programmatic offerings. For further information about OSE, visit inside.mines.edu/Educational_Outreach.

Special Programs and Continuing Education (SPACE)

The SPACE Office administers short courses, special programs, and professional outreach programs to practicing engineers and other working professionals. Short courses, offered both on the CSM campus and throughout the US, provide concentrated instruction in specialized areas and are taught by faculty members, adjuncts, and other experienced professionals. The Office offers a broad array of programming for K-12 teachers and students through its Teacher Enhancement Program, and the Denver Earth Science Project. The Office also coordinates educational programs for international corporations and governments through the International Institute for Professional Advancement and hosts the educational portion of the Mine Safety and Health Training Program. A separate bulletin lists the educational programs offered by the SPACE Office, CSM, 1600 Jackson Street, Suite 160A Golden, CO 80401. Phone: 303 279-5563; FAX 303 277-8683; email space@mines.edu; website www.mines.edu/Educational_Outreach.

Telecommunications

The Telecommunications Office is located in the CTLM building 2nd floor east end room 256 and provides telephone services to the campus. The office is open 8:00am to 4:00pm Monday through Friday, and can be reached by calling (303) 273-3355 or via the web at http://inside.mines.edu/Telecommunications.

Courtesy phones are provided on each floor of the traditional residence halls and Weaver Towers as well as school owned fraternities and sororities. In-room phones are available to students living in Mines Park for $18.50 per month. Students wishing to take advantage of in-room phones in Mines Park should contact the Telecommunications Office to arrange for service. Telephone sets are not provided by the Telecommunications Office.

Students may make long distance calls from any CSM provided phone by using a third party calling card. Access to third party carriers is available through toll-free (800, 888, 877, 866 and 855) numbers provided by the third party carrier along with the appropriate instructions.

Women in Science, Engineering and Mathematics (WISEM) Program

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. For further information, contact: Debra K. Lasich, Executive Director of the Women in Science, Engineering and Mathematics Program, Colorado School of Mines, 1710 Illinois Street, Golden, CO 80401-1869. Phone (303) 273-3097; email dlasich@mines.edu; website http://wisem/mines.edu/.

Directory of the School

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ADMINISTRATION

Executive Staff

M. W. SCOGGINS, 2006-B.S., Ph.D., University of Tulsa; M.S., University of Oklahoma; President

TERENCE E. PARKER, 1994-B.S., M.S., Stanford University; Ph.D., University of California Berkeley; Provost and Executive Vice President; Professor of Engineering

NIGEL T. MIDDLETON, 1990-B.Sc., Ph.D., University of the Witwatersrand, Johannesburg; Senior Vice-President for Strategic Enterprises; Professor of Engineering, P.E., S. Africa

KIRSTEN VOLPI, 2005-B.S., University of Colorado; CPA; Senior Vice President for Finance and Administration

JOHN POATE, 2006-B.S., M.S., Melbourne University; M.A., Ph.D., Australian National University; Vice President for Research and Technology Transfer

DAN FOX, 2005-B.S., Montana State University, M.S., Eastern New Mexico University, Ph.D., University of Northern Colorado; Vice President for Student Life

PETER HAN, 1993-A.B., University of Chicago; M.B.A., University of Colorado; Chief of Staff

ANNE STARK WALKER, 1999-B.S., Northwestern University; J.D., University of Denver; General Counsel

MICHAEL DOUGHERTY, 2003-B.A., Cumberland College: M.B.A., University of Alaska Anchorage; Associate Vice President for Human Resources

ANITA PARISEAU, 2004-B.S., Ithaca College; Director of Alumni Relations/Executive Director CSM Alumni Association

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DIANA M. ANGLIN, 2008-B.S., Western Michigan University; Associate Registrar

DAVID G. BEAUSANG, 1993-B.S., Colorado State University; Computing Support Specialist

DEBORAH BEHNFIELD, 2007, B.A., Evergreen State College; B.A. Metropolitan State College of Denver; Recruitment Coordinator

GARY L. BOWERSOCK, JR, 1996-B.S., Colorado Technical University; Director of Facilities Management

HEATHER A. BOYD, 1990-B.S., Montana State University; M.Ed., Colorado State University; Director of Enrollment Management

THOMAS M. BOYD, 1993-B.S., M.S., Virginia Polytechnic Institute and State University; Ph.D., Columbia University; Associate Provost and Dean of Graduate Studies; Associate Professor of Geophysics

RONALD L. BRUMMETT, 1993-B.A., Metropolitan State College; M.A., University of Northern Colorado; M.B.A., University of Colorado Denver; Director of Student Services

CAROL R. CHAPMAN, 1999-B.A.,Wells College; M.P.A., University of Colorado; Special Assistant to the President

DIXIE CIRILLO, 1991-B.S., University of Northern Colorado; Associate Director of Athletics

JEAN MANNING CLARK, 2008-B.A., University of Phoenix; M.A., University of Phoenix; Director of Career Center and Coordinator of Employer Relations

JULIE COAKLEY, 2001-B.S., University of Toledo; M.S., University of Toledo; Senior Vice President for Strategic Enterprises

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COACHES/ATHLETICS FACULTY

SATYEN BHAKTA, 2011-B.A., Temple University; Instructor and Assistant Football Coach

STEPHANIE BEGLAY, 2007-B.S., Loras College, M.A., Minnesota State University at Mankato; Assistant Athletics Trainer

BOB BENSON, 2008-B.A., University of Vermont, M.Ed, University of Albany; Instructor and Associate Head Football Coach

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W. SCOTT CAREY, 2011-B.S., Tarleton State University; M.S., Northeastern State University; Instructor and Assistant Football Coach

CLEMENT GRINSTEAD, 2001-B.A., B.S. Coe College; Instructor and Assistant Football Coach

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JOSHUA HUTCHENS, 2007-B.S. Purdue, M.S. James Madison; Instructor and Co-Head Wrestling Coach

GREGORY JENSEN, 2000-B.S., M.S., Colorado State University; Instructor and Assistant Trainer

TYLER KIMBLE, 2007-B.S., Colorado State University; Instructor and Head Golf Coach

FRANK KOHLENSTEIN, 1998-B.S., Florida State University; M.S., Montana State University; Instructor and Head Soccer Coach

PAULA KRUEGER, 2003-B.S, M.S., Northern State University Head Women's Basketball Coach

ADAM LONG, 2010-B.S., M.S., Northwest Missori State University; Instructor and Assistant Football Coach

JENNIFER MCINTOSH, 1996-B.S., Russell Sage College, M.S., Chapman University; Head Athletic Trainer

GREG MULHOLLAND, 2007-B.S., Millersville University, M.S., University of Colorado at Denver; Instructor and Assistant Men's Soccer Coach

JERRID OATES, 2004-B.S., Nebraska Wesleyan University, M.S., Fort Hayes State University; Instructor and Head Baseball Coach

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NATHAN ROTHMAN, 2008-B.A., University of Colorado; Instructor and Head Swimming and Diving Coach

BRAD J. SCHICK, 2007-B.A., University of Northern Colorado; M.S. University of Nebraska at Omaha; Instructor and Assistant Men's Basketball Coach

ARTHUR SIEMERS, 2004-B.S., Illinois State University-Normal, M.S., University of Colorado-Boulder, Instructor and Head Track and Field and Cross Country Coach

BRITTNEY SIMPSON, 2008-B.S., Mesa State College, M.B.A., University of Colorado at Colorado Springs; Instructor and Assistant Women's Basketball Coach

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ROBERT A. STITT, 2000- B.A., Doane College; M.A., University of Northern Colorado; Head Football Coach

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LIBRARY FACULTY

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LAURA A. GUY, 2000-B.A., University of Minnesota; M.L.S., University of Wisconsin; Librarian

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LIA VELLA, 2011-B.A,, University of Rochester; Ph.D., University of Buffalo; M.L.I.S., University of Washington; Assistant Librarian

HEATHER WHITEHEAD, 2001-B.S., University of Alberta; M.L.I.S., University of Western Ontario; Associate Librarian

Policies and Procedures

Affirmative Action

Colorado School of Mines has instituted an affirmative action plan, which is available for perusal in numerous CSM offices including the Library, the Dean of Students' Office, and the Office of Human Resources.

Any person feeling that a violation of the following policies has occurred should promptly refer the matter to the Office of Human Resources, located in Guggenheim Hall (2nd floor), for investigation.

The institution's Statement of Equal Opportunity and Equal Access to Educational Programs, and associated staff contacts, can be found on page 10 of this Bulletin as well as the following website: http://inside.mines.edu/Policies.

Colorado School of Mines Unlawful Discrimination Policy and Complaint Procedure

As of June 2011, this policy is under revision. For a complete policy statement please see http://inside.mines.edu/Board_Policies.

Promulgated by the CSM Board of Trustees on March 13, 1992. Amended by the CSM Board of Trustees on June 10, 1999. Amended by the CSM Board of Trustees on June 22, 2000.

Colorado School Of Mines Sexual Harassment Policy and Complaint Procedure

As of June 2011, this policy is under revision. For a complete policy statement please see http://inside.mines.edu/Board_Policies.

Promulgated by the CSM Board of Trustees on March 13, 1992. Amended by the CSM Board of Trustees on March 26, 1998. Amended by the CSM Board of Trustees on June 10, 1999. Amended by the CSM Board of Trustees on June 22, 2000.

Colorado School of Mines Personal Relationships Policy

I. Statement of Authority and Purpose

This policy is promulgated by the Board of Trustees pursuant to the authority conferred upon it by §23-41-104(1), C.R.S. (1988 Repl. Vol.) in order to set forth a policy concerning certain personal relationships at CSM as addressed herein. This policy shall supersede any previously promulgated CSM policy which is in conflict herewith.

II. Preface

Certain amorous, romantic, or sexual relationships in which the parties appear to have consented, but where a definite power differential exists between them, are of serious concern to CSM. Personal relationships which might be appropriate in other circumstances always pose inherent dangers when they occur between an Instructor and a Student, between a Person in a Position of Trust and a Student, and between a Supervisor and a Subordinate Employee. Although both parties to the relationship may have consented at the outset, such relationships are fundamentally asymmetric in nature. It is incumbent upon those with authority not to abuse, nor appear to abuse, the power with which they are entrusted. Accordingly, codes of ethics promulgated by most professional regulatory associations forbid professional-client amorous, romantic, or sexual relationships. The relationships prohibited by this policy shall be viewed in this context, and Instructors, Persons in Positions of Trust, and Supervisors should be aware that any violation of this policy shall result in formal disciplinary action against them.

III. Definitions

For the purposes of this policy, the following definitions shall apply:

A. ***Person in a Position of Trust:*** Any person occupying a position of trust with respect to one or more students at CSM such that engaging in an amorous, romantic, or sexual relationship with any student would compromise the ability of the employee to perform his or her duties. Examples of Persons in Positions of Trust at CSM are those employed in the Office of the Registrar, those employed in the Student Life Office, those employed in the Student Development Office, those employed in Public Safety, resident assistants, and paper graders. The above examples are provided for illustrative purposes only and are not intended to be exhaustive listings or to limit the illustrated category in any manner.

B. ***Instructor:*** Any person who teaches at CSM, including academic faculty members, instructional staff, and graduate students with teaching or tutorial responsibilities.

C. ***Student:*** Any person who is pursuing a course of study at CSM.

D. ***Subordinate Employee:*** Any person employed by CSM who is supervised by another employee.

E. ***Supervisor:*** Any person employed by CSM who occupies a position of authority over another employee with regard to hiring, administering discipline, conducting evaluations, granting salary adjustments, or overseeing task performance.

IV. Policy

A. Personal Relations Between Instructors and Students in the Instructional Context

No Instructor shall engage in an amorous, romantic, or sexual relationship, consensual or otherwise, with a Student who is enrolled in a course being taught by the Instructor, or whose academic work is being supervised by the Instructor.

B. Personal Relationships Between Instructors and Students Outside the Instructional Context

In a personal relationship between an Instructor and a Student for whom the Instructor has no current professional responsibility, the Instructor should be sensitive to the constant possibility that he or she may unexpectedly be placed in a position of responsibility for the instruction or evaluation of the Student. This could entail a request to write a letter of recommendation for the Student or to serve on an admissions or selection committee involving the Student. In addition, an awareness should be maintained that others may speculate that a specific power relationship exists even when none is present, giving rise to assumptions of inequitable academic or professional advantage of the Student. Even if potential conflict of interest issues can be resolved, charges of sexual harassment may arise. In such situations, it is the Instructor who, by virtue of his or her special responsibility, shall be held accountable for unprofessional behavior.

C. Personal Relationships Between Supervisors and Subordinate Employees

No Supervisor shall engage in an amorous, romantic, or sexual relationship, consensual or otherwise, with a Subordinate Employee who reports, either directly or indirectly, to the Supervisor or is under the Supervisor's direct or indirect authority.

D. Personal Relationships Between Persons in Positions of Trust and Students

No Person in a Position of Trust shall engage in an amorous, romantic, or sexual relationship, consensual or otherwise, with a Student.

(Promulgated by the CSM Board of Trustees on February 14, 1992)

Index

T

U

V

W