

# *Colorado School of Mines 2002 – 2003 Undergraduate Bulletin*

To CSM Students

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## Academic Calendar

Fall Semester	2002
Confirmation deadline .....	Aug. 19, Monday
Faculty Conference .....	Aug. 19, Monday
Classes start (1).....	Aug. 20, Tuesday
Graduate Students—last day to register without late fee .....	Aug. 23, Friday
Labor Day (Classes held) .....	Sept. 2, Monday
Last day to register, add or drop courses without a “W” (Census Day) .....	Sept. 4, Wednesday
Fall Break Day .....	Oct. 14, Monday
Midterm grades due .....	Oct. 14, Monday
Last day to withdraw from a course—Continuing students/All graduate students .....	Oct. 29, Tuesday
Priority Registration Spring Semester .....	Nov. 11–15, Monday–Friday
Thanksgiving Break .....	Nov. 28–Dec. 1, Thursday–Sunday
Last day to withdraw from a course—New undergraduate students .....	Nov. 27, Wednesday
Classes end .....	Dec. 5, Thursday
Dead Day .....	Dec. 6, Friday
Graduating students’ lowest possible grades due .....	Dec. 10, Tuesday
Final exams .....	Dec. 7, 9–12, Saturday, Monday–Thursday
Semester ends .....	Dec. 13, Friday
Midyear Degree Convocation .....	Dec. 13, Friday
Final grades due .....	Dec. 16, Monday
Winter Recess .....	Dec. 14–Jan. 8, Saturday–Wednesday

<b>Spring Semester</b>	<b>2003</b>
Confirmation deadline .....	Jan. 8, Wednesday
Classes start (1) .....	Jan. 9, Thursday
Grad Students—last day to register without late fee .....	Jan. 10, Friday
Last day to register, add or drop courses without a “W” (Census Day) .....	Jan. 24, Friday
Midterms grades due .....	March 10, Monday
Spring Break .....	March 17–23, Saturday–Sunday
Last day to withdraw from a course– .....	April 8, Tuesday
All students except new undergraduates & 2nd semester freshmen	
E-Days .....	April 3–5, Thursday–Saturday
Priority Registration Field, Summer, Fall Terms .....	April 7–11, Monday–Friday
Last day to withdraw from a course—new undergraduates & 2nd semester freshmen .....	April 25, Friday
Classes end .....	May 1, Thursday
Dead Day .....	May 2, Friday
Graduating students’ lower possible grades due .....	May 6, Tuesday
Final exams .....	May 3, May 5–8, Saturday, Monday–Thursday
Semester ends .....	May 9, Friday
Commencement .....	May 9, Friday
Final grades due .....	May 12, Monday
<b>Field/Summer Sessions</b>	<b>2003</b>
First Field Term First Day of Class, Registration (1) .....	May 12, Monday
Last day to register, add or drop courses without a “W”—Field Term (Census Day) .....	May 16, Friday
Memorial Day (Holiday—No classes held) .....	May 26, Monday
Last day to withdraw from First Field Term .....	June 6, Friday
First Field Term ends .....	June 20, Friday
Field Term grades due .....	June 23, Monday
Summer School First Day of Class, Registration (1) .....	June 16, Monday
Last day to register, add or drop courses without a “W”—Summer School .....	June 23, Monday
(Census Day)	
Independence Day (Holiday—No classes held) .....	July 4, Friday
Second Field Term begins .....	July 7, Monday
Last day to register, add or drop courses without a “W”—Second Field Term .....	July 11, Friday
Last day to withdraw from Summer School .....	July 11, Friday
Last day to withdraw from Second Field Term .....	Aug. 1, Friday
Summer School ends .....	Aug. 8, Friday
Summer School grades due .....	Aug. 11, Monday
Second Field Term ends .....	Aug. 15, Friday
Second Field Term grades due .....	Aug. 18, Monday

(1) Petition for changes in tuition classification due in the Registrar’s office for this term.

# 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 127 year 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 and Petroleum Refining 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. New methods of exploration, mining and recovery were needed. A number of men with names like Loveland, Berthoud, Arthur Lakes, George West and the Episcopal Bishop Randall proposed a school of mines. In 1874 the Territorial Legislature passed an appropriation of \$5,000 and commissioned W.A.H. 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. With the achievement of statehood in 1876, the Colorado School of Mines was constitutionally established. The first diploma was awarded in 1882.

As CSM grew, its mission expanded. From a rather narrow initial focus on nonfuel minerals, it developed programs as well in petroleum production and refining. More recently it has expanded into the fields of materials science and engineering, energy and environmental engineering, and economics as well as a broader range of 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 has always had an international reputation in resource fields. Graduates have come from nearly every nation in the world and alumni can be found in nearly every nation.

The student body was predominantly white male for many years, reflecting the demographics of the industries it served. The School gave one of the early engineering degrees for women to Florence Caldwell in 1897 but there were many subsequent years when there were no female students. This has changed and today approximately 25% of the overall student body are women and 15% of the undergraduates are underrepresented minorities, thanks to strong recruiting efforts and the opening up of traditionally white male industries.

## Unique Programs

Colorado School of Mines is an institution of engineering and applied science with a special focus in the resource areas. 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. It serves as a model for such programs here and elsewhere.

While many of the programs at CSM are firmly grounded in tradition, they are almost all undergoing continual evolution. 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.

## Location

Golden, Colorado has been the home for CSM since its inception. Located 20 minutes west of Denver, this community of 15,000 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

Colorado School of Mines is accredited through the doctoral degree by the Higher Learning Commission and is a member of the North Central Association. 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, 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 nonvoting student member is elected annually by the student body. 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.

## Section 2- Student Life

### Facilities

#### *Student Center*

The Ben H. Parker Student Center has recently undergone a four million dollar renovation and addition. The building contains the offices for the Vice President of Student Life and Dean of Students, the Director of Student Life, Housing, Conferences Reservation Office, Student Activities and Greek Advisor, ASCSM Offices, and Student Groups. The Student Center also contains the student dining hall, the I-Club, a food court, game room, bookstore, and student lounges and TV room. There are also a number of meeting rooms and banquet facilities in the Student Center. Another addition was completed during the summer of 2001 which contains meeting rooms and banquet facilities as well as the Admissions, Financial Aid and Registrar's Offices, Career Services, International Student Services, the Cashier's Office, and Student Development and Academic Support Services.

### Services

#### *Academic Advising*

Freshmen are advised under the Freshman Mentor Program, designed

- ◆ to ease the transition from high school or work to college,
- ◆ to provide quality academic advising,
- ◆ to provide a resource/contact person for critical periods during the freshman year, and
- ◆ to give students an opportunity to get to know a campus professional.

Each mentor, who is a member of the faculty or professional staff, advises approximately 10 students. Undecided transfer students are advised by the Admissions Office during their first year. Upperclass students and transfer students who have declared a major are advised by an advisor in their option department.

Questions concerning work in a particular course should be discussed with the course instructor. General academic program scheduling and planning questions can be answered by the student's advisor or mentor. The advisor's or mentor's signature is required on the early registration form filed by every student. A student meets with the mentor or advisor before registration. An advising hold is placed on the student before registration until the student's advisor clears the advising hold.

#### *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. 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 300 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.

**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. Gender issues, personal security, and compatibility with roommates 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. Advising on individual learning skills is also available.

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.

#### *International Student Affairs*

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 Host 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) located in Stratton Hall, room 109, develops international opportunities for students and faculty at CSM, including study abroad programs. For information about the international activities of OIP, see p. 111.

### ***English as a Second Language Program***

The INTERLINK program at Colorado School of Mines combines intensive English language instruction with training in skills necessary for successful academic and social life at an American engineering university. Designed to address the special linguistic needs of students in the fields of science and technology, its curriculum focuses on reading, writing, grammar, listening, conversation, pronunciation, and study skills. Instruction is offered in 9-week sessions at five levels of proficiency. At the successful completion of the fifth level, a qualified student can understand, take notes on academic lectures, make oral presentations, read scholarly books and journals, conduct library research, and write essays and research papers.

Admission to the program is open to adults who have completed secondary school in good standing (grade point average of C+ or above) and are able to meet their educational and living expenses. For further information contact INTERLINK Language Center (ESL) at Colorado School of Mines, Golden, CO 80401; call (303) 273-3516 or FAX (303) 273-3529.

### ***Identification Cards***

All new students should have an identification card made as early as possible their first semester. Identification cards are made in the Student Activities Office in the Student Center. In subsequent semesters, validation stickers may also be obtained from the Student Activities Office. Lost, stolen or damaged identification cards will be replaced for a small fee. The identification card is required to check material out of the CSM Library and various other CSM activities may require its presentation. All students are required to carry their ID at all times while on campus.

### ***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 \$45 fee each semester which entitles them to unlimited visits with a physician or nurse as well as prescription and over the counter medications. The health center also provides wellness education, immunizations, allergy shots, flu shots, nutrition counseling and information regarding a wide range of health concerns. Staff members are also available to provide health-promotion events for students groups and residence hall program. The Students Health Center is open Monday through Friday 8-12 and 1-4:45 P.M. It is staffed by RN's throughout the day. Physicians coverage is provided by family practice physicians who are on site for two hours daily and on-call at all times.

Dental services are also provided at the Student Health Center. These services are provided by a dentist who has scheduled hours two days per week four hours per day. Basic services such as x-rays, cleanings, fillings and extractions are available.

To be eligible for care, students must be enrolled in four or more hours; have paid the Health Center fee if they are part time and have a completed Health History Form on file at the Health Center. Supervised by Vice President and Dean of Student Life. Phone: (303) 273-3381; FAX: (303) 279-3155.

### ***Motor Vehicles Parking***

All students are permitted to bring motor vehicles on campus but they must be registered with CSM Public Safety. Regulations for parking may be obtained from CSM Public Safety. Some parking space is restricted, and this must be observed.

### ***Career Center (Placement and Cooperative Education)***

The Career Center assists and advises students in their search for engineering-related employment. Each year industry and government representatives visit the campus to interview students and explain employment opportunities. Fall is the major recruiting season for both summer and full-time positions, but interviews take place in the spring as well. Students must be registered with the Career Center in order to interview, which is accomplished by submitting resumes and signing a card giving the Center permission to disseminate student materials.

A Career Manual is available to students to help in resume writing, interviewing and off-campus job search. Staff members offer individual critiques of resumes and letters, and personal job search advice. A small library of directories and other job search materials is available for check-out. Many workshops are offered throughout the year on job search topics, and video-taped practice interviewing is available.

The Career Center sponsors a Career Day each fall and spring to allow students to explore career options with exhibiting employers. A Shadowing Program is available for students who wish to visit a local professional in order to clarify career goals. For students undecided about which engineer or science career to pursue, career counseling is provided.



The Cooperative Education Program is available to students who have completed three semesters at CSM (two for transfer students). It is an academic program which offers 3 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. Part-time CO-OP is also possible if a student is working 20 hours per week for several semesters. Students must register for CO-OP while on the job (a no credit, no fee class), and must write learning objectives and sign informal contracts with their company's representative to ensure the educational component of the work experience.

Full-time, part-time, summer and CO-OP jobs are publicized in the Career Center as well as on bulletin boards around the campus. Students are often contacted by the Career Center regarding specific opportunities, and resumes are sent by the Center directly to employers. CSM graduates are eligible for the services of the Career Center for 18 months after graduation. Information on starting salaries, summer salaries, job search success rates, and other topics is collected and available through the Center.

### ***Standards, Codes of Conduct***

Every fall, each student is supplied with a Student Handbook that lists all School regulations governing conduct, including discrimination, alcoholic beverages, drugs, academic dishonesty, and distribution of literature, as well as the process for filing a complaint. Anyone having additional questions concerning these regulations should contact the Dean of Students.

### ***Student Publications***

Three 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 Prospector is the student yearbook. Published annually in late spring, its staff strives to capture the essence of a school year in pictures and print.

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 Liberal Arts and International Studies Department provides similar service to the High Grade.

### ***Veterans Counseling***

The Registrar's Office provides veterans counseling 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 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, 1500 Illinois, Golden, CO 80401-1869, or call (303) 273-3097.

### ***Minority Engineering Program***

The Minority Engineering Program is located at 1215 16th 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), Asian Student Association (ASA), 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.

**The 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.

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

## Activities

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, responsibility, 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** serves ASCSM as the campus special events board. The majority of all student campus events are planned by the MAC committees. These committees are: **Friday Afternoon Club (FAC)**, which provides comedians and other performing artists to the campus on most Fridays throughout the academic year; **Special Events** which coordinates events such as the annual Back to School Bashes, Discount Sport Nights at Rockies or Avalanche Games, and one time specialty entertainment; 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, oil-field olympics, and softball, just to name a few. Additional events include a huge fireworks display, 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.

**The Military Ball**, a dinner and dance sponsored by the ROTC Battalion, is held each spring and is one of the most

colorful affairs of the year.

**Winter Carnival**, sponsored by Blue Key, is an all-school ski day held each year at one of the nearby ski slopes.

### *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, 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 recognize different achievements in our students. The Colorado School of Mines honor societies, and their representative areas, are as follows:

- Alpha Phi Omega - Service
- Alpha Sigma Mu - Metals
- Blue Key - Service, Scholarship, Activities
- Kappa Mu Epsilon. - Mathematics
- Order of Omega
- Pi Epsilon Tau - Petroleum Engineering
- Tau Beta Pi - Engineering

### *Interest Organizations*

Interest organizations meet the special and unique needs of the CSM student body by providing co-curricular activities in specific areas. These organizations are:

- Amnesty International
- Anime Club
- Association of Geoscience Students (AGS)
- Ballroom Dance Band
- Campus Crusade for Christ
- Capoeira Clubs
- Choir
- CSM Ambassadors
- Earthworks
- Fellowship of Christian Athletes
- Fellowship of Christian Cowboys
- High Grade
- Math Club
- Mines Little Theatre
- Non Traditional Students
- Oredigger
- Prospector
- Students for Creative Anachronism

### *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.

These organizations are:

- Chinese Student Association

International Student Organization  
Japanese Student Association  
Kuwaiti Student Association  
Middle Eastern Student Association  
Muslim Student Association  
Omani Student Association  
Taiwanese Student Association

### *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. The Colorado School of Mines chapters are as follows:

American Association of Drilling Engineers (AADE)  
American Association of Petroleum Geologists (AAPG)  
American Institute of Chemical Engineers (AIChE)  
American Institute of Mining, Metallurgical & Petroleum Engineers (AIME)  
American Institute of Professional Geologists  
American Ceramic Society (A. Cer. Soc.)  
American Chemical Society  
American Indian Science & Engineering Society (AISES)  
American Society of Civil Engineers (ASCE)  
American Society of Mechanical Engineers (ASME)  
American Society of Metals (ASM International)  
American Welding Society  
Asian Student Association (ASA)  
Association of Engineering Geologists (AEG)  
Association of General Contractors (AGC)  
Institute of Electrical & Electronic Engineers (IEEE)  
National Society of Black Engineers (NSBE)  
Society of American Military Engineers (SAME)  
Society of Automotive Engineers (SAE)  
Society of Economics and Business  
Society of Economic Geologists (SEG)  
Society of Hispanic Professional Engineers (SHPE)  
Society of Mining Engineers (SME)  
Society of Petroleum Engineers (SPE)  
Society of Physics Students (SPS)  
Society of Student Geophysicists (SSG)  
Society of Women Engineers (SWE)  
The Minerals, Metals & Materials Society of AIME

### *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. These clubs are:

Bicycle Club  
Bridge Club  
Caving Club  
Cheerleading  
Ice Hockey Club  
Kayak Club  
Kendo Club  
Lacrosse Club  
Men's Volleyball  
Outdoor Club  
Racquetball Club  
Rugby Club  
Shooting Club  
Ski Club/Team  
Tae Kwon Do Club

Ultimate Frisbee  
Water Polo Club  
Willie Wonka Boarders  
Women's Soccer

### *Outdoor Recreation Program*

The Outdoor Recreation Program is housed at 1224 17th Street, across from the Intramural Field. 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.

## **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 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 medal with 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.** The award is for the graduating senior who has excelled in the Humanities.

**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.

**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.

**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 at CSM are kept at a minimum consistent with the cost of instruction and the amount of state funds appropriated to the School. The following rates are in effect for 2002–2003. Increases can be expected in subsequent years.

## Tuition

### Full-time Students

Resident	Non-resident
\$2,623/sem	\$8,758/sem

For more information see the CSM web site at <http://csmis5.mines.edu/tuition/>.

## Fees

### Regular Semester (Fall/Spring)

During a regular semester, students taking less than 4 credit hours are not required to pay student fees, except for the Technology Fee. Any such student wishing to take part in student activities and receive student privileges may do so by paying full semester fees. All students carrying 4 or more credit hours must pay full student fees as follows:

Health Center*	\$45.00
Associated Students	58.00
Athletics	46.00
Student Services	130.00
Student Assistance	14.00
Technology Fee	60.00
Total	\$353.00

\*A health insurance program is also available. Health insurance is a mandatory fee unless the student can prove coverage through another plan.

### Summer Session

#### Academic Courses

Health Center	\$22.50
Athletics	23.00
Student Services	65.00
Technology Fee	30.00
Total	\$140.50

#### Field Term Courses

On-campus:	Health Center \$17.00
	Student Services \$47.00

Off-campus: Arrangements and payment for transportation, food, lodging, and other expenses must be made with the department concerned. (Geology Department camping fee is \$135.)

#### Miscellaneous

New Student Orientation	\$40.00
New International Stu. Orient.	\$55.00
(exempt from refund policy)	
Chem Lab Fee	\$30.00
Engineering Field Session	\$50.00
Graduation (Bachelors)	\$90.00

Student Health Insurance - At publication 2002–2003 rates had not been determined.

#### Military Science

Lab Fee	\$175.00
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## Descriptions of Fees and Other Charges

The following mandatory, non-waivable fees are charged by the Colorado School of Mines to all students enrolled for 7.0 semester hours or more:

Health Center Fee - Revenues support physician/Medical services to students.	\$45.00/term
Associated Students Fee - Revenues support student organizations/events/activities; e.g., newspaper, homecoming, E-days. Expenditures must be approved by ASCSM.	\$58.00/term
Athletics Fee - Revenues support intercollegiate athletics and entitle student entrance to all scheduled events and use of the facilities.	\$46.00/term
Student Assistance Fee: funds safety awareness programs, training seminars for abuse issues, campus lighting, and parking facility maintenance.	\$14.00/term
Student Services Fee - Revenues support bond indebtedness and other student services; e.g., Placement/Co-Op, Student Development Center, Student Activities, Student Life, and services provided in the Student Center.	\$130.00/term
Technology Fee: funds technology infrastructure and equipment for maximum student use. The School matches the student fee revenues dollar for dollar.	\$60.00/term

The following mandatory, waivable fee is charged by the Colorado School of Mines to all degree seeking students, regardless of full-time or part-time student status:

Student Health Insurance - Revenues contribute to a self-insurance fund. At publication 2002–2003 rates had not been - determined.

The following are established fees that are case dependent.

Late Insurance Waiver Fee - Revenues provide funds for the administration of the health insurance program.	\$60.00
Chemistry Lab Fee - Revenues provide a contingency against breakage of laboratory equipment; e.g., test tubes, beakers, etc. .....	\$30.00/course
Field Camp Fee - Revenues support the instructional activities/services provided during Field session. depending on Dept	\$100.00 - \$800.00
Military Science Lab Fee - Revenues support the instructional activities of the Military Science Department.	\$175.00 ROTC
New Student Orientation Fee - Revenues support the new student orientation program provided to freshmen and transfer students at the start of the Fall and Spring semesters. This fee is exempt from refund policy.	\$40.00
New International Students .....	\$55.00
On-line Course Fee .....	\$40.00/credit hour
Summer Orientation Fee - Revenues support the Explore CSM programs provided to freshmen students and their parents during the summer. ....	\$40.00
Transcript Fee - Revenues support the cost of providing transcripts.	\$2.00/copy
Yearbook Fee - Revenues support the publication of the CSM yearbook, The Prospector.	\$30.00/yr.
Add/Drop Charge - Revenues offset the cost of processing Add/Drop registration.	\$4.00 each
Late Payment Penalty - Revenues offset billing costs for late payments. 1.5% per month of outstanding balance	
Housing Application Fee .....	\$50.00
Damage Deposit, (Housing) - Revenues are used to repair or replace damaged items/rooms in CSM housing units. Mines Pk & P.Village .....	\$400.00
Bike Locker Rental - Revenues go to provide and maintain locker facilities for residence hall student bicycles.	\$40.00/sem
Residence Hall Room Charge - Revenues support maintenance, improvements and residence hall administration. See Housing Rates on next page	
Meal Plan Charges - Revenues provide meals and maintain cafeteria equipment for the students on meal plans. See Meal Plans on next page	
Residence Hall Association Fee - Revenues support social activities for the residence hall students.	\$35.00/year
Housing and Rental Fees - Rental fees for housing rentals go to maintain the rental properties, pay utility charges, and maintain and improve properties. .... See Housing Rates on next page	
Tuition Paid-Out - CSM has advanced tuition to another school. Charges are reimbursement request for those advances. Only for sponsored students .....	Paid by sponsor
Books/Supplies Fee - Advances made to or on behalf of the student. Charges are reimbursement only. Only for sponsored students Paid by sponsor	
Computer Usage Fees - Revenues assist in providing research computing services.	\$500.00/term Paid by sponsor
Refunds or Advances - These charges are reimbursement requests for funds advanced to or on behalf of the student. Funds received replace those advances. ....	N/A
Payments - CSM must repay to the bank any student funds for which a student becomes ineligible. Funds collected from the student replace those payments. ....	N/A
Grants and Scholarships (Recalled) When students become ineligible for grant, loan or scholarship money which they have received, the recall of those funds are reflected. ....	N/A
Return Check - The amount of a student's check which has been returned for insufficient funds.	N/A
Returned Check Charge - Revenues offset bank fees for returned checks.	\$20.00
Voice mail Fee: Assessed to students living in campus housing who request voice mail services. (Optional) .....	\$45.00/year \$22.50/sem

In all instances, the costs to collect these 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 fall under the same guidelines as payment of tuition and fees. Rates below are in effect for the 2000-2001 Academic year. Included is a "flexible" meal plan which guarantees students a designated number of meals per week and gives them between \$50.00 - \$75.00 to spend as they wish on additional meals or in the deli at the Student Center. For more information, please contact the Student Life Office at (303) 273-3350.

### *Rates for 2001-2002 (per year)*

#### **Residence Halls (Students must choose a meal plan)**

##### **Bradford and Randall Halls**

Double Room.....	\$ 3,020
Single Room .....	\$ 3,595
Double Room as Single.....	\$ 3,915

##### **Morgan and Thomas Halls**



Double Room.....	\$ 3,105	
Single Room .....	\$ 3,700	
Double Room as Single.....	\$ 3,985	
<b>Weaver Towers</b>		
Double Room.....	\$ 3,475	
Single Room .....	\$ 4,055	
Double Room as Single.....	\$ 4,467	
“E” Room, Single.....	\$ 4,356	
Residence Hall Association Fee .....	\$70 included above	
	<u>01-02</u>	<u>02-03</u>
<b>Sigma Nu House</b> .....	\$ 3,235	\$ 3,431
<b>FJI</b> .....	\$ 3,510	\$ 3,722
<b>Meal Plans (per year)</b>		
Marble Plan (19-meal + plan) .....	\$ 2,815	
.....	plus \$50 declining balance	
Diamond (19-meal plan) .....	\$ 2,764	
Granite (15-meal plan) .....	\$ 2,693	
Quartz (160-meal plan) .....	\$ 2,583	
.....	plus \$75 declining balance	
<b>Field Session (Six weeks)</b>		
Thomas Hall		
Double Room .....	\$ 330	
Single Room .....	\$ 575	
Meal Plans		
Gold Card (declining balance) .....	\$ 250.00 minimum	
<b>Summer Session (Eight weeks)</b>		
Thomas Hall Double Room .....	\$ 430	
Single Room .....	\$ 685	
Meal Plans		
Gold Card (declining balance) .....	\$ 330 minimum	
<b>Mines Park</b>		
<b>Family Housing</b>		
1 Bedroom.....	\$ 589	
2 Bedroom.....	\$ 673	
<b>Apartment Housing</b>		
1 Bedroom.....	\$ 589	
2 Bedroom.....	\$ 792	
3 Bedroom.....	\$ 1,053	
<b>Prospector Village (per month)**</b>		
2 Bedroom Apartment.....	\$ 600	
<b>Additional Rentals</b>		
1220 17th Street.....	\$ 560	

\*Tenant pays gas and electricity only

\*\* CSM pays all public utilities, gas, electricity, water. Tenant pays \$18.50/month per phone line (optional). Tenant pays \$45.00 per voice mail (optional) per year.

### **Residence Hall Application**

Information and application for residence hall space are 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 mailed to the student to be signed by the student and his or her parents and returned to the Residence Life Office . Only upon receipt and written acknowledgement of the residence hall contract 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 of \$50 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, \$25 of the deposit will be refunded if notice of the cancellation is received in writing by the Residence Life Office on or before May 15 of the current year.

Contracts are issued for the full academic year and no cancellation will be accepted after May 15, 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 15. 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 should mail their payment to:

Cashier  
Colorado School of Mines  
Golden, CO 80401-1887

Please note your social security number on payment.

### *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.

To comply with federal regulations surrounding student financial aid programs, the Director of Financial Aid may modify this schedule in individual circumstances.

The schedule above applies to the Fall and Spring semesters. The time periods for the Summer sessions - Field and Summer - 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.

## **Residency Qualifications**

A student is classified as a resident or nonresident for tuition purposes at the time admission is granted. 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 meets 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 22 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.

## **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 \$28 million in total assistance in 2001-2002, including over \$8 million in grants and scholarships.

### ***Applying for Assistance***

The CSM Application for Admission serves as the application for CSM merit-based scholarships for new students (the Athletic and Military Science Departments 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.

After the student's and family's financial circumstances are reviewed, a financial aid award is sent to the student.

New students are notified beginning in late March, and continuing students are sent an award letter in early June.

### *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 12 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 who have special talents or achievements. Academic awards to new students are made on the basis of their high school records, SAT or ACT test scores, academic interests, and extracurricular activities. Continuing students receive 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.

**President's Scholarships** are awarded to incoming freshmen, and typically continue for four years (or eight semesters) if the student continues to meet the academic requirements for renewal.

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

**Specially named scholarships** are provided by friends of CSM who are interested in assisting qualified students to prepare for careers in science and engineering related to the energy industries and high technology. The generosity of the following donors is recognized:

#### *Scholarship/Donor*

Adolph Coors Jr. Memorial	Various
Adolph Coors Foundation Minority Program	Adolph Coors Foundation
Alcoa Foundation	Alcoa Foundation
Robert L. Allardyce Endowment	Robert L. Allardyce
Amoco CEPR	Amoco Foundation
Amoco Foundation Fund	Amoco Foundation
The S.E. Anderson '32 Fund	S.E. Anderson
Frank & Peter Andrews Endowed	Estate of P.T. Andrews
George & Marjorie Ansell Endowed	Dr & Mrs Ansell
ARCO Foundation	ARCO Foundation
ARCO Minority Scholarship	ARCO
ARCS Foundation	ARCS Foundation
Benjamin Arkin Memorial	Harry and Betty Arkin
Timothy Ashe & Blair Burwell Endowed	Various
R.C. Baker Foundation	R.C. Baker Foundation
Barlow & Haun Endowed	Barlow & Haun
Paul Bartunek Memorial	Estate of Paul Bartunek/Various
C.W. Barry Endowed	Various
Boettcher Foundation	Boettcher Foundation
David S. Bolin Endowed	Various
BP Exploration Inc.	BP Exploration
Quenton L. Brewer Memorial Endowed	Quenton Brewer
David C. Brown Fund	David C. and Yukiko Brown
Dean Burger Memorial Fund	Ben L. Fryrear
Bruce Carlson Mining Fund	Various
Michael E. Carr Endowed	Michael Carr
Lynll Champion Endowed	Charles Champion

Celcius Scholarship	Celcius
Chevron Corp. USA	Chevron
Faculty/CR	Various
Norman J. Christie Canadian Endowed	Various
Ted Christiansen Fund	Ted Christiansen
Melvin F. Coolbaugh Award	Class '33 Alumni
Class of 39 Endowed Athletic	Class of '39/Various
Class of 1942 Memorial	Various
Class of 1952 Endowed	Class of '52/Various
Collester Endowed Fund	Stewart M. Collester
Malcom E. Collier Endowed	Malcom Collier, Jr.
Coulter Foundation Undergraduate	
V.V. Coulter Foundation	
Cyprus Minerals Company	Cyprus
Chester Davis Chemistry	Chester Davis
Lawrence S. DeMarco Memorial	Various
Denver Gem & Mineral Guild	Denver Gem & Mineral
Denver Geophysical Society	Denver Geophysical Society
Kuno Doerr, Jr. Memorial	Q.M. Fitzgerald
Tenney Cook DeSollar	Estate of Edythe Desollar
Philip F. Dickson Memorial	Family of P F. Dickson
Brian & Elizabeth Downward Memorial	Various
Edna Dumke Memorial	Various
Faculty, Division of Engineering	Various
Exxon Coal & Mineral Co.	Exxon
FMC Gold Student Support	FMC Foundation
Charles F. Fogarty Fund	Mrs. Charles F. Fogarty
Foundry Educational Foundation	Foundry Educational Foundation
Frank C. Frischknecht Geophysics Fund	Dr. Jaqueline Frischknecht
Maxwell E. Gardner Memorial	Various
Garg Endowed Fund	Arvind & Om Garg
Faculty/Geochemistry	Various
Faculty/Geology	Various
Robert L. Gibson Endowed	Estate of R.L. Gibson
Gulf Oil Foundation	Gulf Oil Foundation
Margaret & Al Harding Fund	Mr & Mrs Harding
Charles J. Hares Memorial	Various
George Robert & Robert Michael Harris	Robert Harris
Scott W. Hazen Endowed Financial Aid	Scott & Dorothy Hazen
H.H. Harris Foundation	H.H. Harris Foundation
Hill Foundation	Hill Foundation
Robert E. Hochscheid Memorial	Various
Edward C. Horne	Mr. Horne
Charles Horvath Endowed	C. Horvath Estate
David C. Johnston Memorial	Geo R. Brown
Kaiser Aluminum Fund	Kaiser Aluminum
Wm. Keck Foundation	Wm. Keck Foundation
John V. Kline Memorial	Estate of John Kline/Various
James A. Kohm Memorial	F. A. Kohm
Richard & Marie Kuehl Scholarship	Richard & Marie Kuehl
Francis J. & Mary Labriola Endowed	Mr. & Mrs. Labriola
Parker Liddell Memorial	Estate of Parker Liddell
Linn Scholarship	Linn Family
Frank Lindeman Jr. Memorial	Various
George & Susan Lindsay	Susan Lindsay Trust

John P. Lockridge Fund	John P. Lockridge
Paul Cyrus Mann Memorial	Various
Marathon Oil Company	Marathon Oil
B.E. Mares Trust Undergrad Scholarship in Petroleum Engineering	B.E. Mares
Barbara Jean Martinez Memorial	Martinez Family/Various
Math Undergraduate	Various
Vernon L. Mattson Fund	Alience M. Mattson
Maxwell L. McCormick Memorial	Maxwell McCormick
Joseph McNeil Memorial	Harry L. McNeill
Thomas Mead Endowed	William Mead
Donald & Barbara Miller	Donald & Barbara Miller
Minerals Industry Education Foundation	EndowedMinerals Inc. Education Foundation
Faculty Mining Fund	Various
Minorco (USA) Scholarship	Minorco
Mobil Oil Corp	Mobil Oil
Rex Monahan Scholarship in Geology	Rex Monahan
John Moore Endowed Scholarship	Florence Moore
James D. & Lois H. Mulryan Endowed	James & Lois Mulryan
Earl H. Murchison Memorial	Irene Murchison
Newmont Mining Corporation	Newmont Mining
Duane T. Nutter Estate	Bequest
Oryx Energy Company	Oryx
John W. Page Foundation	J.W. Page Foundation
Ben Parker & James Boyd Student Development	Dr. & Mrs James Boyd
Russell Barnett Paul Memorial	Lee Paul
Pennzoil Student Financial Aid	Pennzoil
Franklin H. Persse Scholarship	Franklin H. Persse
Phelps Dodge NASP	Phelps Dodge
John S. Phillips Memorial Fund/Geology	D.R. Phillips
Phillips Petroleum Co.	Phillips Petroleum
Robert G. Piper/Wisconsin Centrifugal Endowed Fund	Wisconsin Centrifugal
Paula S. Pustmueller	Various
Ben M. Rastall	Ben Rastall
Runners of the Rockies	Runners of the Rockies
Rocky Mtn. Coal Mining Institute	Rocky Mtn Coal Institute
Rocky Mountain Chapter ASM	ASM
Rowlinson Endowed	Norman Rowlinson
Robert Sayre Endowed	Robert Sayre
Schlechten Fund	Daniel Delaney
Schlumberger Collegiate Award	Schlumberger Foundation.
Viola Seaver Memorial	V. Seaver Estate
Shell Foundation Incentive Fund	Shell
Robert Shipley Memorial	Ulsinternl Inc
SME-AIME Coal Division Fund	SME-AIME
Sonnenfeld PHD	Amoco
Eugene M. Staritzky Fund	Anna S. Stern
Ted P. Stockmar Fund	Holme Roberts Owen
Stoddard Endowed Memorial	Edna L. Stoddard
Jeanne Storrer & R. Charles Earlougher Endowed	Charles Earlougher
Ruth and Vernon Taylor Foundation	R & V Taylor
J. & M. Thompson Endowed Undergraduate - Mining	J. & M. Thompson
Robert E. Thurmond	Robert Thurmond
H. Trueblood Foundation Geology	Harry Trueblood Foundation
Union Pacific Corporation	Union Pacific Corporation
Union Pacific Foundation	Union Pacific

Unocal Corp. Academic	Union Oil	
C. Richard Wagner Memorial Endowed	Evelyn Wagner	
Bill and Grace Waldschmidt	Various	
Michael Colin Watts Fund	Kiwanis /Monta Vista	
G.C. Weaver	G.C. Weaver	
Frederick L. (Fritz) and Virginia Weigand Scholarship Fund		Frederick Weigand
Loren Weimer Memorial	Bob & Ruth Weimer	
Frank & Mary Weismann	F. & M. Weismann	
Anna Lee White Endowed	Mrs Anna Lee White	
Charles H. Wickman Memorial	Charles Wickman	
John H. & Harriette Wilson Student Aid-Endowed	Mr & Mrs John Wilson	
Jerome Yopps Memorial	Various	

**Athletic scholarships** for up to full tuition 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.

## Financial Aid Policies

### *General*

CSM students requesting or receiving financial assistance sponsored by the U.S. Government, the State of Colorado, or the Colorado School of Mines are required to report to the CSM Financial Aid Office all financial assistance offered or received from all sources including CSM immediately upon receipt or notification of such assistance. For the purpose of this paragraph, "financial assistance" shall include, but not be limited to, grants, scholarships, fellowships, or loans funded by public or private sources, as well as all income not considered taxable income by the Internal Revenue Service. Upon receipt of this information, CSM shall evaluate, and may adjust any financial assistance provided to the student from CSM, Colorado, or federal funds. No student shall receive financial assistance from CSM if such student's total assistance from all sources exceeds the total cost of the student's education at CSM. For the purpose of this paragraph, the "total cost of education" shall be defined to include the cost of tuition, fees, books, room and board, 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 Parent Loan for Undergraduate Students are provided in whole or part by appropriations of the United States Congress. The Colorado General Assembly provides funds for the Colorado Grant, Colorado Scholarship, Colorado Athletic Scholarship, 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 completing a minimum of 12 credits each semester with a minimum 2.000 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. If students are deficient in either the credit hour or grade average measure, they will receive a one semester probationary period during which they must return to satisfactory standing by completing at least 12 credits with a minimum 2.000 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. Financial aid eligibility termination may be appealed to the Director of Financial Aid on the basis of extenuating or special circumstances having negatively affected the student's academic performance.

### ***Study Abroad***

Students who will be studying abroad through a program sponsored by CSM may apply for all forms of financial assistance as if they were registered for and attending classes at CSM. Financial assistance will be based on the student's actual expenses for the program of study abroad.

For additional information about Study Abroad opportunities, contact the Office of International Programs, Stratton 109; (303) 384-2121.

### ***Refunds***

If students completely withdraw from all of their classes during a semester, they may be eligible for a refund (a reduction in tuition and fees, and room or board if they live on campus, and a return of funds to the financial aid programs from which the student is receiving assistance). There will be no refund given after the date on which students have completed at least 60% of the semester. The refund will be calculated as required by Federal law or regulation, or by the method described in the section on "Payments and Refunds," using the method that will provide the largest reduction in charges for the student. For the purposes of this policy, the official withdrawal date is the date as specified on the withdrawal form by the student. If the student withdraws unofficially by leaving campus without completing the check-out procedure, the official withdrawal date will be the last date on which the student's class attendance can be verified.

## ***Section 4 - Living Facilities***

### **Residence Halls**

Colorado School of Mines has five residence halls for men and women. The traditional style includes Bradford, Randall, Morgan, and Thomas Halls with primarily double bedrooms and a bathroom on each floor. 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. Each Residence Hall complex houses mailboxes, lounge areas, TV room, and coin operated washers and dryers. Each occupant has a wardrobe or closet, storage drawers, mirror, a study desk and chair, and a wall bookshelf. All rooms are equipped with data connections, cable TV (basic) service, a phone (campus, with optional voice mail), and upgraded electrical systems. 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. Living in the CSM Residence Halls is convenient, comfortable, and provides the best opportunity for students to take advantage of the student activities offered on campus.

### **Dining Facilities**

Colorado School of Mines operates a dining hall in the Ben H. Parker Student Center. Under the provisions for the operation of the residence halls, students who live in the residence halls are required to board in the School dining hall. Breakfast, lunch and dinner are served Monday through Friday, lunch and dinner on Saturday and brunch and dinner on Sunday. 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, Christmas and Spring Break).

### **Family Housing**

Prospector Village is a complex of 69 apartments located on the west edge of the campus. These units are two-bedroom apartments. Each apartment is approximately 800 square feet in size and is heated from steam, as is the rest of campus. Apartments are equipped with stove, refrigerator, and draperies.

### **Mines Park**

The Mines Park apartment complex is located west of the 6th Avenue and 19th Street intersection on 55 acres owned by CSM. Recently completed construction offers 1 & 2 bedroom units in family housing and 1, 2, & 3 bedroom units in other areas.

Units are complete with refrigerators, stoves, dishwashers, cable television and campus phone hook-ups and T-1 connections to the campus network system. There is a community center which contains the laundry facility and recreational/study space.

Rates are as follows:

<i>Prospector Village</i>		<i>Mines Park</i>	
2 bedroom	\$600/mo	1 bedroom	\$589/mo



2 bedroom \$673/mo

**Apartment Housing**

- 1 bedroom \$589/mo
- 2 bedroom \$792/mo
- 3 bedroom \$1053/mo

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

**Fraternities, Sororities**

A student who is a member of one of the national Greek organizations on campus is eligible to live in Fraternity or Sorority housing. Most of the organizations have their own houses, and provide room and board to members living in the house. 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 \$325 to \$395 a month. Housing is also available in the community of Golden, where apartment rental ranges from \$550 to \$1,000 a month.

# Section 5 - Undergraduate Information

**Admission Requirements**

Colorado School of Mines admits students who have demonstrated they can do the classroom and laboratory work and profit 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) rank in class, (4) ACT or SAT scores, 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 printed. The Board of Trustees, CSM’s 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 third of the 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 13 units of secondary school work must be completed in grades 9-12:

Algebra .....	2
Geometry .....	1
Advanced Mathematics (including Trigonometry) .....	1
English .....	4
History or Social Studies .....	2
Laboratory Science .....	3

One unit, including laboratory, must be either chemistry or physics. Second and third units may be chemistry, physics, 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. Three additional academic units (social studies, mathematics, English, science, or foreign language) are required. These units must be acceptable to the applicant’s high school to meet graduation requirements. For applicants submitting GED Equivalency Diplomas, these units may be completed by the GED test.
5. Applicants from the United States and Canada are required to submit the scores of either the Scholastic Aptitude

Test (SAT) of the College Entrance Examination Board or the American College Test (ACT) battery. Applications for either the SAT or ACT may be obtained from the high school counselors, or by writing to Educational Testing Service, P.O. Box 592, Princeton, NJ 08541 for the SAT; or to the American College Testing Program, P.O. Box 168, Iowa City, IA 52243 for the ACT. You may also register online at [www.collegeboard.com](http://www.collegeboard.com) (SAT) and [www.act.org](http://www.act.org) (ACT).

### *Transfer Students*

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

1. Students transferring from another college or university must have completed the same high school course requirements as entering freshmen. A transcript of the applicant's high school record is required. ACT or SAT scores are not required if the student has completed a minimum of 30 credit hours of college credit.
2. Applicants must present college transcripts from all colleges attended. Applicants should have an overall 2.5 (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 correspond to those at CSM to meet graduation requirements are eligible for transfer credit if the grade earned is not lower than a C or its equivalent.

### *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 apply for admission as a transfer student.
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 for admission application may be secured from the Admissions Office.

### *International Students*

The minimum admission requirements for those students who are not citizens of the United States or Canada are as follows:

1. Students from outside the United States and Canada must meet the specified unit requirements in secondary education for entering freshmen, or for students entering after having completed some college education. Students from countries using the English system of examinations must have earned First Class or First Division rank on their most recent examination to be eligible for admission.
2. The Test of English as a Foreign Language (TOEFL) is required of all international students whose native language is not English. Information and application forms for this test, which is given four times each year all over the world, may be obtained from the College Entrance Examination Board, P.O. Box 592, Princeton, NJ 08541, U.S.A.
3. If a TOEFL exam score indicates that the applicant will be handicapped academically, as a condition for admission the applicant may be required to enroll in the INTERLINK Language program at CSM until the required proficiency is achieved. The INTERLINK Language program offers intensive English language instruction and skills development for academic success. See the detailed description of INTERLINK in Section 8 of this *Bulletin*.

### *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 transferred to 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. This includes applicants from Colorado, applicants from out of state, and applicants who are not citizens and who live outside of the United States.

Applications for undergraduate study cannot be accepted later than 21 days prior to the date of registration 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 Graduates*

Colorado high school applicants should obtain applications from their high school counselor or principal or write the Admissions Office. Out-of-state applicants should write the Admissions Office, Colorado School of Mines, 1600 Maple Street, Golden, CO 80401, for application forms. Applicants can apply online at [www.mines.edu](http://www.mines.edu).

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 scores. 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*

Undergraduate students at another college or university who wish to transfer to CSM should request an application for admission from the Admissions Office or apply online at [www.mines.edu](http://www.mines.edu).

A transfer student should apply for admission at the beginning of the final quarter 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. Admissions 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*

Course work completed 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). For a score of three (credit) on the test, credit may or may not be given subject to a study of the A.P. test and related materials, placement test data, high school record, and other test scores available. No credit will be given if the test grade is 2 (pass) or 1 (fail).

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 in the subject. Information can be secured from the College Entrance Examination Board, P.O. Box 592, Princeton, NJ 08541.

### *Declaration of Option*

Since the curriculum during the first two semesters at CSM is the same for everyone, students are not required to choose a major before the end of the freshman year. By the beginning of the junior year, all students must have declared a major.

### *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, 35, and 1606. Undergraduates must register for and maintain 12 hours, and graduate students must register for and maintain 10 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, addresses, marital status, or dependents are to be reported to the Veterans Counseling Office as soon as possible so that overpayment or underpayment may be avoided. Veterans must see the Veteran's Counselor 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 Commission on 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. 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, the department head of the student's option, and the Vice President for Academic Affairs. Upon return, credit will be received subject to review by the appropriate department head. Forms for this purpose are available in the Registrar's Office.

#### *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, the Registrar, and the Vice President for Academic Affairs.

In all cases, requests for transfer credit are initiated in the Admissions Office and processed by the Registrar.

### *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 tenth week for any reason with a grade of W. After the tenth week, no withdrawals are permitted except in cases of withdrawal from school or for extenuating circumstances upon approval by the Registrar. A grade of F will be given in courses which are withdrawn from after the deadline without approval.

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

All add/drop 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/mentor 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 only be given by the Registrar.

A \$4.00 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 add/drop 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.

### ***Absenteeism***

Class attendance is required of all undergraduates unless the student is representing the School in an authorized activity, in which case the student will be allowed to make up any work missed. Students who miss academic work (including but not limited to exams, homework, labs) while participating in school sponsored activities must either be given the opportunity to make up this work in a reasonable period of time or be excused from such work. It is the responsibility of the student to initiate arrangements for such work. Proof of illness may be required before makeup of missed work is permitted. Excessive absence may result in a failing grade in the course. Determination of excessive absence is a departmental prerogative.

The Office of the Dean of Students, if properly informed, will send a notice of excused absence *of three days or more* to faculty members for (1) an absence because of illness or injury for which documentation will be required; (2) an absence because of a death in the immediate family, i.e., a spouse, child, parent, grandparent, or sibling. For excused absences students must be provided the opportunity to make up all missed work.

### ***Withdrawal from School***

A student may officially withdraw from CSM by processing a Withdrawal from School form available in the Student Development Office. Completion of the form through the Student Development Office 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 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.

### ***Grades***

When a student registers in a course, one of the following grades will appear on his academic record, 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 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
M	Thesis Completed

### ***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.

### ***Progress Grade.***

The progress grade (PRG), carrying no point value, is used primarily for multi-semester courses, such as thesis or certain special project courses which are spread over two terms. The progress grade will be awarded in MACS111, MACS112, and PHGN100 to students completing the course for the FIRST time who would otherwise have received a grade of "D" (an enrollment with a grade of "W" is not considered a completion). A student may appeal the assignment of the "PRG" grade to the Dean of Students.

It is required that a student receiving a progress grade be re-registered in the same course in the next semester of attendance. It is further required, in undergraduate courses, that a letter grade be given by the department at the end of that semester.

A student may not drop a course in which re-registered for the purpose of completing a course in which a progress grade was received the previous semester. If a progress grade is received for a course taken in the spring semester, the student may, with the permission of the department head of the course, re-register in that course in the summer session, in which case the letter grade must be given at the end of the summer session.

#### *Forgiveness of "F" Grade.*

When a student completing MACS111 or MACS112 or PHGN100 for the FIRST time receives an "F" in the course but subsequently receives a grade of "D" or higher in that course, the "F" received for the first completion will be changed to a "W". (If an "F" is received the next time a course is taken after getting a grade of "W", it will be forgiven. However, for the purpose of this rule a prior enrollment with a grade of "PRG" will be considered a completion and a subsequent "F" will not be forgiven.)

#### *NC Grade.*

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.

#### *Grade Appeal Process*

Student appeals on grades are to be heard by the Faculty Affairs Committee of the CSM Faculty Senate if they cannot be resolved at a lower level. The appeal process leading to a hearing by the Faculty Affairs Committee is as follows:

1. The student should attempt to work out the dispute with the faculty member responsible for the course.
2. The student must appeal within two weeks of issuance of the grade; the Department Head/Division Director must appoint a faculty mediator within one week of receiving the appeal, and the faculty mediator must submit a finding within one week of being appointed.
3. The student must notify the Department Head/Division Director within one week of receiving the faculty mediator's finding; the Department Head/Division Director must appoint an ad hoc committee within one week of receiving the notification, and the ad hoc committee must submit a finding within two weeks of being appointed.
4. The student must submit the case statement to the VPAA within one week of receiving the ad hoc committee's finding; the VPAA must obtain the written statements and submit the case to the Faculty Affairs Committee within one week of receiving the case statement, and the Faculty Affairs Committee must render a decision within two weeks of receiving the case.

This schedule can be modified upon the mutual agreement of the student, the Department Head/Division Director, and the Vice President for Academic Affairs.

#### *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 less than 10 nor 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 Dean of Students or Registrar 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.

### *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.

### *Graduation Awards*

Graduation awards are determined by the student's cumulative academic record at the end of the preceding semester. Students achieving a final cumulative grade point average of 3.5 or higher, however, will have "with High Scholastic Honors" shown on their diplomas and on their transcripts.

### *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. Provisional probation does not affect a student's being in good standing.

## **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 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.

When a part-time degree undergraduate has attempted a total of 12 quality hours of credit with a cumulative grade-point average of less than 2.0, the student will be placed on academic probation by the Dean of Students. Should students not earn a 2.0 grade-point average for the next semester of attendance, they will be subject to suspension.

### *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.

<b>Total Quality Hours</b>	<b>Required Cumulative G.P. Average</b>	<b>Last Semester G.P. Average</b>
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
131-150.5	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 Dean of Students. Students on suspension who have been given permission to enroll in a summer session by the Dean may not enroll in any subsequent term at CSM without the written permission of the Readmissions Committee. Readmissions Committee meetings are held prior to the beginning of each regular semester and at the end of the spring term.

A student who intends to appear in person before the Readmissions Committee must register in the Dean of Students Office in person or by letter. 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 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. Appearing by letter will not be permitted for continuing students in January.

The Readmissions Committee meets immediately before classes start and the first day of classes. 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 extending beyond the first day of classes, 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 Readmissions Committee and receive written permission 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, 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. Student also have the right to file complaints with The Family Educational Rights and Privacy Act Office (FERPA) concerning alleged failures by the institution to comply with the Act. Copies of local policy can be found in the Registrar's Office.

**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, 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 must so inform the Registrar before the end of the first two weeks of the fall semester the student is registered for. 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-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 Dean of Students. 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 student's 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 dean or designated representative. If the record involves a list including other students, steps will be taken to preclude the viewing of the other student name and information.



**Challenge of the Record.** If the student wishes to challenge any part of the record, the appropriate dean will be so notified in writing. The dean may then (1) remove and destroy the disputed document, or (2) inform the student that it is his decision that the document represents a necessary part of the record; and, if the student wishes to appeal, (3) convene a meeting of the student and the document originator (if reasonably available) in the presence of the Vice President for Academic Affairs as mediator, whose decision will be final.

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

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

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

## **General Information**

### *Academic Calendar*

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

### *Classification of Students*

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

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 is defined as a matriculated degree student enrolled for less than 10 hours during the regular academic year or less than 5 hours in summer session.

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 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.

### *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, and the 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 first enrollment. 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. 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; 273-3750.

### ***Summer Session***

The summer session is divided into two independent units: a period not to exceed 6 weeks for required field and laboratory courses and an 8-week on-campus summer school during which some regular school year courses are offered.

### ***Dead Week***

All final examinations will take place during the examinations week specified in the Academic Calendar. With the possible exception of laboratory examinations, no other examinations will be given during the week preceding examinations week (Dead Week).

### ***Full-time Enrollment***

Full-time enrollment for enrollment 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 field session is 6 credit hours, and full-time enrollment for summer session is 6 credit hours.

## **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 (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 comprising the department course sequence 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 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. Applications are available in the Registrar's Office.

The Registrar's Office provides the service of doing preliminary degree audits. It is the ultimate 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'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, the Registrar and the Vice President for Academic Affairs. The course substitution form can be obtained in the Registrar's Office.

A student may not be a candidate for a graduate and an undergraduate degree at the same time. To be a candidate the student must first gain admission to one school and make satisfactory progress toward a degree offered by that school.

## 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, eleven 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.

### The Core Curriculum

Core requirements for graduation include the following:

**In Mathematics** and the Basic Sciences, 12 semester hours in Calculus for Scientists and Engineers and 3 semester hours in Differential Equations (2 semester hours in Differential Equations for Geological Engineering majors); 8 semester hours in the Principles of Chemistry; and 9 semester hours in Physics.

**In Design**, 6 semester hours in Design Engineering Practices Introductory Course Sequence.

**In Systems**, 9 semester hours in Earth and Environmental Systems, Engineering Systems and Human Systems.

**In Humanities and the Social Sciences**, 10 semester hours in Nature and Human Values, Principles of Economics, Human Systems, and a restricted cluster of 9 semester hours in H&SS electives. Note that the Human Systems course is inclusive in both the Humanities and Social Sciences and the Systems core segments. Note that the economics requirement can be satisfied by taking the Microeconomics/Macroeconomics sequence (EBGN311 & EBGN312) instead of taking Principles of Economics. This option is recommended for students considering a major

or minor in economics.

**In Physical Education**, 2 semester hours.

**In Freshman Orientation and Success**, 0.5 semester hours.

**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. 32).
2. Free electives to satisfy degree requirements may not exceed three semester hours in concert band, chorus, studio art, *Oredigger*, *Prospector*, and physical education and athletics.

### The Freshman Year

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

#### Fall Semester

<i>subject code** and course number</i>	lec.	lab.	sem.	hrs.
CHGN121 Principles of Chemistry I	3	3		4
MACS111 Calculus for Scientists & Eng'n's I	4			4
SYGN101* Earth and Environmental Systems	3	3		4
LIHU100* Nature and Human Values	4			4
CSM101 Freshman Success Seminar	0.5			0.5
PAGN101 Physical Education I		0.5		0.5
<b>Total</b>				17

#### Spring Semester

	lec.	lab.	sem.	hrs.
CHGN124 Principles of Chemistry II	3			3
CHGN126 Quantitative Chem. Measurements		3		1
MACS112 Calculus for Scientists & Eng'n's II	4			4
EPIC151* Design I	2	3		3
PHGN100 Physics I	3.5	3		4.5
PAGN102 Physical Education II		2		0.5
<b>Total</b>				16

\* For scheduling purposes, registration in combinations of SYGN101, LIHU100 and EPIC151 will vary between the fall and spring semesters. In some cases the combinations may include taking EBGN211 in the freshman instead of the sophomore year, whereupon one of the \* courses is shifted to the sophomore year. 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
DCGN	Core Science and Engineering Fundamentals
EBGN	Economics and Business
EGES	Engineering Systems (Engineering)
EGGN	Engineering
EPIC	EPICS
ESGN	Environmental Science and Engineering
GEGN	Geological Engineering
GEGX	Geochemical Exploration (Geology)
GEOC	Oceanography (Geology)
GEOL	Geology
GOGN	Geo-Engineering (Mining)
HNRS	Honors Program
LAIS	Liberal Arts & International Studies
LICM	Communication
LIFL	Foreign Languages
LIHU	Humanities
LIMU	Band; Choir
LISS	Social Sciences
MACS	Mathematical & Computer Sciences
MNGN	Mining Engineering
MSGN	Military Science
MTGN	Metallurgical & Materials Engr'ng

PAGN	Physical Education and Athletics
PEGN	Petroleum Engineering
PHGN	Physics GPGN Geophysics
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 eleven undergraduate degree programs early in the sophomore year.

### *Curriculum Changes*

In accordance with the statement on Curriculum Changes on page 32, the Colorado School of Mines is completing a phased period of curriculum revision. To confirm that they are progressing according to the requirements of the new curriculum, students should consult their academic advisors on a regular basis and should carefully consult any Bulletin Addenda that may be published during this period.

### *Special Programs*

#### **EPICS (Engineering Practices Introductory Course Sequence)**

EPICS is a two-semester sequence of courses for freshman and sophomores, 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 self-educate; and the ability to communicate effectively.

An award-winning program, 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 “projects,” open-ended problems which the students solve in teams. Starting with simple case studies, the projects grow in length and complexity to a final, full-semester project 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) in arriving at their solutions.

Written and oral communications are studied and practiced as an integral part of the project work. Graphics and computing skills are integrated with projects wherever possible.

Among the topics studied by students in EPICS are: use of the computer as a problem-solving tool, and the use of word-processing, graphics, spreadsheet and CAD packages; 3-D visualization; audience analysis and the preparation of a variety of technical documents; oral communication in the staff format; interpersonal skills in group work; project management.

The EPICS program is required of all undergraduates.

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

The LAIS Writing Center located in room 263 of the Green Center (phone: 303-273-3085) is a teaching facility providing all CSM students with an opportunity to enhance their writing proficiency. The LAIS Writing Center faculty are experienced technical writers and professional writing instructors. The Center assists students 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 provided in a computerized, electronic classroom which is used extensively by students in the required freshman course, LIHU100 Nature and Human Values.

#### **Writing Across the Curriculum (WAC)**

To support the institutional goal in developing professional communication skills, required writing and communication intensive courses are designated in both the core and in the degree-granting programs. The LAIS Writing Center supports the WAC program.

In addition to disciplinary writing experience, students also obtain writing experience outside their disciplines as courses in the Division of Liberal Arts and International Studies are virtually all writing intensive. Writing intensive courses are designated with (WI) in Section 6 of this *Bulletin, Description of Courses*.

#### **The Guy T. McBride, Jr. Honors Program in Public Affairs for Engineers**

The McBride Honors Program was instituted in 1978 through a grant from the National Endowment for the Humanities. Honors offers a 24-semester-hour program of seminars 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 and to gain the sensitivity to prove, project, and test the moral and social implications of their future professional judgements and activities, not only for the particular organizations with which they will be involved, but also for the nation and the world. To achieve this goal, the program seeks to bring themes from the humanities and the social sciences into the engineering curriculum that will encourage in students habits of thought necessary for effective management and enlightened leadership.

This program leads to a certificate and a Minor in Public Affairs for Engineers.

### **Bioengineering and the Life Sciences**

The Colorado School of Mines is introducing programmatic offerings in selected areas of Bioengineering and the Life Sciences with intended areas of special interest and minor tracks in Biomedical Engineering, Pre-Medical and Life Sciences, Biomaterials Engineering, Bio-Physics, Environmental Biotechnology, and Bio-Mathematics, preceded by common course requirements in general biology, cell biology and physiology, and an introduction to genetics. This program is under development, and interested students should consult with the office of Professor Rahmat Shoureshi, Brown Hall 330A, telephone 303 384-2032, rshoures@mines.edu, to confirm current offerings and the status of the program.

### **Minor Program/Area of Special Interest**

Established Minor Programs/Areas of Special Interest 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 must consist of a minimum of 18 credit hours of a logical sequence of courses, only three hours of which may be taken in the student's degree-granting department. An AREA OF SPECIAL INTEREST must consist of a minimum of twelve credit hours of a logical sequence of courses, only three hours of which may be at the 100- or 200-level. No more than three credit hours of the sequence may be specifically required by the degree program in which the student is graduating. 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. Please see the Department for specific course requirements.

### **Study Abroad**

Students wishing to pursue study abroad opportunities should contact the Office of International Programs (109 Stratton Hall), listed under the Services section of this Bulletin, p.144. Colorado School of Mines encourages students to include an international study/work experience in their undergraduate education. CSM maintains student exchange programs with universities in Mexico, Western Europe, Australia, Japan, and China. 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 Office of International Programs has developed a resource center for study abroad information in its office, 109 Stratton Hall, phone 303-384-2121. Students are invited to use the resource materials and meet with staff in the Office of International Programs to discuss overseas study opportunities.

## **Combined Undergraduate/Graduate Programs**

### **A. Overview**

Several degree programs offer CSM undergraduate students the opportunity to begin work on a Graduate Certificate, Professional Degree, or Master's Degree while completing the requirements for their Bachelor's Degree. 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 CSM offer several advantages to students who choose to enroll in them:

1. Students can earn a graduate degree in a field that complements their undergraduate major or, in special cases, in the same field.
2. Students who plan to go directly into industry leave CSM 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 program leading to a Graduate Certificate or Non-Thesis Master's Degree assures students of automatic acceptance into full graduate status if they maintain good standing while in early-acceptance status.
6. Students may receive both degrees at the same time, providing them access to both undergraduate and graduate benefits (such as financial aid) while completing their programs.
7. In many cases, students will be able to complete both Bachelor's and Master's Degrees in five years of total enrollment at CSM.

Certain graduate programs may allow Combined 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. Those courses must meet all requirements for graduate credit, and their

grades are included in calculating the graduate GPA. Check the departmental section of the Bulletin to determine which programs provide this opportunity.

At the time of publication of this Bulletin, Combined Programs were available leading to graduate certificates in International Political Economy and leading to Master of Science or Master of Engineering degrees in Engineering and Technology Management, Engineering Systems, Materials Science, and Metallurgical and Materials Engineering. Additional programs may be added in the future, and students interested in Combined Graduate Programs not listed here are encouraged to contact the Graduate School or their department of choice for current information.

### ***B. Admission Process***

Students may apply for Early Admission to the Combined Graduate Program any time after completing the first semester of their sophomore year at CSM. Applicants should submit the standard Graduate Application form indicating that they are applying for the Combined Graduate Program. GRE scores and letters of reference are not required. Transcripts are required only if the applicants received part of their freshman/sophomore credits at another institution.

Following Early Admission, students will be assigned graduate advisors in the programs in which they plan to receive their graduate certificates or degrees. Prior to registration for the next semester, students and their graduate advisors will plan a strategy for completing both the undergraduate and graduate programs as efficiently as possible. The students also will continue to have undergraduate advisors in the home department or division for their Bachelor's Degrees.

Upon achieving Senior standing, students may request admission to full graduate status. Admission will be automatic for students who have maintained good standing as defined below and who will be candidates for certificates or non-thesis degrees. Those students may submit their requests to the Graduate Office by memo or email. Students who have not maintained good standing or who will be candidates for thesis degrees must submit a standard application package for the certificate or degree being sought.

### ***C. Requirements***

In order to maintain good standing in the Combined Program:

1. Students who have been granted Early Admission to the Combined Program must register full time and maintain a minimum semester GPA of 3.0 during each semester subsequent to admission, including the semester in which they were accepted.
2. Students who have been granted full graduate status must satisfy all requirements (course, research and thesis credits, minimum GPA, etc.) of the graduate program in which they are enrolled. Note that all courses, undergraduate and graduate, taken after full admission count toward the minimum GPA required to be making satisfactory progress.

After students have been accepted into full graduate status, they will have dual status and will have all of the privileges and be subject to all expectations of both undergraduate and graduate programs. Students having dual status may take both undergraduate and graduate courses, may register for internship, research, or thesis credits as required for their graduate program and may have access to financial aid available through both programs.

## **Chemical Engineering**

JAMES F. ELY, Professor and Head of Department

ROBERT M. BALDWIN, Professor

ANNETTE L. BUNGE, Professor

ANTHONY M. DEAN, W.K. Coors Distinguished Professor

RONALD L. MILLER, Professor

E. DENDY SLOAN, Weaver Distinguished Professor

JOHN R. DORGAN, Associate Professor

J. THOMAS MCKINNON, Associate Professor

J. DOUGLAS WAY, Associate Professor

DAVID W.M. MARR, Associate Professor

CLARE McCABE, Assistant Professor

COLIN A. WOLDEN, Assistant Professor

DAVID T. WU, Assistant Professor

JAMES H. GARY, Professor Emeritus

JOHN O. GOLDEN, Professor Emeritus

ARTHUR J. KIDNAY, Professor Emeritus

VICTOR F. YESAVAGE, Professor Emeritus

MICHAEL S. GRABOSKI, Research Professor

ROBERT D. KNECHT, Research Professor

SERGEI KISELEV, Research Associate Professor

HANS-HEINRICH CARSTENSEN, Research Assistant Professor

## Program Description

The field of chemical engineering is extremely broad, and encompasses all technologies and industries where chemical processing is utilized in any form. Students with baccalaureate (B.S.) chemical engineering degrees from CSM can find employment in many and 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 manufacture, petroleum and petrochemical processing, and process and product design.

The practice of chemical engineering draws from the fundamentals of chemistry, mathematics, and physics. Accordingly, undergraduate students must initially complete a program of study that stresses these three basic fields of science. Chemical engineering coursework blends these three 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 transport, thermodynamics and 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 chemical engineers to understand how microscopic, molecular-level properties can influence the macroscopic behavior of materials 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 a senior-level capstone course in molecular perspectives. Our undergraduate program at CSM is exemplified by intensive integration of computer-aided molecular 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 six-week intensive "field session". Here, the fundamentals of heat, mass, and momentum transport and applied thermodynamics are reviewed in a practical, applications-oriented setting. The important subjects of teamwork, critical thinking, and oral and written technical communications skills are also stressed in this course.

Facilities for the study of chemical engineering at the Colorado School of Mines are among the best in the nation. Our modern in-house computer network supports over 50 workstations, and is anchored by an IBM SP-2 parallel supercomputer. Specialized undergraduate laboratory facilities exist for the study of polymer properties, and for reaction engineering and unit operations. In 1992, the department moved into a new \$11 million facility which included both new classroom and office space, as well as high quality laboratories for undergraduate and graduate research. 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 Mines undergraduate chemical engineering students have won several national competitions and awards based on research conducted while pursuing their baccalaureate degree.

The program leading to the degree Bachelor of Science in Chemical 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 Goals (Bachelor of Science in Chemical Engineering)*

The goals of the Chemical Engineering program at CSM are to:

- ◆ Instill in our students a high-quality basic education in chemical engineering fundamentals;
- ◆ Develop the skills required to apply these fundamentals to the synthesis, analysis, and evaluation of chemical engineering processes and systems; and
- ◆ Foster personal development to ensure a lifetime of professional success and an appreciation of the ethical and societal responsibilities of a chemical engineer.

### *Curriculum*

The chemical engineering curriculum is structured according to the goals outlined above. Accordingly, the program of study is organized to include 3 semesters of science and general engineering fundamentals followed by 5 semesters of chemical engineering fundamentals and applications. An optional 'track' system is introduced at the junior year which allows students to structure free electives into one of several specialty applications areas. Courses in the chemical engineering portion of the curriculum may be categorized according to the following general system.

#### *A. Chemical Engineering Fundamentals*

The following courses represent the basic knowledge component of the chemical engineering curriculum at CSM. 1. Mass and Energy Balances (ChEN201) 2. Computational Methods (ChEN200) 3. Fluid Mechanics (ChEN307) 4. Heat Transfer (ChEN308) 5. Chemical Engineering Thermodynamics (ChEN357) 6. Mass Transfer (ChEN375) 7. Transport Phenomena (ChEN430)

#### *B. Chemical 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. Molecular Perspectives in Chemical Engineering (ChEN440)

### C. Chemical Engineering Elective Tracks

Students in chemical engineering may elect to structure free electives into a formal Minor program of study (18 hours of coursework), an Area of Special Interest (12 hours) or a Specialty Track in Chemical Engineering (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. Specialty tracks in chemical engineering are available in the following areas:

- Microelectronics
- Bio Engineering and Life Sciences
- Polymer and materials
- Environmental
- Petroleum and petrochemicals
- Business and Economics

Details on recommended courses for each of these tracks can be obtained from the student's academic advisor.

### Degree Requirements (Chemical Engineering)

<b>Sophomore Year Fall Semester</b>	lec.	lab.	sem.hrs.
MACS213 Calculus for Scientists & Eng'n's III	4		4
PHGN200 Physics II	3.5	3	4.5
DCGN209 Introduction to Thermodynamics	3		3
Programming Elective*	2		2
CHGN221 Organic Chemistry I	3	1	4
PAGN201 Physical Education III		2	0.5
<b>Total</b>			<b>18</b>
*ChEN200, MACS260, or MACS261			
<b>Sophomore Year Spring Semester</b>	lec.	lab.	sem.hrs.
MACS315 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	4
EPIC251 Design II	2	3	3
PAGN202 Physical Education IV		2	0.5
<b>Total</b>			<b>17.5</b>
<b>Junior Year Fall Semester</b>	lec.	lab.	sem.hrs.
SYGN201/2 Engineering Systems	3		3
CHGN351 Physical Chemistry I	3		3
ChEN307 Fluid Mechanics	3		3
ChEN357 Chemical. Eng. Thermodynamics	3	1	3
ChEN358 Chemical. Eng. Thermodynamics Lab		1	1
SYGN200 Human Systems	3		3
<b>Total</b>			<b>17</b>
<b>Junior Year Spring Semester</b>	lec.	lab.	sem.hrs.
CHGN353 Physical Chemistry II	3	1	4
ChEN375 Chemical Eng. Mass Transfer	3		3
ChEN308 Chemical Eng. Heat Transfer	3		3
Elective*	3		3
LAI/EBGN H&SS Elective I	3		3
<b>Total</b>			<b>16</b>
<b>Summer Field Session</b>	lec.	lab.	sem.hrs.
ChEN312/313 Unit Operations Laboratory		6	6
<b>Total</b>			<b>6</b>
<b>Senior Year Fall Semester</b>	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
<b>Senior Year Spring Semester</b>	lec.	lab. sem.hrs.
ChEN402 Chemical Engineering Design	3	3
ChEN403 Process Dynamics and Control	3	3
Elective*	3	3
LAIS/EBGN H&SS Elective III	3	3
ChEN421 Engineering Economics	3	3
Total		15
<b>Degree total</b>		137.5

\*one of the electives must be a 400-level Chemical Engineering course.

## Chemistry and Geochemistry

PAUL W. JAGODZINSKI, Professor and Department Head

DEAN W. DICKERHOOF, Professor

DONALD L. MACALADY, Professor

PATRICK MACCARTHY, Professor

MICHAEL J. PAVELICH, Professor

KENT J. VOORHEES, Professor

SCOTT W. COWLEY, Associate Professor

MARK E. EBERHART, Associate Professor

DANIEL M. KNAUSS, Associate Professor

KEVIN W. MANDERNACK, Associate Professor

E. CRAIG SIMMONS, Associate Professor

KIM R. WILLIAMS, Associate Professor

C. JEFFREY HARLAN, Assistant Professor

DAVID T. WU, Assistant Professor

STEVEN F. DEC, Lecturer

JAMES F. RANVILLE, Research Assistant Professor

RAMON E. BISQUE, Professor Emeritus

STEPHEN R. DANIEL, 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

MAYNARD SLAUGHTER, Professor Emeritus

DAVID M. UPDEGRAFF, Professor Emeritus

THOMAS R. WILDEMAN, Professor Emeritus

JOHN T. WILLIAMS, Professor Emeritus

ROBERT D. WITTERS, Professor Emeritus

CHARLES W. STARKS, Associate Professor Emeritus

### Program Description

Chemistry provides fundamental knowledge critical to satisfying many of society's needs: feeding and clothing and housing the world's people, finding and using sources of energy, improving health care, ensuring national security, and protecting the environment. The programs of the Chemistry and Geochemistry Department are 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, a specific B.S. curricular track emphasizing environmental chemistry is offered along with a more flexible track which can be tailored to optimize preparation consistent with students' 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 contain extensive instrumentation for: gas chromatography (GC), high-performance liquid chromatography (HPLC), ion chromatography (IC), supercritical-fluid

chromatography (SFC), inductively-coupled-plasma-atomic emission spectroscopy (ICP-AES) field-flow fractionation (fff), mass spectrometry (MS, GC/MS, GC/MS/MS, PY/MS, PY/GC/MS, SFC/MS, MALDI-TOF), nuclear magnetic resonance spectrometry (solids and liquids), infrared spectrophotometry (FTIR), visible-ultraviolet spectrophotometry, microscopy, X-ray photoelectron spectrometry (XPS), and thermogravimetric analysis (TGA).

### *Program Goals (Bachelor of Science in Chemistry)*

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, interferences, theory of operation of analytical instruments (atomic and molecular spectroscopy, mass spectrometry, magnetic resonance spectrometry, chromatography and other separation methods, electroanalytical methods, and thermal methods), calibration, standardization, stoichiometry of analysis, equilibrium and kinetics 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.
- ◆ 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, 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.

### *Laboratory and communication skills*

- ◆ Analytical methods - gravimetry, titrimetry, sample dissolution, fusion, quantitative spectrophotometry, GC, HPLC, GC/MS, potentiometry, 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, CA on-line, 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

### *Applications*

- ◆ Area of special interest courses-application of chemistry fundamentals 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)*

The B.S. curricula in chemistry are outlined below. The restrictions specific to the environmental chemistry track are labeled (env) while those specific to the other track are labeled (chm); those common to both tracks bear no label. In the environmental track the area of special interest must be in Environmental Science and Engineering (ESGN) (see page 51).

<b>Sophomore Year Fall Semester</b>	lec.	lab.	sem.	hrs.
MACS213 Calculus for Scientists & Eng'rs III	4			4
PHGN200 Physics II	3.5	3		4.5
DCGN209 Introduction to Thermodynamics	3			3
CHGN221 Organic Chemistry I	3	3		4
PAGN201 Physical Education III	2			0.5
Total				16

<b>Sophomore Year Spring Semester</b>	lec.	lab.	sem.	hrs.
CHGN222 Organic Chemistry II	3	3		4
SYGN201/2 Engineering Systems	3			3
MACS315 Differential Equations	3			3
CHGN335 Instrumental Analysis	3			3
CHGN201 Thermodynamics Laboratory		3		1
EPIC251 Design II	2	3		3
PAGN202 Physical Education IV	2			0.5
Total				17.5

<b>Junior Year Fall Semester</b>	lec.	lab.	sem.	hrs.
SYGN200 Human Systems	3			3
CHGN428 Biochemistry	3			3
CHGN336 Analytical Chemistry	3			3
CHGN337 Analytical Chemistry Laboratory		3		1
CHGN351 Physical Chemistry I	3	3		4
Area of Special Interest Elective ( <i>chm**</i> )	3			3
ESGN - Environmental Elective ( <i>env**</i> )	3			3
Total				17

*\*\*specialty restrictions*

<b>Junior Year Spring Semester</b>	lec.	lab.	sem.	hrs.
CHGN353 Physical Chemistry II	3	3		4
CHGN341 Descriptive Inorganic Chemistry	3			3
CHGN323 Qualitative Organic Analysis	1	3		2
EBGN201 Principles of Economics	3			3
Area of Special Interest Elective ( <i>chm**</i> )	3			3
Free elective	3			3
LAIS/EBGN H&SS Elective I	3			3
Total				18

*\*\*specialty restrictions*

<b>Junior-Senior Year Summer Field Session</b>	lec.	lab.	sem.	hrs.
CHGN490 Synthesis & Characterization		18		6
Total				6

<b>Senior Year Fall Semester</b>	lec.	lab.	sem.	hrs.
CHGN495 Research		9		3
Area of Special Interest Elective ( <i>chm**</i> )	3			3
ESGN Area of Special Interest ( <i>env**</i> )	6			6
LAIS/EBGN H&SS Cluster Elective II	3			3
Free elective	3			3
Free elective ( <i>chm**</i> )	3			3
Total				15

*\*\*specialty restrictions*

<b>Senior Year Spring Semester</b>	lec.	lab.	sem.	hrs.
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CHGN495 Undergraduate Research	9	3
CHGN410 Surface Chemistry ( <i>env**</i> )	3	3
Area of Special Interest Elective ( <i>chm**</i> )	3	3
ESGN Area of Special Interest ( <i>env**</i> )	3	3
LAIS/EBGN H&SS Cluster Elective III	3	3
CHGN401 Theoretical Inorganic Chem. ( <i>chm**</i> )	3	3
CHGN403 Environmental Chemistry ( <i>env**</i> )	3	3
Free elective ( <i>chm**</i> )	3	3
Total		15
<b>Degree Total</b>		137.5

### *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.

## Economics and Business

RODERICK G. EGGERT, Professor and Division Director

CAROL DAHL, Professor

R. E. D. WOOLSEY, Professor

GRAHAM A. DAVIS, Associate Professor

MICHAEL R. WALLS, Associate Professor

JANIS M. CAREY, Assistant Professor

SHEKHAR JAYANTHI, Assistant Professor

IRINA KHINDANOVA, Assistant Professor

DAVID MOORE, Assistant Professor

ALEXANDRA NEWMAN, Assistant Professor

LUIS SOSA, Assistant Professor

JAMES M. OTTO, Research Professor and Director, Institute for Global Resources Policy and Management

JOHN STERMOLE, Lecturer

ANN DOZORETZ, Instructor

DAVID E. FLETCHER, Professor Emeritus

ALFRED PETRICK, Jr., Professor Emeritus

ODED RUDAWSKY, Professor Emeritus

FRANKLIN J. STERMOLE, Professor Emeritus

JOHN E. TILTON, Coulter Professor Emeritus

JOHN A. CORDES, Associate 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 are awarded as a Bachelor of Arts, with a strong liberal arts component. Our degree, the only one of its kind in Colorado, 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 Goals (Bachelor of Science in Economics)*

The goals of the undergraduate program in economics and business are:

To provide economics majors 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 economics majors 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

Within the major, students can choose a special concentration in Global Business or Technology. If students do not choose one of these options, they will complete the (default) Economics and Business option. 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, business, and the humanities and social sciences more generally. 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.

### Degree Requirements in Economics

#### Economics and Business Option (default)

<b>Sophomore Year Fall Semester</b>	lec.	lab.	sem.	hrs.
EBGN311 Principles of Microeconomics*	3			3
PHGN200 Physics II	3.5	3		4.5
MACS213 Calc. for Scientists & Engineers III	4			4
SYGN200 Human Systems	3			3
EPICS251 or EPICS252 Design II	2	3		3
PAGN201 Physical Education III	2			0.5
Total				18
<b>Sophomore Year Spring Semester</b>	lec.	lab.	sem.	hrs.
EBGN312 Principles of Macroeconomics*	3			3
MACS315 Differential Equations	3			3
MACS332 Linear Algebra	3			3
SYGN201/2 Engineered Systems	3			3
PAGN202 Physical Education IV	2			0.5
Free Elective	3			3
Total				15.5
<b>Junior Year Fall Semester</b>	lec.	lab.	sem.	hrs.
EBGN325 Operations Research	3			3
EBGN411 Intermediate Microeconomics	3			3
EBGN412 Intermediate Macroeconomics	3			3
EBGN Elective I	3			3
MACS323 Probability and Statistics	3			3
LAIS H&SS Cluster Elective I	3			3
Total				18
<b>Junior Year Spring Semester</b>	lec.	lab.	sem.	hrs.
EBGN321 Engineering Economics	3			3
EBGN409 Math Econ. or EBG455 Lin. Prog.**	3			3
EBGN Elective II	3			3
LAIS Restricted Elective I	3			3
LAIS H&SS Cluster Elective II	3			3
Free Elective	3			3
Total				18
<b>Summer Field Session</b>	lec.	lab.	sem.	hrs.
EBGN402 Field Session 1	3			3
Total				3
<b>Senior Year Fall Semester</b>	lec.	lab.	sem.	hrs.
EBGN490 Econometrics	3			3
EBGN Elective III	3			3
LAIS Restricted Elective II	3			3
LAIS H&SS Cluster Elective III	3			3
Free Electives	6			6
Total				18
<b>Senior Year Spring Semester</b>	lec.	lab.	sem.	hrs.
EBGN Elective IV	3			3
LAIS Restricted Elective III	3			3
Free Electives	9			9

Total	15
<b>Degree Total</b>	<b>138.5</b>

\* Students who complete the EBG311/312 sequence are not required to take EBG201. For students pursuing a major in economics, EBG201 is not a substitute for either EBG311 or EBG312.

\*\* Students must take either EBG409 or EBG455.

### Technology Option

<b>Sophomore Year Fall Semester</b>	lec. lab.sem. hrs.
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Same courses as in default option above.

Total	18
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<b>Sophomore Year Spring Semester</b>	lec.lab.sem. hrs.
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Same courses as in default option above.

Total	15.5
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<b>Junior Year Fall Semester</b>	lec.lab. sem. hrs.
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EBGN325 Operations Research	3	3
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EBGN411 Intermediate Microeconomics	3	3
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EBGN412 Intermediate Macroeconomics	3	3
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EBGN Technology Elective I	3	3
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MACS323 Probability and Statistics	3	3
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LAIS H&SS Cluster Elective I	3	3
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Total	18
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<b>Junior Year Spring Semester</b>	lec.lab. sem. hrs.
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EBGN321 Engineering Economics	3	3
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EBGN409 Math Econ or EBG 455 Lin. Prog.**	3	3
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EBGN Technology Elective II	3	3
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LAIS Technology Elective I	3	3
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LAIS H&SS Cluster Elective II	3	3
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Free Elective	3	3
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Total	18
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<b>Summer Field Session</b>	lec.lab. sem. hrs.
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EBGN402 Field Session 1	3	3
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Total	3
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<b>Senior Year Fall Semester</b>	lec.lab. sem. hrs.
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EBGN490 Econometrics	3	3
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EBGN Technology Elective III	3	3
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LAIS Technology Elective II	3	3
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LAIS H&SS Cluster Elective III	3	3
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Free Electives	6	6
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Total	18
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<b>Senior Year Spring Semester</b>	lec.lab. sem. hrs.
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EBGN Technology Elective IV	3	3
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LAIS Technology Elective III	3	3
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Free Electives	9	9
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Total	15
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<b>Degree Total</b>	<b>138.5</b>
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\*\* Students must take either EBG409 or EBG455.

### Global Business Option

<b>Sophomore Year Fall Semester</b>	lec. lab.sem. hrs.
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Same courses as in default option above.

Total	18
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<b>Sophomore Year Spring Semester</b>	lec.lab.sem. hrs.
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Same courses as in default option above.

Total	15.5
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<b>Junior Year Fall Semester</b>	lec.lab. sem. hrs.
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EBGN325 Operations Research	3	3
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EBGN411 Intermediate Microeconomics	3	3
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EBGN412 Intermediate Macroeconomics	3	3
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EBGN Global Business Elective I	3	3
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MACS323 Probability and Statistics	3	3
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LAIS H&SS Cluster Elective I	3	3
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Total		18
<b>Junior Year Spring Semester</b>	lec.lab. sem. hrs.	
EBGN321 Engineering Economics	3	3
EBGN409 Math Econ or EBGN 455 Lin. Prog.**	3	3
EBGN Global Business Elective II	3	3
LIFL Foreign Language I*	3	3
LAIS H&SS Cluster Elective II	3	3
Free Elective	3	3
Total		18
<b>Summer Field Session</b>	lec.lab. sem. hrs.	
EBGN402 Field Session 1	6	3
Total		3
<b>Senior Year Fall Semester</b>	lec.lab. sem. hrs.	
EBGN490 Econometrics	3	3
EBGN Global Business Elective III	3	3
LAIS Global Business Elective I	3	3
LIFL Foreign Language II*	3	3
LAIS H&SS Cluster Elective III	3	3
Free Elective	3	3
Total		18
<b>Senior Year Spring Semester</b>	lec.lab. sem. hrs.	
EBGN Global Business Elective IV	3	3
LAIS Global Business Elective II	3	3
Free Electives	9	9
Total		15
<b>Degree Total</b>		138.5

\*Must be in same language.

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

### *Electives for the Economics Major Listed by Specialization*

#### **Economics and Business Specialization (default)**

Economics and Business specialization students take 12 hours from the following list of EBGN electives, of which at least 3 hours must be a 400-level course that has EBGN411 and/or EBGN412 as prerequisites.

EBGN304 Personal Finance  
 EBGN305 Financial Accounting  
 EBGN306 Managerial Accounting  
 EBGN310 Environmental and Resource Economics  
 EBGN314 Principles of Management  
 EBGN315 Business Strategy  
 EBGN320 Economics and Technology  
 EBGN330 Energy Economics  
 EBGN342 Economic Development  
 EBGN345 Principles of Corporate Finance  
 EBGN401 History of Economic Thought  
 EBGN409 Mathematical Economics<sup>†</sup>  
 EBGN441 International Trade  
 EBGN445 International Business Finance  
 EBGN455 Linear Programming<sup>†</sup>  
 EBGN495 Economic Forecasting  
 EBGN5XX<sup>††</sup>

<sup>†</sup>The eligible course is the one not taken as part of the EBGN core.

<sup>††</sup>Seniors with at least a 2.50 cumulative GPA may take a 500-level course with the consent of their department and the Dean of Graduate Studies.

Economics and Business specialization students take 9 hours from the following list of LAIS restricted electives.

Courses used to satisfy the H&SS cluster requirements cannot be double counted.

LICM301 Professional Oral Communication  
 LICM306 Selected Topics in Written Communication  
 LIHU398A Comparative Political Cultures  
 LIHU498A History of Technology  
 LISS330 Managing Cultural Differences



LISS335 International Political Economy  
 LISS340 International Political Economy of Latin America  
 LISS342 International Political Economy of Asia  
 LISS344 International Political Economy of the Middle East  
 LISS351 The History of Eastern Europe and Russia since 1914  
 LISS362 Science and Technology Policy  
 LISS364 Engineering, Science, and Technology: Social/Environmental Context  
 LISS375 Introduction to Law and Legal Systems  
 LISS430 Globalization  
 LISS431 Global Environmental Issues  
 LISS433 Global Corporations  
 LISS440 Latin American Development  
 LISS441 Hemispheric Integration in the Americas  
 LISS461 Technology and Gender

### **Technology Specialization**

Technology specialization students take 12 hours from the following list of EBGN courses, of which 3 hours must be Economics and Technology, and at least 3 hours must be a 400-level course that has EBGN411 and/or EBGN412 as prerequisites.

EBGN314 Principles of Management  
 EBGN315 Business Strategy  
 EBGN320 Economics and Technology  
 EBGN409 Mathematical Economics<sup>†</sup>  
 EBGN455 Linear Programming<sup>†</sup>  
 EBGN495 Economic Forecasting  
 EBGN5XX<sup>††</sup>

<sup>†</sup>The eligible course is the one not taken as part of the EBGN core.

<sup>††</sup>Seniors with at least a 2.50 cumulative GPA may take a 500-level course with the consent of their department and the Dean of Graduate Studies.

Technology specialization students take 9 hours from the following list of LAIS courses. Courses used to satisfy the H&SS cluster requirements cannot be double counted.

LICM301 Professional Oral Communication  
 LICM306 Selected Topics in Written Communication  
 LIHU498A History of Technology  
 LISS362 Science and Technology Policy  
 LISS364 Engineering, Science and Technology: Social and Environmental Context  
 LISS461 Technology and Gender

### **Global Business Specialization**

Global Business specialization students take 12 hours from the following list of EBGN courses, of which at least 3 hours must be a 400-level course that has EBGN411 and/or EBGN412 as prerequisites.

EBGN305 Financial Accounting  
 EBGN306 Managerial Accounting  
 EBGN314 Principles of Management  
 EBGN315 Business Strategy  
 EBGN342 Economic Development  
 EBGN345 Principles of Corporate Finance  
 EBGN409 Mathematical Economics<sup>†</sup>  
 EBGN455 Linear Programming<sup>†</sup>  
 EBGN441 International Trade  
 EBGN445 International Business Finance  
 EBGN495 Economic Forecasting  
 EBGN5XX<sup>††</sup>

<sup>†</sup>The eligible course is the one not taken as part of the EBGN core.

<sup>††</sup>Seniors with at least a 2.50 cumulative GPA may take a 500-level course with the consent of their department and the Dean of Graduate Studies.

Global Business specialization students take 6 hours from the following list of LAIS courses. Courses used to satisfy the H&SS cluster requirements cannot be double counted.

LICM301 Professional Oral Communication

LICM306 Selected Topics in Written Communication  
 LIHU398A Comparative Political Cultures  
 LISS330 Managing Cultural Differences  
 LISS335 International Political Economy  
 LISS340 International Political Economy of Latin America  
 LISS342 International Political Economy of Asia  
 LISS344 International Political Economy of the Middle East  
 LISS351 The History of Eastern Europe and Russia since 1914  
 LISS375 Introduction to Law and Legal Systems  
 LISS431 Global Environmental Issues  
 LISS433 Global Corporations  
 LISS440 Latin American Development  
 LISS441 Hemispheric Integration in the Americas

### *Minor Program*

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 Microeconomics (EBGN311) and Principles of Macroeconomics (EBGN312). Students who complete the EBGN311/312 sequence are not required to take EBGN201 to satisfy their CSM core curriculum requirement. If a student has already taken EBGN201 in addition to EBGN311 and EBGN312, he/she should choose 3 additional courses from the lists below. If a student has not taken EBGN201, he/she should choose 4 additional courses from the lists below. Students can 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 cluster electives can be counted toward the minor.

### *Area of Special Interest*

The area of special interest in Economics and Business requires that students complete either Principles of Economics (EBGN201) and 3 other courses in economics and business chosen from the lists below, for a total of 12 credit hours, or Principles of Microeconomics (EBGN311), Principles of Macroeconomics (EBGN312) and 2 other courses chosen from the lists below, for a total of 12 credit hours. Students who complete the EBGN311/312 sequence are not required to take EBGN201 to satisfy their core curriculum requirement. Economics courses taken as part of the Humanities and Social Sciences cluster electives can be counted toward the area of special interest.

<b>Economics Focus</b>	lec.	lab.	sem.	hrs.
EBGN310 Environmental and Resource Economics	3			3
EBGN315 Business Strategy	3			3
EBGN320 Economics and Technology	3			3
EBGN330 Energy Economics	3			3
EBGN342 Economic Development	3			3
EBGN401 History of Economic Thought	3			3
EBGN409 Mathematical Economics	3			3
EBGN411 Intermediate Microeconomics	3			3
EBGN412 Intermediate Macroeconomics	3			3
EBGN441 International Economics	3			3
EBGN490 Econometrics	3			3
EBGN495 Economic Forecasting	3			3
<b>Business</b>	lec.	lab.	sem.	hrs.
EBGN304 Personal Finance	3			3
EBGN305 Financial Accounting	3			3
EBGN306 Managerial Accounting	3			3
EBGN314 Principles of Management	3			3
EBGN321 Engineering Economics	3			3
EBGN325 Operations Research/Operations Mgmt	3			3
EBGN345 Corporate Finance	3			3
EBGN445 International Business Finance	3			3
EBGN455 Linear Programming	3			3

## **Engineering**

JOAN P. GOSINK, Professor and Division Director  
 D. VAUGHAN GRIFFITHS, Professor  
 ROBERT J. KEE, George R. Brown Distinguished Professor of Engineering  
 ROBERT H. KING, Professor and Assistant Division Director

MARK A. LINNE, Professor  
NIGEL T. MIDDLETON, Professor and Vice-President for Academic Affairs  
GRAHAM G. W. MUSTOE, Professor  
PANKAJ SEN, Professor  
RAHMAT A. SHOURESHI, Gerard August Dobelman Distinguished Professor of Engineering  
JOHN R. BERGER, Associate Professor  
JEAN-PIERRE DELPLANQUE, Associate Professor  
WILLIAM A. HOFF, Associate Professor  
PANOS D. KIOUSIS, Associate Professor  
NING LU, Associate Professor  
MARK T. LUSK, Associate Professor  
DAVID R. MUÑOZ, Associate Professor  
KARL R. NELSON, Associate Professor  
TERENCE E. PARKER, Associate Professor  
MARCELO GODOY SIMOES, Associate Professor  
CATHERINE K. SKOKAN, Associate Professor  
RAY RUICHONG ZHANG, Associate Professor  
RICHARD CHRISTENSON, Assistant Professor  
CHRISTIAN DEBRUNNER, Assistant Professor  
JOHN P. H. STEELE, Assistant Professor  
MONEESH UPMANYU, Assistant Professor  
TYRONE VINCENT, Assistant Professor  
SANAA ABDEL-AZIM, Lecturer  
CANDACE S. AMMERMAN, Lecturer  
RON KNOSHAUG, Lecturer  
HAROLD W. OLSEN, Research Professor  
MICHAEL B. McGRATH, Emeritus Professor  
GABRIEL M. NEUNZERT, Emeritus 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 a branch of civil, electrical, environmental or mechanical engineering. The program emphasizes fundamental engineering principles to provide a viable basis for lifelong learning. 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 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 Goals (Bachelor of Science in Engineering)*

- ◆ Graduates will understand the design and analysis of engineering systems and the interdisciplinary nature of engineering.
- ◆ Graduates will have an appreciation for engineering practice as it relates to the earth, energy, materials and environment.
- ◆ Graduates will have the engineering expertise and lifelong learning skills to meet the present and future needs of society.
- ◆ Graduates will be able to incorporate non-technical constraints and opportunities (i.e. aesthetic, social, ethical, etc.) in their engineering practice.
- ◆ Graduates will be well-prepared to assume entry level positions in industry or to enter appropriate graduate programs.

### *Curriculum*

During their first two years at CSM, students complete a set of core courses that include basic sciences, to provide knowledge about nature and its phenomena, and engineering sciences, to extend the basic sciences through creative use of laws of nature. Course work in mathematics is an essential part of the curriculum, giving engineering students essential tools for modeling, analyzing and predicting physical phenomena. A total of forty-six credit hours address the important areas of mathematics and the basic sciences. The core also includes liberal arts and international studies which enrich the educational experience and instill a greater understanding of how engineering decisions impact human and social affairs.

Engineering design course work begins in the freshmen year in Design I, and continues through the four-year curriculum. This experience teaches design methodology and stresses the creative and synthesis aspects of the engineering profession. Three systems-oriented core courses demonstrate the linkages among earth and environmental systems, human systems, and engineered systems.

Students complete an advanced core that includes electronics and circuit theory, engineering mechanics, advanced mathematics, thermodynamics, economics, engineering design, and additional studies in liberal arts and international topics. In their last two years of study, students must choose a specialty, consisting of at least 24 credit hours in civil, electrical, environmental or mechanical engineering, plus at least 9 credit hours of free electives. These electives, at the student's discretion, can be used to obtain 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, stressing the interdisciplinary nature of engineering systems. The projects are generated by customer demand, and include experiential verification to ensure a realistic design experience. Throughout their academic careers, students will benefit from interaction with well-qualified faculty who maintain research and professional leadership.

Prospective students should note that this is an integrated, broad-based and interdisciplinary engineering program. Specifically, the curriculum incorporates topics related to the minerals, energy and materials industries such as "Earth and Environmental Systems", "Earth Systems Engineering", and "Materials Engineering Systems", while excluding some of the subjects that might be taught in more traditional majors in civil, electrical, environmental or mechanical engineering. We emphasize the analysis and design of engineering systems 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 grants from the Department of Education/ Fund for the Improvement of Post-Secondary Education, the National Science Foundation, the Parsons Foundation, Chevron, Kennecott Mining, and Fluor Daniel.

The **Civil Engineering Specialty** builds on the applied mechanics principles of the core curriculum to focus in geotechnics and structures. Students are required to take courses in soil mechanics, foundations, structural theory, structural design and surveying. In addition, students must choose three electives from a list of civil oriented courses which includes opportunities for individual study projects.

The **Electrical Engineering Specialty** has focused depth in the areas of electromechanical energy conversion, power distribution, signal and system analysis, and instrumentation. The program includes microprocessor-based systems design, electronic devices and systems, communications, signal processing, and control 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 applied mechanics and thermosciences with an emphasis on analytical methods and engineering design of machinery. Topics such as heat transfer, advanced thermodynamics and advanced stress analysis are an important part of the mechanical engineering program, which also includes control theory, and vibrations.

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 extensive teaching and research laboratories. Interdisciplinary laboratories include the IBM Automated Systems Laboratory, the Multidisciplinary Engineering Laboratories, the USGS Soil Mechanics Laboratory, and environmental engineering laboratories in Coolbaugh Hall.

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

### *Degree Requirements in Engineering*

<b>Sophomore Year Fall Semester</b>	lec.	lab.	sem.hrs.
DCGN241 Statics	3		3
SYGN201/202*			
Engineered Earth / Materials Systems	3		3
MACS213 Calc. for Scists & Engr/Ers III	4		4
PHGN200 Physics II	3	3	4.5
MACS260/261**Programming	2/3		2/3
PAGN2XX Physical Education	2		0.5
<b>Total</b>			<b>17/18</b>

\*CE and Env. Specialty students take SYGN201, Engineered Earth Systems; EE and ME Specialty students take SYGN202,

Engineered Materials Systems.

\*\*CE and Env. Specialty students take Fortran Programming, MACS260 (2.0 credit hours); ME and EE Specialty students take Computer Programming Concepts (C++) (3.0 credit hours), MACS261.

<b>Sophomore Year Spring Semester</b>	lec.	lab.	sem.hrs.
MACS315 Differential Equations	3		3
PAGN2XX Physical Education	2		0.5
SYGN200 Human Systems	3		3
EGGN320 Mechanics of Materials	3		3
DCGN381 Elect. Circuits, Elect. & Pwr.	3		3
EGGN250 Multi-disc. Eng. Lab. I		4.5	1.5
EPIC251 Design II	3	1	3
Total			17

### **Civil Specialty**

<b>Sophomore-Junior Year Summer Field Session</b>	lec.	lab.	sem.hrs.
EGGN 234 Field session - Civil			3
Total			3

<b>Junior Year Fall Semester</b>	lec.	lab.	sem.hrs.
MACS348 Engineering Mathematics	3		3
MACS323 Probability & Statistics	3		3
EGGN315 Dynamics	3		3
EGGN351 Fluid Mechanics	3		3
EGGN342 Structural Theory	3		3
Civil Specialty Elective	3		3
Total			18

<b>Junior Year Spring Semester</b>	lec.	lab.	sem.hrs.
LAIS/EBGN H&SS cluster elective I	3		3
EGGN371 Engineering Thermodynamics	3		3
EGGN444/445 Design of Steel or Concrete Structures	3		3
EGGN361 Soil Mechanics	3		3
EGGN363 Soil Mechanics Lab	3		1
Civil Specialty Elective	3		3
Total			16

<b>Senior Year Fall Semester</b>	lec.	lab.	sem.hrs.
LAIS/EBGN H&SS cluster elective II	3		3
EGGN350 Multi-disc. Eng. Lab. II		4.5	1.5
EGGN491 Senior Design I	3	3	4
EBGN201 Principles of Economics	3		3
EGGN413 Computer Aided Engineering	3		3
EGGN464 Foundations	3		3
Total			17.5

<b>Senior Year Spring Semester</b>	lec.	lab.	sem.hrs.
Free electives	9		9
LAIS/EBGN H&SS cluster elective III	3		3
EGGN492 Senior Design II	1	6	3
EGGN Civil Specialty Elective	3		3
Total			18

**Degree Total** 139.5

### **Electrical Specialty**

<b>Junior Year Fall Semester</b>	lec.	lab.	sem.hrs.
MACS323 Probability & Statistics	3		3
MACS348 Engineering Mathematics	3		3
PHGN300 Modern Physics	3		3
EGGN382 Engineering Circuit Analysis	1	3	2
EGGN388 Information Systems Science	3		3
EGGN384 Digital Logic	3	3	4
Total			18

<b>Junior Year Spring Semester</b>	lec.	lab.	sem.hrs.
LAIS/EBGN H&SS cluster elective I	3		3

EGGN351 Fluid Mechanics	3		3
EGGN350 Multi-disc. Eng. Lab. II		4.5	1.5
EGGN371 Engineering Thermodynamics	3		3
EGGN385 Electronic Devices&Circuits	3	3	4
EGGN389 Fund. of Electric Machinery	3	3	4
Total			18.5

**Junior-Senior Year**

<b>Summer Field Session</b>	lec.	lab.	sem.hrs.
EGGN 334 Field session - Electrical	3		3
Total			3

<b>Senior Year Fall Semester</b>	lec.	lab.	sem.hrs.
LAIS/EBGN H&SS cluster elective II	3		3
EGGN – Electrical Specialty Elective	3		3
EGGN450 Multi-disc. Eng. Lab. III		3	1
EGGN491 Senior Design I	3	3	4
EBGN201 Principles of Economics	3		3
EGGN407 Feedback Control Systems	3		3
Total			17

<b>Senior Year Spring Semester</b>	lec.	lab.	sem.hrs.
Free electives	9		9
LAIS/EBGN H&SS cluster elective III	3		3
EGGN492 Senior Design II	1	6	3
EGGN Electrical Specialty Elective	3		3
Total			18

**Degree Total** 142.5

**Environmental Specialty**

<b>Junior Year Fall Semester</b>	lec.	lab.	sem.hrs.
MACS323 Probability & Statistics	3		3
MACS348 Engineering Mathematics	3		3
EGGN351 Fluid Mechanics	3		3
EGGN371 Engineering Thermodynamics	3		3
EGGN315 Dynamics	3		3
EGGN353 Environmental Sci. & Eng. I	3		3
Total			18

<b>Junior Year Spring Semester</b>	lec.	lab.	sem.hrs.
LAIS/EBGN H&SS cluster elective I	3	3	
EGGN350 Multi-disc. Eng. Lab. II		4.5	1.5
EGGN413/407			
CAE/Feedback Control Systems	3		3
EGGN354 Environmental Sci. & Eng. II	3		3
Free elective	3		3
EGGN Environmental Specialty Elective	3		3
Total			16.5

**Junior-Senior Year**

<b>Summer Field Session</b>	lec.	lab.	sem.hrs.
EGGN 335 Field Session Environmental			3
Total			3

<b>Senior Year Fall Semester</b>	lec.	lab.	sem.hrs.
EGGN491 Senior Design I	3	3	4
Free elective	3		3
EGGN Environmental Specialty Elective	6		6
EBGN201 Principles of Economics	3		3
Total			16

<b>Senior Year Spring Semester</b>	lec.	lab.	sem.hrs.
Free elective	3		3
LAIS/EBGN H&SS cluster elective II	3		3
LAIS/EBGN H&SS cluster elective III	3		3
EGGN492 Senior Design II	1	6	3
EGGN Environmental Specialty Elective	6		6
Total			18

**Degree Total** 138.5

**Mechanical Specialty**

**Sophomore-Junior Year**

<b>Summer Field Session</b>	lec.	lab.	sem.hrs.
EGGN 235 Field Session - Mechanical			3
Total			3

<b>Junior Year Fall Semester</b>	lec.	lab.	sem.hrs.
MACS323 Probability & Statistics	3		3
MACS348 Engineering Mathematics	3		3
LAIS/EBGN H&SS cluster elective I	3		3
EGGN315 Dynamics	3		3
EGGN371 Engineering Thermodynamics	3		3
EGGN388 Information Systems Science	3		3
Total			18

<b>Junior Year Spring Semester</b>	lec.	lab.	sem.hrs.
LAIS/EBGN H&SS cluster elective II	3		3
EBGN201 Principles of Economics	3		3
EGGN351 Fluid Mechanics	3		3
EGGN350 Multi-disc. Eng. Lab. II		4.5	1.5
EGGN407 Feedback Control Systems	3		3
EGGN Mechanical Specialty Elective	3		3
Total			16.5

<b>Senior Year Fall Semester</b>	lec.	lab.	sem.hrs.
EGGN450 Multi-disc. Eng. Lab. III		3	1
EGGN491 Senior Design I	3	3	4
Free elective	3		3
EGGN413 Computer-Aided Engineering	3		3
EGGN471 Heat Transfer	3		3
EGGN411 Machine Design	3	3	4
Total			18

<b>Senior Year Spring Semester</b>	lec.	lab.	sem.hrs.
Free elective	6		6
LAIS/EBGN H&SS cluster elective III	3		3
EGGN492 Senior Design II	1	6	3
EGGN Mechanical Specialty Elective	6		6
Total			18

**Degree Total** 141.5

**Engineering Specialty Electives**

**Civil Specialty**

Civil Specialty students are required to take three courses from the following list.

- EGGN333 Geographical Measurement Systems
- EGGN340 Cooperative Education (Civil)
- EGGN353 Fund. of Environmental Science and Engineering I
- EGGN354 Fund. of Environmental Science and Engineering II
- EGGN398 Steel Bridge/Concrete Canoe
- EGGN399 Independent Study (Civil)
- EGGN422 Advanced Mechanics of Materials
- EGGN442 Finite Element Methods For Engineers
- EGGN444/445 Steel Design or Concrete Design (one of the two courses is required; see Junior Spring Semester)
- EGGN451 Hydraulic Problems
- EGGN453 Wastewater Engineering
- EGGN454 Water Supply Engineering
- EGGN455 Solid and Hazardous Waste Engineering
- EGGN456 Scientific Basis of Environmental Regulations
- EGGN457 Site Remediation Engineering
- EGGN465 Unsaturated Soil Mechanics
- EGGN473 Fluid Mechanics II
- EGGN478 Engineering Dynamics
- EGGN488 Reliability of Engineering Systems
- EGGN498 Steel Bridge/Concrete Canoe

EGGN499 Independent Study (Civil)  
EBGN421 Engineering Economics  
MNGN321 Introduction to Rock Mechanics  
MNGN404 Tunneling  
MNGN405 Rock Mechanics in Mining  
MNGN406 Design and Support of Underground Excavations  
GEGN467 Groundwater Engineering  
GEGN468 Engineering Geology and Geotechnics

### **Electrical Specialty**

Electrical specialty students are required to take two from the following list of electrical technical elective courses:

EGGN482 Microcomputer Architecture and Interfacing  
EGGN483 Analog and Digital Communications Systems  
EGGN484 Power Systems Analysis  
EGGN485 Power Electronics  
PHGN361 Intermediate Electromagnetism  
PHGN440 Solid State Physics  
PHGN435 Microelectronics Processing Laboratory  
EGES510 Image and Multidimensional Signal Processing  
EGES511 Digital Signal Processing  
EGES512 Computer Vision  
EGES517 Theory and Design of Advanced Control systems  
EGES521 Mechatronics  
EGES523 Design of Digital Control Systems  
EGES585 Advanced High Power Electronics

### **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 in Environmental Specialty courses. In addition students are required to take five courses from the following focus areas. At least one course must be taken from three of the focus areas:

#### *Solid and Hazardous Waste Engineering*

EGGN/ESGN457 Site Remediation Engineering  
ESGN462 Solid Waste Minimization  
ESGN463 Industrial Waste: Recycling and Marketing

#### *Water and Waste Water Engineering*

EGGN/ESGN453 Wastewater Engineering  
EGGN/ESGN454 Water Supply Engineering  
EGGN/ESGN455 Solid and Hazardous Waste Engineering  
ESGN440 Environmental Pollution: Sources, Characteristics, Transport and Fate

#### *Fluid Mechanics*

EGGN451 Hydraulic Problems  
EGGN473 Fluid Mechanics II  
GEGN467 Groundwater Engineering

*Applied Environmental Biology and Chemistry* (a maximum of two courses in this category may be applied towards the required Environmental Specialty Electives)

ESGN301 Environmental Biology  
ESGN/ChGN302 Environmental Chemistry  
ESGN456 Scientific Basis of Environmental Regulations  
ChGN462 Microbiology and the Environment

### **Mechanical Specialty**

Mechanical specialty students are required to take three from the following list of mechanical elective courses:

EGGN400 Intro. to Robotics for the Minerals and Construction Industries  
EGGN403 Thermodynamics II  
EGGN422 Advanced Mechanics of Materials  
EGGN442 Finite Element Methods for Engineers  
EGGN473 Fluid Mechanics II  
EGGN478 Engineering Dynamics  
CHEN/EBGN421 Engineering Economics



PHGN350 Intermediate Mechanics  
 MTGN/EGGN390 Materials and Manufacturing Processes  
 MTGN445 Mechanical Properties of Materials  
 MTGN450 Statistical Control of Materials Processes  
 MTGN464 Forging and Forming  
 MNGN321 Intro. to Rock Mechanics

*Division of Engineering Areas of Special Interest and Minor Programs*

**General Requirements**

A **Minor Program** of study must consist of a minimum of 18 credit hours of a logical sequence of courses, only three hours of which may be taken at the 100- or 200- level. No more than six credit hours of the sequence may be taken in the student's degree granting department.

An **Area of Special Interest (ASI)** must consist of a minimum of 12 credit hours of a logical sequence of courses, only three hours of which may be taken at the 100- or 200-level. No more than three credit hours of the sequence may be specifically required by the degree program in which the student is graduating.

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. The first is a program in General Engineering which is suited to students who are not pursuing an engineering degree. This program offers foundation coursework in engineering which is compatible with many of the topics in the Fundamentals of Engineering examination. The second is a program in Engineering Specialties which is suited to students pursuing an engineering degree, and who have therefore completed much of the coursework represented in the General Engineering program. Students may opt to pursue minors or ASIs in civil, electrical, environmental or mechanical engineering within the Engineering Specialties program.

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 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.

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.
EGGN361 Soil Mechanics	3 sem hrs.
EGGN363 Soil Mechanics Laboratory	1 sem hrs.
EGGN444 Design of Steel Structures	3 sem hrs.
EGGN445 Design of Reinforced Concrete Structures	3 sem hrs.
EGGN451 Hydraulic Problems	3 sem hrs.
EGGN464 Foundations	3 sem hrs.
EGGN333 Geographic Measurement Systems	3 sem hrs.
EGGN354 Fundamentals of Environmental Science and Engineering II	3 sem hrs.
EGGN422 Advanced Mechanics of Materials	3 sem hrs.

EGGN442 Finite Element Methods for Engineers	3 sem hrs.
EGGN453 Wastewater Engineering	3 sem hrs.
EGGN454 Water Supply Engineering	3 sem hrs.
EGGN465 Unsaturated Soil Mechanics	3 sem hrs.
EGGN478 Engineering Dynamics	3 sem hrs.
EGGN498 Numerical Methods for Engineers	3 sem hrs.
EGGN498 Advanced Soil Mechanics	3 sem hrs.
EGGN499 Dynamics of Structures and Soils	3 sem hrs.
MNGN321 Introduction to Rock Mechanics	3 sem hrs.
GEGN467 Groundwater Engineering	4 sem hrs.
GEGN468 Engineering Geology and Geotechnics	4 sem hrs.

### **Electrical**

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

DCGN381 Introduction to Electrical Circuits, Electronics and Power	3 sem hrs.
EGGN382 Engineering Circuit Analysis	2 sem hrs.
EGGN388 Information Systems Science	3 sem hrs.

Additional courses are to be selected from:

EGGN334 Engineering Field Session, Electrical Specialty	3 sem hrs.
EGGN384 Digital Logic	4 sem hrs.
EGGN385 Electronic Devices and Circuits	4 sem hrs.
EGGN389 Fundamentals of Electric Machinery	4 sem hrs.
EGGN407 Introduction to Feedback Control Systems	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.
EGES510 Image and Multidimensional Signal Processing	3 sem hrs.
EGES511 Digital Signal Processing	3 sem hrs.
EGES512 Computer Vision	3 sem hrs.
EGES517 Theory and Design of Advanced Control Systems	3 sem hrs.
EGES521 Mechatronics	3 sem hrs.
EGES523 Design of Digital Control Systems	3 sem hrs.
EGES585 Advanced High Power Electronics	3 sem hrs.

### **Environmental**

A twelve credit ASI or eighteen credit minor sequence must be selected from:

EGGN353 Fund. of Environ. Science & Engineering I	3 sem hrs.
EGGN354 Fund. of Environ. Science & Engineering II	3 sem hrs.
ESGN440 Environmental Pollution: Sources, Characteristics, Transport and Fate	3 sem hrs.
EGGN453 Wastewater Engineering	3 sem hrs.
EGGN454 Water Supply Engineering	3 sem hrs.
EGGN/ESGN455 Solid and Hazardous Waste Engineering	3 sem hrs.
EGGN457 Site Remediation Engineering	3 sem hrs.
ESGN462 Solid Waste Minimization	3 sem hrs.
ESGN463 Industrial Waste: Recycling and Marketing	3 sem hrs.

### **Mechanical**

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

EGGN351 Fluid Mechanics	3 sem hrs.
EGGN403 Thermodynamics II	3 sem hrs.
EGGN471 Heat Transfer	3 sem hrs.
EGGN473 Fluid Mechanics II	3 sem hrs.
EGGN411 Machine Design	3 sem hrs.
EGGN413 Computer-Aided Engineering	3 sem hrs.
EGGN400 Introduction to Robotics	3 sem hrs.
EGGN407 Feedback Control Systems	3 sem hrs.
EGGN422 Advanced Mechanics of Materials	3 sem hrs.

### ***Five-year 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 advanced coursework in Engineering Systems. Upon completion of the

program, students receive two degrees, the Bachelor of Science in Engineering and the Master of Science in Engineering Systems.

Students must apply to enter this program in their mid-Sophomore or beginning Junior year. 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), and maintain a B average. 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 Systems graduate program.

At the graduate level, students must complete EGES 501, 502, 503 and 504 (a total of 12 credits), plus an additional 18 credits of approved graduate coursework, and maintain a B average.

Interested students can obtain additional information from the Division of Engineering.

### ***Five-Year Combined Engineering Physics or Chemistry Baccalaureate and Engineering 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 BS program with a reduced set of engineering classes. These classes come in one of two tracks: Electrical engineering, and Mechanical engineering. At the end of the fourth year, the student is awarded an Engineering Physics BS or Chemistry BS, as appropriate. Students in this program are automatically entered into the Engineering Systems Masters degree program. Just as any graduate student, it is possible for them to graduate in one year (non-thesis option) with a Masters of Engineering in Engineering Systems degree.

Students must apply to enter this program in their mid-Sophomore or beginning Junior year. To complete the undergraduate portion of the program, students must take the classes indicated by the “typical” class sequence for the appropriate track, maintain a B average, find an appropriate Senior Design project that can lead into a Masters report or a Masters thesis by the start of the Senior year, and find a Division of Engineering advisor by the start of the Senior year and make sure that he/she agrees with the subject and scope of the Senior Design project. 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 Systems graduate program.

Interested students can obtain additional information and detailed curricula from the Division of Engineering or the Physics Department.

## **Environmental Science and Engineering**

ROBERT SIEGRIST, Professor and Interim Division Director

BRUCE D. HONEYMAN, Professor

TISSA ILLANGASEKARE, Professor and AMAX Distinguished Chair

PHILIPPE ROSS, Professor

RONALD R.H. COHEN, Associate Professor

LINDA A. FIGUEROA, Associate Professor

DIANNE AHMANN, Assistant Professor

JÖRG DREWES, Assistant Professor

JUNKO MUNAKATA MARR, Assistant Professor

ROBERT F. HOLUB, Research Professor

MICHAEL SEIBERT, Research Professor

JOHN C. EMERICK, Research Associate Professor

MARIA L. GHIRARDI, Research Associate Professor

MATTHIAS KOHLER, Research Associate 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***

See entries in this Bulletin under Engineering 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***

All students pursuing the ESE Minor or ASI are required to take ESGN353 and ESGN354. Any course offered by

the ESE Division (all ESGN numbered courses) may be applied to the ESE Minor or ASI. In addition, courses offered by other academic departments may be applied, with approval, to the ESE Minor or ASI. Examples of such courses are listed below:

CHGN403 Introduction to Environmental Chemistry  
GEGN467 Groundwater Engineering  
GEGN470 Ground-Water Engineering Design  
GEOC407 Atmosphere, Weather and Climate  
GEOC408 Introduction to Oceanography  
PHGN404 Physics of the Environment

Students should review the restrictions currently placed on all Minor and ASI programs at CSM by consulting the Description of Undergraduate Programs; Minor Programs/Area of Special Interest section of this bulletin. Note particularly the limitations on the number of hours, which may be taken at the 100 or 200 level or in the students degree-granting department when planning a Minor Program. In addition to ESGN courses and courses listed above one course from the list below may be applied to the ESE Minor program (the list below is not applicable to the ESE ASI Program):

EBGN470 Environmental Economics  
LISS364 Engineering, Science and Technology  
LISS431 Global Environmental Issues  
LISS460 Technology and Wilderness  
LISS480 Environmental Politics and Policy  
LISS482 Water Politics and Policy

Undergraduates considering the ESE Minor or ASI Programs should note that hours applied to these ESE Programs may also satisfy general science, engineering, humanities or Senior Seminar requirements specific to your degree-granting department. Undergraduates who choose to pursue an ESE Minor or ASI should complete a Minor Declaration form (available from the Registrar's office). The Minor Declaration Form serves as a Curriculum Plan for the ESE Minor and ASI Programs (this plan can be changed at any time with the approval of the students degree-granting department and the ESE Division). Further details concerning the ESE Minor and ASI Programs can be obtained from the ESE Division.

## Geology and Geological Engineering

MURRAY W. HITZMAN, Professor, Charles F. Fogarty Professor of Economic Geology, and Department Head

WENDY J. HARRISON, Professor

NEIL F. HURLEY, Professor, Charles Boettcher Distinguished Chair in Petroleum Geology

KEENAN LEE, Professor

EILEEN POETER, Professor

SAMUEL B. ROMBERGER, Professor

A. KEITH TURNER, Professor

JOHN E. WARME, Professor

RICHARD F. WENDLANDT, Professor

L. GRAHAM CLOSS, Associate Professor

JOHN B. CURTIS, Associate Professor

MICHAEL A. GARDNER, Associate Professor

JERRY D. HIGGINS, Associate Professor

GREGORY S. HOLDEN, Associate Professor and Assistant Department Head

JOHN D. HUMPHREY, Associate Professor

KEVIN W. MANDERNACK, Associate Professor

PAUL SANTI, Associate Professor

ERIC P. NELSON, Associate Professor

JOHN E. McCRAY, Assistant Professor

DONNA S. ANDERSON, Research Assistant Professor

MARY CARR, Research Assistant Professor

GEOFF THYNE, Research Assistant Professor

TIMOTHY A. CROSS, Associate Professor Emeritus

JOSEPH J. FINNEY, Professor Emeritus

THOMAS L.T. GROSE, Professor Emeritus

JOHN D. HAUN, Professor Emeritus

RICHARD W. HUTCHINSON, Professor Emeritus

ROBERT J. WEIMER, 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 the Accreditation Board for Engineering and Technology, 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 or 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.

Students interested in careers in Geological Engineering are encouraged to enroll in a one unit Spring course (GEOL 102) entitled "Careers in Geological Engineering". The course, a series of presentations by faculty and outside professionals on all aspects of these careers, is designed to provide students with the background necessary to make informed career decisions. All students are invited to participate.

### *Program Goals (Bachelor of Science in Geological Engineering)*

In addition to achieving the goals described in the CSM Graduate Profile and the ABET Accreditation Criteria, the Geological Engineering Program at CSM has established the following goals:

Graduates of the Department should have depth and breadth in one or more of the following fields: ground-water engineering, engineering geology and geotechnics, environmental geology, and natural resource exploration and development. They should have the knowledge and experience to recognize problems and design solutions through application of scientific and engineering principles and methods.

Graduates must have the communication skills which permit them to convey technical information, geoscience and geoengineering concepts, and results of technical studies to peers and the lay public. Communication skills include oral, written and graphic presentations, computer-based retrieval, manipulation and analysis of technical information, and general computer literacy.

Graduates should appreciate and respect the characteristics and worth of leadership and teamwork, and should possess the attitude that teamwork and cooperation are equally important values as leadership.

Graduates should have the skills and desire, as well as technical breadth and depth, to continue their personal and professional growth through life-long learning. Graduates should have the understanding that personal and professional flexibility, creativity, resourcefulness, receptivity and openness are crucial attributes to continued growth and success in increasingly diverse, multi-disciplinary technical environments.

Graduates should appreciate and respect diversity of culture, language, religion, social-political-economic systems, approaches toward thinking and analysis, and personal preference. They should feel capable of working in a technical capacity and communicating with others in an international geoscience and geoengineering arena.

Graduates should practice ethical behavior and integrity, and they should function such that their society benefits from their work in the geosciences and geoengineering disciplines.

### ***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:

1. CSM Freshman Common Core - 33 sem hrs.
2. Mathematics, Physics and Computer Science (beyond Freshman year) - 16.5 sem hrs.
3. Earth Systems Engr & Design II (GE Option) - 6 sem hrs.
4. Basic Geoscience - 19 to 23 sem hrs.
5. Basic Engineering Sciences - 12 sem hrs.
6. Geological Engineering Field Methods - 8 sem hrs.
7. Geological Engineering and related engineering topics - 24 to 28 sem hrs.
8. Humanities & Social Sciences (beyond Freshman yr) - 15 sem hrs.
9. Free Electives - 9 sem hrs.

### **Degree Requirements (Geological Engineering)**

<b>Sophomore Year Fall Semester</b>	lec.	lab.	sem. hrs.
SYGN201 Engineered Earth Systems	2	3	3
MACS213 Calc. for Scientists & Engr's III	4		4
PHGN200 Physics II	3.5	3	4.5
DCGN241 Statics	3		3
SYGN200 Human Systems	3		3
PAGN201 Physical Education III		2	0.5
<b>Total</b>			<b>18</b>
<b>Sophomore Year Spring Semester</b>	lec.	lab.	sem. hrs.
EPICS251 Design II	2	3	3
GEOL212 Mineralogy	2	3	3
GEOL201 Hist. Geology and Paleontology	3	3	4
MACS312 Differential Equations	2		2
MACS261 Computer Programming Concepts	3		3
EGGN320 Mechanics of Materials	3		3
PAGN202 Physical Education IV		2	0.5
<b>Total</b>			<b>18.5</b>

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.*

<b>Junior Year Fall Semester</b>	lec.	lab.	sem. hrs.
GEOL221 Optical Mineralogy	2	4	3
GEOL309 Structural Geology	3	3	4
DCGN209 Introduction to Thermodynamics	3		3
EBGN201 Principles of Economics	3		3
Tech Elective I *	3		3
<b>Total</b>			<b>16</b>

<b>Junior Year Spring Semester</b>	lec.	lab.	sem.	hrs.
GEOL307 Igneous & Metamorphic Petrology	3	6		5
GEGN317 Geologic Field Methods		6		2
GEOL314 Stratigraphy	3	3		4
LAIS/EBGN H&SS Cluster Elective I	3			3
Tech Elective II *	3			3
EGGN351 Fluid Mechanics	3			3
<b>Total</b>				<b>20</b>

\*Technical Electives I & II: Either MNGN 321 or EGGN 361 is required as ONE of the technical electives. An additional technical elective must be selected so that the total technical elective credit hours are composed of a balance of engineering science and engineering design.

<b>Summer Field Term</b>	lec.	lab.	sem.	hrs.
GEGN316 Field Geology		6		6

<b>Senior Year Fall Semester</b>	lec.	lab.	sem.	hrs.
GEGN4—Option Elective	3	3		4
GEGN4—Option Elective	3	3		4
LAIS/EBGN H&SS Cluster Elective II	3			3
GPGN311 Survey of Exploration Geophysics**	3	3		4
Free Elective				3
<b>Total</b>				<b>18</b>

\*\*Other appropriate Applied Geophysics courses may be substituted for GPGN311 with approval of GE Department.

<b>Senior Year Spring Semester</b>	lec.	lab.	sem.	hrs.
GEGN4—Design Elective	2	3		3
GEGN4—Design Elective	2	3		3
LAIS/EBGN H&SS Cluster Elective III	3			3
MACS323 Probability & Statistics	3			3
Free Elective				3
Free Elective				3
<b>Total</b>				<b>18</b>

**Degree Total** 147.5

#### **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.*

<b>Junior Year Fall Semester</b>	lec.	lab.	sem.	hrs.
GEGN342 Geomorphology	2	3		3
GEOL309 Structural Geology	3	3		4
DCGN209 Introduction to Thermodynamics*	3			3
EBGN201 Principles of Economics	3			3
EGGN361 Soil Mechanics	3			3
EGGN363 Soil Mechanics Lab	3			1
<b>Total</b>				<b>17</b>

\*Students in this concentration may substitute EGGN 371 for DCGN 209 with permission.

<b>Junior Year Spring Semester</b>	lec.	lab.	sem.	hrs.
GEOL306 Petrology	3	3		4
GEGN317 Geological Field Methods		6		2
GEOL314 Stratigraphy	3	3		4
LAIS/EBGN H&SS Cluster Elective I	3			3

MNGN321 Rock Mechanics	2	3	3
EGGN351 Fluid Mechanics	3		3
Total			19
<b>Summer Field Term</b>	lec.	lab.	sem. hrs.
GEGN316 Field Geology		6	6
<b>Senior Year Fall Semester</b>	lec.	lab.	sem. hrs.
GEGN468 Engineering Geology	3	3	4
GEGN467 Ground-Water Engineering	3	3	4
LAIS/EBGN H&SS Cluster Elective II	3		3
GPGN311 Survey of Exploration Geophysics**	3	3	4
Free Elective	3		3
Total			18
<b>Senior Year Spring Semester</b>	lec.	lab.	sem. hrs.
GEGN469 Engineering Geology Design	3		3
GEGN470 Ground-Water Engineering Design	3		3
LAIS/EBGN H&SS Cluster Elective III	3		3
MACS323 Probability & Statistics	3		3
Free Elective	3		3
Free Elective	3		3
Total			18
<b>Degree Total</b>			147.5

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  
MNGN404 Tunneling  
MNGN445/446 Open Pit Slope Design  
EBGN421 Engineering Economics  
EGGN454 Water Supply Engineering  
GEGN442 Advanced Engineering Geomorphology  
GEGN475 Applications of Geographic Information Systems  
GEGN499 Independent Study in Engineering Geology

**Ground-Water Engineering Emphasis:**

GEGN481 Advanced Hydrology  
GEGN483 Math Modeling of Ground-Water Systems  
EBGN421 Engineering Economics  
GEGN475 Applications of Geographic Information Systems  
GEGN499 Independent Study in Hydrogeology

**Geological Engineering Minor**

Students, other than Geological Engineering majors, desiring to receive a minor in Geological Engineering must complete 18 hours of Geology and Geological Engineering courses as follows:

1. SYGN101 Earth and Environmental Systems
2. At least one course from each of the following groups:
  - Petrology/Mineralogy*
    - GEOL210 Materials of the Earth or
    - GEOL212 Mineralogy and
    - GEOL307 Petrology or
    - GEGN306 Petrology
  - Structural Geology*
    - GEOL308 Applied Structural Geology or
    - GEOL309 Structural Geology and Tectonics
  - Stratigraphy*
    - GEOL314 Stratigraphy or
    - GEOL315 Sedimentology and Stratigraphy
3. One senior area elective course can be chosen from the following:
  - GEGN401 Mineral Deposits



- GEGN438 Petroleum Geology
- GEGN467 Ground-Water Engineering
- GEGN468 Engineering Geology & Geotechnics
- 4. Elective Geology & Geological Engineering courses to total 18 credits. (Design electives listed below are strongly recommended.)
  - GEGN403 Mineral Exploration Design
  - GEGN439 Multi-Disciplinary Petroleum Design
  - GEGN469 Engineering Geology Design
  - GEGN470 Ground-Water Engineering Design

#### **Area of Special Interest**

An Area of Special Interest (ASI) consists of 12 or more hours of course work. To receive an ASI, a student must take at least 12 hours of a logical sequence of courses, only three credit hours of which may be at the 100- or 200-level. Additionally a total of not more than three credit hours of the sequence may be specifically required by the degree program in which the student is graduating. For Geological Engineering, ASI students must satisfy item 2 of the Geological Engineering minor requirements above, or gain written approval of an alternative program.

## **Geophysics**

TERENCE K. YOUNG, Professor and Department Head

THOMAS L. DAVIS, Professor

ALEXANDER A. KAUFMAN, Professor

KENNETH L. LARNER, Charles Henry Green Professor of Exploration Geophysics

GARY R. OLHOEFT, Professor

MAX PEETERS, Baker Hughes Professor of Petrophysics and Borehole Geophysics

PHILLIP R. ROMIG, Professor and Dean of Graduate Studies and Research

JOHN A. SCALES, Professor

ROEL K. SNIEDER, Keck Foundation Professor of Basic Exploration Science

ILYA D. TSVANKIN, Professor

THOMAS M. BOYD, Associate Professor

YAOGUO LI, Associate Professor

NORMAN BLEISTEIN, Research Professor

MICHAEL L. BATZLE, Research Associate Professor

ROBERT D. BENSON, Research Associate Professor

HENGREN XIA, Research Assistant Professor

ROBERT L. KRANZ, Adjunct Associate Professor

WARREN B. HAMILTON, Distinguished Senior Scientist

PIETER HOEKSTRA, Distinguished Senior Scientist

THOMAS R. LAFEHR, Distinguished Senior Scientist

MISAC N. NABIGHIAN, Distinguished Senior Scientist

ADEL ZOHDY, Distinguished Senior Scientist

FRANK A. HADSELL, Professor Emeritus

GUY H. TOWLE, Professor Emeritus

JAMES E. WHITE, Professor Emeritus

### **Program Description**

Geophysics entails study of the Earth's interior through physical measurements collected either 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.

The Earth supplies all materials needed by our society, serves as the repository of used products, and provides a home to all its inhabitants. Therefore, geophysics and geophysical engineering have important roles to play in the solution of challenging problems facing the inhabitants of this planet. Oil companies and mining firms employ geophysicists to explore for hidden resources around the world. Geophysical engineers assess the Earth's near-surface properties when sites are chosen for large construction projects and waste-management operations. Geophysical technology is used in environmental applications such as groundwater surveys and tracking the flow of contaminants. On the global scale, geophysicists try to understand such Earth processes as heat flow, gravitational, magnetic, electric, thermal, and stress fields within the Earth's interior.

Founded in 1926, the Department of Geophysics at the Colorado School of Mines is the largest department in the Western World that specializes in applied geophysical research and education. Even so, with 20 active faculty and an average class size of 10, students receive individualized attention in a close-knit community where almost everybody

knows each other by name. CSM's Department of Geophysics is one of only two undergraduate geophysical engineering programs in the 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. Given the interdisciplinary nature of geophysics, the undergraduate curriculum requires students to become thoroughly familiar with geological, mathematical, and physical theories in addition to the various geophysical methodologies.

Traditionally, the resource industry has been, and continues to be, the largest employer of CSM geophysics graduates. Within this industry, graduates find employment with the major oil companies, independent contracting companies, and mineral exploration companies that carry out field data acquisition, processing, and interpretation. Graduates also find employment in engineering and geotechnical industries, government agencies, and the myriad of small contracting firms specializing in characterization of the shallow subsurface of the Earth. For the past decade, 100% of CSM's geophysics graduates have found employment in their chosen field, with about 20% choosing to pursue graduate studies.

**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.

**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.

**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's petrophysics laboratory for measuring properties of porous rocks. Undergraduate students also have their own room which is equipped with networked PCs and provides a friendly environment for work, study, relaxation, and socializing.

### *Program Goals (Bachelor of Science in Geophysical Engineering)*

Geophysical engineers and geophysicists must apply quantitative techniques to analyze an entity as complex as the Earth. Geophysical graduates, therefore, require a special combination of traits and abilities to thrive in this discipline. In addition to achieving the goals described in the CSM Graduate Profile and the ABET Accreditation Criteria, the Geophysics Program at CSM strives to graduate students who:

1. Think for themselves and demonstrate the willingness to question conventional formulations of problems, and are capable of solving these problems independently.
2. Are creative and demonstrate the ability to conceive and validate new hypotheses, new problem descriptions, and new methods for analyzing data.
3. Are good experimentalists and have demonstrated the ability to design and carry out a geophysical field survey or laboratory experiment and ensure that the recorded data are of the highest-possible quality.
4. Can deal rationally with uncertainty and have demonstrated that they understand that geophysical data are always incomplete and uncertain; can quantify the uncertainty and recognize when it is not acceptable to make decisions based on these data.
5. Have demonstrated qualities that are the foundation of leadership; know the importance of taking risks, and are able to make good judgments about the level of risk that is commensurate with their knowledge, experience, and chance of failure; realize that failure is unavoidable if you want to learn and grow.

### *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:

***Degree Requirements (Geophysical Engineering)***

<b>Sophomore Year Fall Semester</b>	Lec.	Lab	Sem.	Hrs
EBGN201 Principles of Economics	3			3
MACS213 Calculus for Scientists & Engineers III	4			4
(1)MACS261 Computer Programming Concepts	3			3
PAGN201 Physical Education	2			0.5
PHGN200 Physics II	3.5	3		4.5
SYGN201 Engineered Earth Systems	2	3		3
<b>Total</b>				<b>18</b>
<b>Sophomore Year Spring Semester</b>	Lec.	Lab	Sem.	Hrs
EPIC251 Design II Earth Engineering	2	3		3
GEOL201 Historical Geology & Paleontology	3			3
GPGN210 Materials of the Earth	3	3		4
(2)GPGN249 Applied Math for Geophysics	3		3 (2)	
MACS315 Differential Equations	3			3
PAGN202 Physical Education	2			0.5
SYGN200 Human Systems	3			3
<b>Total</b>				<b>19.5</b>
<b>Junior Year Fall Semester</b>	Lec.	Lab	Sem.	Hrs.
GEOL309 Structural Geology and Tectonics	3	3		4
GPGN303 Introduction to Gravity and Magnetic Methods	3	3		4
GPGN306 Linear Systems Analysis	3			3
GPGN320 Continuum Mechanics	3			3
GPGN321 Theory of Fields I: Static Fields	3			3
<b>Total</b>				<b>17</b>
<b>Junior Year Spring Semester</b>	Lec.	Lab	Sem.	Hrs.
GEOL314 Stratigraphy	3	3		4
GPGN302 Introduction to Seismic Methods	3	3		4
GPGN315 Field Methods for Geophysicists		6		2
GPGN308 Introduction to Electrical and Electromagnetic Methods	3	3		4
GPGN322 Theory of Fields II: Time Varying Fields	3			3
(3)Electives	3			3
<b>Total</b>				<b>20</b>
<b>Summer Session</b>	Lec.	Lab	Sem.	Hrs.
GPGN486 Geophysics Field Camp	4			4
<b>Total</b>				<b>4</b>
<b>Senior Year Fall Semester</b>	Lec.	Lab	Sem.	Hrs.
GPGN404 Digital Systems Analysis	3			3
(4)Advanced Geophysical Methods Elective	3	3		4
(4)Advanced Geophysical Methods Elective or DCGN381 Electrical Circuits	3	3		4
(5)GPGN438 Senior Design or GPGN 439 in Spring Semester	1	6		3
(3)Electives	6			6
<b>Total</b>				<b>19</b>
<b>Senior Year Spring Semester</b>	Lec.	Lab	Sem.	Hrs.
GPGN432 Formation Evaluation	2	2		3
GPGN494 Physics of the Earth	3			3
(5)GPGN439 Multi-disciplinary Petro. Design or GPGN438 beginning Fall Semester	3			3
(3)Electives	9			9
<b>Total</b>				<b>15</b>

<sup>(1)</sup>The preferred semester for MACS261 is in the Fall. Students who do not choose the Geophysics major until the Spring, however, can take MACS261 in the Spring, in exchange with HSS-III.

<sup>(2)</sup>Differential Equations (MACS315) should be taken before or concurrently with Applied Mathematics for Geophysicists (GPGN249)

<sup>(3)</sup>Electives must include at least 9 hours in an approved HSS Cluster. The Department of Geophysics encourages its students to consider organizing their electives to form a Minor or an Area of Special Interest (ASI). A guide suggesting various Minor and ASI programs can be obtained from the Department office.

<sup>(4)</sup>Students are encouraged to take two Advanced Geophysical Methods electives (GPGN404, GPGN422, or GPGN452), but they may substitute DCGN381 Electrical Circuits for one GP Methods elective.

<sup>(5)</sup>Students can take either GPGN438 or GPGN439 for their Senior Design Requirement. The multidisciplinary design course GPGN439 is strongly recommended for students interested in Petroleum Exploration and Production. GPGN438 is a variable credit-hour course that students can register in either or both Fall and Spring semesters of their senior years. Students must earn a total of 3 credit hours in GPGN438.

### *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 must include some of the following geophysics methods courses.

GPGN210, Materials of the Earth

GPGN302, Seismic Methods

GPGN303, Gravity and Magnetic Methods

GPGN308, Electrical and Electromagnetic Methods

GPGN419, Well Log Analysis and Formation Evaluation

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 should consult with the Department of Geophysics to get their sequence of courses approved before embarking on a minor program.

## **Liberal Arts and International Studies**

ARTHUR B. SACKS, Professor and Division Director

RICHARD G. OLSON, 2002-2003 Hennebach Visiting Professor

CARL MITCHAM, Professor

BARBARA M. OLDS, Professor and Associate Vice President for Academic Affairs

EUL-SOO PANG, Professor

HUSSEIN A. AMERY, Associate Professor

JAMES V. JESUDASON, Associate Professor

JUAN C. LUCENA, Associate Professor

KATHLEEN H. OCHS, Associate Professor

LAURA J. PANG, Associate Professor

KAREN B. WILEY, Associate Professor

JUAN E. de CASTRO, Assistant Professor

JOHN R. HEILBRUNN, Assistant Professor

SUZANNE M. MOON, Assistant Professor

ROBERT KLIMEK, Lecturer

TONYA LEFTON, Lecturer

JON LEYDENS, Lecturer and Writing Program Administrator

JAMES LOUGH, Lecturer

SUZANNE M. NORTHCOTE, Lecturer

SANDRA WOODSON, Lecturer

BETTY J. CANNON, Emeritus Associate Professor

W. JOHN CIESLEWICZ, Emeritus Professor

DONALD I. DICKINSON, Emeritus Professor

WILTON ECKLEY, Emeritus Professor

PETER HARTLEY, Emeritus Associate Professor

T. GRAHAM HEREFORD, Emeritus Professor

JOHN A. HOGAN, Emeritus Professor

GEORGE W. JOHNSON, Emeritus Professor  
ANTON G. PEGIS, Emeritus Professor  
JOSEPH D. SNEED, Emeritus Professor  
RONALD V. WIEDENHOEFT, Emeritus Professor  
THOMAS PHILIPOSE, University Emeritus Professor

## Program Description

The Division of Liberal Arts and International Studies (LAIS) does not offer an undergraduate degree, but instead offers a curriculum comprising a coherent sequence in the humanities and social sciences appropriate to a CSM education. The LAIS curriculum includes two core courses (LIHU100, Nature and Human Values, and SYGN200 Human Systems) and additional course work in one of four thematic clusters (See Cluster Requirements). To complete the humanities and social science requirements of the core, students also take EBG211, Principles of Economics, offered by the Division of Economics and Business. The focus of the entire core is human-environment interactions, and acknowledges that human systems are embedded in and dependent on environmental systems. This theme is consistent with the mission of CSM, with the mission of LAIS, and with the goals of the CSM Graduate Profile. The three electives are organized in clusters designed to increase depth of learning.

The Liberal Arts and International Studies Division provides students with an understanding of the cultural, philosophical, social, political, environmental, and economic contexts in which science and engineering function. LAIS offerings enable students to learn how their responsibilities extend beyond the technical mastery of science and technology to the consequences for human society and the rest of life on Earth. Because of those larger responsibilities, the LAIS mission includes preparing students for effective political and social thought and action.

Liberal arts exist for their intrinsic value. They are the arts of the free mind developing its powers for their own sake; they are the basis for the free, liberal, unhindered development of intellect and imagination addressing intrinsically worthy concerns. They are essential for preserving an open, creative and responsible society. The liberal arts include philosophy, literature, language, history, political science, the creative arts and the social sciences generally.

International Studies applies the liberal arts to the study of international political economy, which is the interplay between economic, political, cultural, historical, and environmental forces that shape the relations among the world's developed and developing areas. International Studies focus especially on the role of the state and the market.

The LAIS mission is crucial to defining the implications of CSM's commitment to stewardship of the Earth and to the permanent sustainability of both social organization and environmental resources and systems that such a commitment requires. A good foundation in the subjects provided by the LAIS Division is essential for graduating men and women who can provide the technical means for society's material needs in a manner that leaves posterity at an undiminished level of both social and environmental quality.

As a service to the CSM community, the LAIS Division operates the LAIS Writing Center, which provides students with instruction tailored to their individual writing problems, and faculty with support for Writing Across the Curriculum.

### *Program Goals*

The course work in the Division of Liberal Arts and International Studies is designed to help CSM develop in students the ability to: engage in life-long learning and recognize the value of doing so by acquiring: the broad education necessary to:

- a) understand the impact of engineering solutions in contemporary, global, international, societal, and ethical contexts;
- b) understand the role of Humanities and Social Sciences in identifying, formulating, and solving engineering problems;
- c) prepare people to live and work in a complex world;
- d) understand the meaning and implications of "stewardship of the Earth;"
- e) to communicate effectively in writing and orally.

### *Curriculum*

Key to courses offered by the LAIS Division:

LICM Communication  
LIFL Foreign Language  
LIHU Humanities  
LIMU Music  
LIHN McBride Honors  
LISS Social Sciences  
SYGN Systems

CSM students in all majors must take 19 credit-hours in humanities and social science courses. These courses are

housed in the Division of Liberal Arts and International Studies (LAIS) and the Division of Economics and Business (EB). The student's program in humanities and social sciences must demonstrate both breadth and depth and cannot be limited to a selection of unrelated introductory courses.

Ten of the 19 hours are specified: LIHU100, Nature and Human Values (4 credit-hours); SYGN200, Human Systems (3 credit-hours); and EBG201, Principles of Economics (3 credit-hours). The remaining 9 credit-hours must be chosen from a thematic cluster area (see below.)

Students in the McBride Honors Program must take LIHU100 and EBG201, but they are exempt from SYGN200 and the clusters requirement (see Minor Programs below.)

*NOTE:* Students may elect to satisfy the economics core requirement by taking both EBG311 and EBG312 instead of EBG201. Students considering a major in economics are advised to take the EBG311/312 sequence instead of taking EBG201.

*NOTE:* Any LAIS course, including Communication and Music courses, may be taken as a free elective.

*NOTE:* See the Foreign Languages (LIFL) entry in Section VI description of courses of this Bulletin for the CSM foreign language policy.

#### **Required Courses**

LIHU100	Nature and Human Values	4 sem hrs.
EBGN201	Principles of Economics	3 sem hrs.
SYGN200	Human Systems	3 sem hrs.
LAIS/EBGN	H&SS Cluster Electives	9 sem hrs.
Total		19 sem hrs.

#### **Cluster Requirements**

1. Undergraduate students are required to take a minimum of 9 credit-hours from one of the following clusters: Humankind and Values; Society and Decisions; Environment, Resources, Science, and Technology; and International Studies.
2. Three of the 9 credit-hours must be a 400-level LIHU or LISS course, or a 400-level EBG course with a policy focus as indicated in the clusters lists.
3. Single majors in Economics must take all 9 credit-hours from LAIS.
4. Students other than single majors in Economics may take up to 6 credit-hours in EBG.

#### **HUMANKIND AND VALUES**

LIHU300 Journey Motif in Modern Literature  
LIHU301 Writing Fiction  
LIHU310 Engineering as a Human Pursuit  
LIHU330 Western Civilization since the Renaissance  
LIHU334 Literary Heritage of the Western World  
LIHU338 Art, Architecture, and Cities  
LIHU339 Musical Traditions of the Western World  
LIHU375 Patterns of American Culture  
LIHU398 Special Topics (contact LAIS for qualifying topics in a given semester)  
LIHU401 The American Dream: Illusion or Reality?  
LIHU402 Heroes and Anti-Heroes  
LIHU403 Mythology  
LIHU404 Transcendent Vision  
LIHU470 Becoming American: Literary Perspectives  
LIHU480 Urban Quality of Life  
LIHU498 Special Topics (contact LAIS for qualifying topics in a given semester)  
LISS300 Cultural Anthropology  
LISS312 Introduction to Religions  
LISS330 Managing Cultural Differences  
LISS398 Special Topics (contact LAIS for qualifying topics in a given semester)  
LISS410 Utopias/Dystopias  
LISS415 Invisible Machine  
LISS432 Cultural Dynamics of Global Development  
LISS461 Technology and Gender: Issues  
LISS474 Constitutional Law and Politics  
LISS498 Special Topics (contact LAIS for qualifying topics in a given semester)

#### **SOCIETY AND DECISIONS**

EBGN311 Principles of Microeconomics  
EBGN312 Principles of Macroeconomics

EBGN410 Natural Resource Economics  
 EBG430 Energy Economics  
 EBG442 Economic Development  
 EBG470 Environmental Economics  
 EBG498 Special Topics (contact LAIS or EB for qualifying topics in a given semester)  
 LIHU330 Main Currents in the History of the Western World  
 LIHU350 History of War  
 LIHU360 History of Science and Technology: Beginning to 1500  
 LIHU398 Special Topics (contact LAIS for qualifying topics in a given semester)  
 LIHU479 The American Military Experience  
 LIHU498 Special Topics (contact LAIS for qualifying topics in a given semester)  
 LISS335 International Political Economy  
 LISS340 International Political Economy of Latin America  
 LISS342 International Political Economy of Asia  
 LISS344 International Political Economy of the Middle East  
 LISS351 The History of Eastern Europe and Russia since 1914  
 LISS362 Science and Technology Policy  
 LISS372 American Political Experience  
 LISS375 Introduction to Law and Legal Systems  
 LISS398 Special Topics (contact LAIS for qualifying topics in a given semester)  
 LISS435 Political Risk Assessment  
 LISS439 Political Risk Assessment Research Seminar  
 LISS450 American Mining History  
 LISS455 Japanese History and Culture  
 LISS474 Constitutional Law and Politics

LISS480 Environmental Politics and Policy  
 LISS482 Water Politics and Policy  
 LISS498 Special Topics (contact LAIS for qualifying topics in a given semester)

**ENVIRONMENT, RESOURCES, SCIENCE,  
AND TECHNOLOGY**

EBGN311 Principles of Microeconomics  
 EBG410 Natural Resource Economics  
 EBG430 Energy Economics  
 EBG470 Environmental Economics  
 EBG498 Special Topics (contact LAIS or EB for qualifying topics in a given semester)  
 LIHU310 Engineering as a Human Pursuit  
 LIHU338 Art, Architecture, and Cities  
 LIHU360 History of Science and Technology: Beginning to 1500  
 LIHU398 Special Topics (contact LAIS for qualifying topics in a given semester)  
 LIHU404 Transcendent Vision  
 LIHU480 Urban Quality of Life  
 LIHU498 Special Topics (contact LAIS for qualifying topics in a given semester)  
 LISS398 Special Topics (contact LAIS for qualifying topics in a given semester)  
 LISS410 Utopias/Dystopias  
 LISS415 Invisible Machine  
 LISS431 Global Environmental Issues  
 LISS450 American Mining History  
 LISS461 Technology and Gender: Issues  
 LISS480 Environmental Politics and Policy  
 LISS482 Water Politics and Policy  
 LISS498 Special Topics (contact LAIS for qualifying topics in a given semester)

**INTERNATIONAL STUDIES**

EBGN311 Principles of Microeconomics  
 EBG312 Principles of Macroeconomics  
 EBG441 International Trade  
 EBG442 Economic Development  
 EBG498 Special Topics (contact LAIS or EB for qualifying topics in a given semester)  
 LIFLxxx All LIFL (foreign language) COURSES  
 LISS330 Managing Cultural Differences  
 LISS335 International Political Economy

LISS340	International Political Economy of Latin America
LISS342	International Political Economy of Asia
LISS344	International Political Economy of the Middle East
LISS398	Special Topics (contact LAIS for qualifying topics in a given semester)
LISS430	Globalization
LISS431	Global Environmental Issues
LISS432	Cultural Dynamics of Global Development
LISS433	Global Corporations
LISS434	International Field Practicum
LISS435	Political Risk Assessment
LISS437	Corruption and Development
LISS439	Political Risk Assessment Research Seminar
LISS440	Latin American Development
LISS441	Hemispheric Integration in the Americas
LISS442	Asian Development
LISS446	International Political Economy of Africa
LISS498	Special Topics (contact LAIS for qualifying topics in a given semester)

### *Minor Programs*

The Division of Liberal Arts and International Studies offers five minor programs. Students who elect to pursue a minor usually will automatically satisfy their cluster requirements. They will also need to use their free elective hours to complete a minor. Students may choose to pursue an Area of Special Interest (ASI) in any of the minor programs except the McBride Honors Program. Minors are a minimum of 18 credit-hours; ASIs are a minimum of 12 credit-hours.

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.

The five minors or ASIs available and their advisors are:

Environmental Policy Minor. Dr. Karen Wiley

Humanities Minor. Dr. Juan de Castro

International Political Economy Minor.

Dr. Laura Pang

Science, Technology, and Society Minor.

Dr. Carl Mitcham

Undergraduate Individual Minor.

Advisor depends on field of study.

Students should consult these advisors for the specific requirements for these minors.

#### **Environmental Policy Minor**

Program Advisor: Dr. Karen Wiley. The primary objective of the Environmental Policy (EP) Minor is to give students some basic background in the primary skill and knowledge areas relevant to careers in environmental policy: economics, politics, policy analysis, law, and ethics.

#### **Humanities Minor**

Program Advisor: Dr. Juan de Castro. The focus in the humanities is the memorial record of the human imagination and intellect, discovering, recreating, and critically examining the essential core of experience that sustains the human spirit in all adventures of our common life. The making of this record appears in various forms of art, including literature, visual arts, and music, as well as in philosophy and history. The Humanities (HU) Minor offers a variety of opportunities to explore the wealth of our heritage. Students work with the HU Advisor to design a minor program appropriate to their interests and background.

#### **International Political Economy Minor**

Program Advisor: Dr. Laura Pang. 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 Program at CSM includes courses focusing on Latin America, Asia, and the Islamic World; courses with a global focus; and foreign language study. Students may opt for the 19-hour minor or a 22-hour certificate. The certificate is identical to the minor, with the addition of an international field practicum in which the student works abroad in a setting appropriate to his or her major field of study. Students may also pursue an ASI in International Political Economy.

A graduate certificate in International Political Economy or in International Political Economy of Resources is also available; consult the *CSM Graduate Bulletin* for details.

### **Science, Technology, and Society Minor**

Program Advisor: Dr. Carl Mitcham. The Science, Technology, and Society (STS) Minor focuses on science and technology (or technoscience) in a societal context: how technoscience influences society, and how society influences technosciences. Courses provide historical and analytical approaches to questions inevitably confronting professional scientists, engineers, managers, and policy makers in both public and private sectors. Such questions concern, for example, professional ethical responsibilities, intellectual property rights, science policy formation, appropriate regulatory regimes, assessments of societal impacts, and the roles of technical innovation in economic development or international competitiveness. Students work with the STS Advisor to tailor a course sequence appropriate to their interests and background.

### **Undergraduate Individual Minor**

Program Advisor: Depends on field of study. Students declaring an Undergraduate Individual Minor in LAIS must choose 19 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.

### **Studio Art: CSM and Red Rocks Community College**

In addition to a one-credit elective course in studio art-painting offered at CSM through the LAIS Division, CSM undergraduate students are eligible to enroll in a broad range of one-credit free elective studio art courses offered by special, experimental arrangement with Red Rocks Community College (RRCC).

Credits earned in studio art courses, at CSM or RRCC, may not be applied toward meeting either the undergraduate "core" or "cluster" requirements in humanities and social sciences at CSM. CSM undergraduates are eligible to take as a free elective a maximum of one studio art course per semester offered by RRCC. Tuition for CSM students is collected by CSM. No additional tuition is charged, but students are required to pay all relevant student fees directly to RRCC.

Specific details concerning any given semester's RRCC studio art offerings, and applications for enrolling in such courses may be obtained from the Office of the CSM Registrar. Students may enroll in the LAIS studio art painting course, however, using normal registration procedures to enroll in any regular CSM course.

## **Mathematical and Computer Sciences**

GRAEME FAIRWEATHER, Professor and Department Head

BERNARD BIALECKI, Professor

JOHN DeSANTO, Professor

WILLY A.M. HEREMAN, Professor

RAGHU KRISHNAPURAM, Professor

PAUL A. MARTIN, Professor

ALYN P. ROCKWOOD, Professor

JUNPING WANG, Professor

BARBARA B. BATH, Associate Professor

TRACY KAY CAMP, Associate Professor

MAARTEN V. de HOOP, Associate Professor

DINESH MEHTA, Associate Professor

WILLIAM C. NAVIDI, Associate Professor

ROBERT G. UNDERWOOD, Associate Professor

ERIK S. VAN VLECK, Associate Professor

MICHAEL COLAGROSSO, Assistant Professor

JAE YOUNG LEE, Assistant Professor

BARBARA M. MOSKAL, Assistant Professor

LUIS TENORIO, Assistant Professor

HUGH KING, Senior Lecturer

G. GUSTAVE GREIVEL, Lecturer

JIMMY DEE LEES, Lecturer  
NATHAN PALMER, Lecturer  
CYNDI RADER, Lecturer  
TERI WOODINGTON Lecturer  
WILLIAM R. ASTLE, Professor Emeritus  
NORMAN BLEISTEIN, Professor Emeritus  
ARDEL J. BOES, Professor Emeritus  
STEVEN PRUESS, Professor Emeritus  
RUTH MAURER, Associate Professor Emerita

## 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 two tracks: one is Mathematical and Computer Sciences with an emphasis on modeling, analysis and computation, the other is the computer sciences option. Either track offers a unique opportunity to study mathematical and computer sciences in an engineering environment. Both tracks emphasize technical competence, problem solving, team work, 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 the 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 “field session” program to engage high level undergraduate students in problems of practical applicability for potential employers. Field session is designed to simulate an industrial job or research environment; students work on a project in small teams, make weekly project reports and present final written and oral reports. The close collaboration with potential employers or professors improves communication between field session students and the private sector as well as with sponsors from other disciplines on campus.

Mathematical and Computer Sciences majors can use a twelve credit hour block of 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:

**Applied Mathematics:** Classical scattering theory, dynamical systems, nonlinear partial differential equations, numerical analysis, seismic inversion methods, symbolic computing, and mathematics education.

**Applied Computer Sciences:** Artificial intelligence, neural networks, parallel processing, pattern recognition, computer vision, computer graphics, databases, and fuzzy set theory.

**Applied Statistics:** Stochastic modeling, Monte Carlo methods, biostatistics, statistical genetics, statistical methods in cosmology, and inverse problems.

### *Program Goals and Objectives (Bachelor of Science in Mathematical and Computer Sciences)*

Develop technical expertise within mathematics/computer sciences, by

Designing and implementing systems and solutions within mathematics/computer sciences;

Using appropriate technology as a tool to solve problems in mathematics/computer sciences;

Creating efficient algorithms and well structured programs.

Develop breadth and depth of knowledge within mathematics/computer sciences, by

Extending course material to solve original problems;

Applying knowledge of mathematics/computer sciences;

Identifying, formulating and solving mathematics/computer sciences problems;

Analyzing and interpreting data.

Develop an understanding and appreciation of the relationship of mathematics/computer sciences to other fields, by

Applying mathematics/computer sciences to solve problems in other fields;

Working cooperatively in multi-disciplinary teams;

Choosing appropriate technology to solve problems in other disciplines.

Communicate mathematics/computer sciences effectively by

Communicating orally;

Communicating in writing;

Working cooperatively in teams;

Creating well documented and well structured programs;  
 Understanding and interpreting written material in mathematics/computer sciences.

### 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 two study options, one in modeling, analysis and computation, and the other in computer science.

### Degree Requirements (Mathematical and Computer Sciences)

#### Modeling, Analysis and Computation Option

<b>Sophomore Year Fall Semester</b>	lec.	lab.	sem.	hrs.
MACS213 Calc. for Scientists & Engn'rs III	4			4
MACS261 Computer Programming Concepts	3			3
EPIC251 Design II	2	3		3
PHGN200 Physics II	3.5	3		4.5
*EBGN201 Principles of Economics/ SYGN201/202	3			3
PAGN201 Physical Education III		2		0.5
<b>Total</b>				<b>18</b>

<b>Sophomore Year Spring Semester</b>	lec.	lab.	sem.	hrs.
MACS262 Data Structures	3			3
MACS315 Differential Equations	3			3
MACS332 Linear Algebra	3			3
*SYGN201/202 Systems/EBGN211	3			3
Free Elective	3			3
PAGN202 Physical Education IV		2		0.5
<b>Total</b>				<b>15.5</b>

\*Student can choose order of EBGN211 and SYGN201/202

<b>Junior Year Fall Semester</b>	lec.	lab.	sem.	hrs.
MACS—Computing Course*	3			3
MACS434 Prob. and Statistics for Engineers	3			3
Free Elective	3			3
SYGN200 Human Systems	3			3
Technical Area of Special Interest	3			3
<b>Total</b>				<b>15</b>

\*Computing Course—choice of MACS440, MACS441, MACS443, MACS406.

<b>Junior Year Spring Semester</b>	lec.	lab.	sem.	hrs.
MACS333 Intro. to Mathematical Modeling	3			3
MACS358 Discrete Math & Algeb. Struct.	3			3
MACS—Mathematics Elective	3			3
LAIS/EBGN H&SS Cluster Elective I	3			3
Free Elective	3			3
Technical Area of Special Interest	3			3
<b>Total</b>				<b>18</b>

<b>Summer Field Session</b>	lec.	lab.	sem.	hrs.
MACS370 Field Course (six weeks)				6
<b>Total</b>				<b>6</b>

<b>Senior Year Fall Semester</b>	lec.	lab.	sem.	hrs.
MACS401 Real Analysis	3			3
MACS—Modeling Course*	3			3
MACS461 Senior Seminar	1			1
LAIS/EBGN H&SS Cluster Elective II	3			3
MACS—Mathematics Elective	3			3

Technical Area of Special Interest	3	3
Total		16

\*MACS Modeling Course—choice (see department for listings).

<b>Senior Year Spring Semester</b>	lec.	lab.	sem.	hrs.
MACS407 Intro to Scientific Computing	3			3
MACS462 Senior Seminar	1			1
MACS—Mathematics Elective	3			3
LAIS/EBGN H&SS Cluster Elective III	3			3
Free Elective	3			3
Technical Area of Special Interest	3			3
Total				16
<b>Degree Total</b>				137.5

**Computer Sciences Option**

<b>Sophomore Year Fall Semester</b>	lec.	lab.	sem.	hrs.
MACS213 Calc. for Scientists & Engn'rs III	4			4
MACS261 Computer Program'ng Concepts	3			3
EPIC251 Design II	3	1		3
PHGN200 Physics II	3	3		4.5
EBGN201 Principles of Economics/ SYGN201/202	3			3
PAGN201 Physical Education III		2		0.5
Total				18

<b>Sophomore Year Spring Semester</b>	lec.	lab.	sem.	hrs.
MACS262 Data Structures	3			3
MACS315 Differential Equations	3			3
MACS332 Linear Algebra	3			3
*SYGN201/202 Systems/EBGN201	3			3
Free Elective	3			3
PAGN202 Physical Education IV		2		0.5
Total				15.5

\*Student can choose order of EBGN211 and SYGN201/202

<b>Junior Year Fall Semester</b>	lec.	lab.	sem.	hrs.
MACS306 Software Engineering	3			3
MACS323 Prob. and Stat. for Engineers	3			3
MACS341 Mach. Org. & Assembly Lang. Prog.	3			3
MACS358 Discrete Math & Algebraic Struct.	3			3
SYGN200 Human Systems	3			3
Technical Area of Special Interest	3			3
Total				18

<b>Junior Year Spring Semester</b>	lec.	lab.	sem.	hrs.
MACS406 Dsgn. & Analysis of Algorithms	3			3
MACS407 Intro to Scientific Computing	3			3
Free elective	3			3
LAIS/EBGN H&SS Cluster Elective I	3			3
Technical Area of Special Interest	3			3
Total				15

<b>Summer Field Session</b>	lec.	lab.	sem.	hrs.
MACS370 Field Course (six weeks)				6
Total				6

<b>Senior Year Fall Semester</b>	lec.	lab.	sem.	hrs.
MACS442 Operating Systems	3			3
MACS461 Senior Seminar	1			1
MACS Computer Science Elective	3			3
Technical Area of Special Interest	3			3
Free elective	3			3
LAIS/EBGN H&SS Cluster Elective II	3			3
Total				16

<b>Senior Year Spring Semester</b>	lec.	lab.	sem.	hrs.
MACS400 Princ. of Programming Languages	3			3
MACS462 Senior Seminar II	1			1

MACS Computer Science Elective	3	3
LAIS/EBGN H&SS Cluster Elective III	3	3
Free elective	3	3
Technical Area of Special Interest	3	3
Total		16
<b>Degree Total</b>		<b>137.5</b>

### *Minors in Mathematical and Computer Sciences*

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

MACS323 Probability and Statistics for Engineers  
 MACS332 Linear Algebra  
 MACS333 Introduction to Mathematical Modeling  
 MACS407 Introduction to Scientific Computing

For the Minor, in addition the student should take:

MACS261 Computer Programming Concepts  
 MACS4XX One additional 400-level course

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

MACS262 Data Structures  
 MACS306 Software Engineering  
 MACS341 Machine Organization and Assembly Language Programming or  
 MACS358 Discrete Mathematics & Algebraic Structures  
 MACS406 Design and Analysis of Algorithms or  
 MACS407 Introduction to Scientific Computing

For the Minor, the student should fulfill ASI, but must take 341 and a 400-level course, which may not be a language transferred from another university.

## **The Guy T. McBride, Jr. Honors Program in Public Affairs for Engineers**

Principal Tutor: Dr. Juan C. Lucena.

The McBride Honors Program (Honors) was instituted in 1978 through a grant from the National Endowment for the Humanities. The program offers 24 semester hours of seminars and off-campus activities that have the primary goal of providing a select number of CSM students the opportunity to cross the boundaries of their technical expertise into the ethical, cultural, and socio-political dimensions of science and technology. Students will gain the sensitivity to prove, project, and test the moral and social implications of their future professional judgements and activities, not only for the particular organizations with which they will be involved, but also for the nation and the world. To achieve this goal, the program seeks to bring themes from the humanities and the social sciences into the CSM curriculum that will encourage in students the habits of thought necessary for effective management and enlightened leadership.

Designed by teams of faculty members from the humanities, social sciences, sciences, and engineering, the curriculum of the McBride Honors Program features the following educational experiences:

- Small seminars guided by moderators from various disciplines.
- An interdisciplinary approach that integrates domestic and global perspectives into the curriculum.
- Opportunity for one-to-one long-lasting relationships between faculty and students.
- Opportunity to develop and practice oral and written skills.
- Opportunity to interact with visiting scholars.
- Opportunity to attend the Washington Public Policy Seminar in Washington, DC.
- Overseas study with CSM students and faculty.
- Intellectual relationships and camaraderie.
- Public affairs or policy related internship.

A central experience in the program is the Practicum (an internship, overseas study, or public service), which comes during the summer following the junior year. Because engineers and scientists will no doubt continue to assume significant responsibilities as leaders in public and private sectors, it is essential that CSM students be prepared for more than the traditional first jobs in industry. Leadership and management demand an understanding of the accelerating pace of change that marks the social, political, and economic currents of society and a commitment to social and environmental responsibility. While the seminars in the program are designed to nourish such an understanding, the goal of the internship is to put students into situations where they may see firsthand the kinds of challenges they will face in their professional lives.

Foreign study is also possible during the summer of the junior year, either through CSM-sponsored trips or through individual plans arranged in consultation with the Principal Tutor. The cost for any foreign study is the responsibility of the student.

The McBride Honors Program seeks to enroll students who can profit most from the learning experiences upon which the program is based while contributing to faculty and peer learning. Whereas most conventional honors programs admit students almost exclusively on the basis of academic record, in the McBride Honors Program test scores, grade point, and class rank form only part of the criteria used in the admission process. Students must demonstrate their leadership potential, versatility of mind, and writing and speaking abilities through an essay and through an interview with faculty members.

Although the educational experiences in the McBride Honors Program are rigorous and demand a high degree of persistence from the students, CSM graduates who have completed the program have gained positions of their choice in industry more easily than others and have been successful in winning admission to high-quality graduate and professional schools.

**Minor and Certificate:** Students completing the program receive a certificate and are recognized as having earned a Minor in Public Affairs.

## Metallurgical and Materials Engineering

JOHN J. MOORE, Trustees Professor and Department Head

GLEN R. EDWARDS, Professor

JOHN P. HAGER, Hazen Research Inc. 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

DENNIS W. READEY, Herman F. Coors Distinguished Professor

JOHN G. SPEER, Professor

PATRICK R. TAYLOR, George S. Ansell Distinguished Professor of Chemical Metallurgy

CHESTER J. VANTYNE, FIERP Professor

ROBERT H. FROST, Associate Professor

HANS-JOACHIM KLEEBE, Associate Professor

IVAR E. REIMANIS, Associate Professor

STEVEN W. THOMPSON, Associate Professor

KELLY T. MILLER, Assistant Professor

FREDERICK J. FRAIKOR, Research Professor

GEORGE S. ANSELL, President and Professor Emeritus

W. REX BULL, Professor Emeritus

GERALD L. DePOORTER, Associate Professor Emeritus

GEORGE KRAUSS, University Professor Emeritus

WILLIAM M. MUELLER, Vice President for Academic Affairs Emeritus and 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 objective 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 would have acquired and developed the necessary background and skills for successful careers in the 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, 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 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 best in the nation. The laboratories, in conjunction with class-room 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 and processing-and-testing of ceramic materials. Mechanical testing facilities include computerized machines for tensile, compression, torsion, toughness, fatigue and thermo-mechanical testing. There are also other highly specialized research laboratories dedicated to: robotics, artificial intelligence, 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 an analytical scanning transmission electron microscopy and the latest in scanning 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 the Accreditation Board for Engineering and Technology, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012, telephone (410) 347-7700.

#### *Program Goals (Bachelor of Science in Metallurgical and Materials Engineering)*

The Metallurgical and Materials Engineering Program is designed to support five primary educational goals.

- ◆ Provide a thorough knowledge of materials engineering fundamentals.
- ◆ Provide experience in the applications of fundamental materials-concepts to solve related problems.
- ◆ Build written and oral communications skills in conjunction with teamwork skills.
- ◆ Impart the ability for self-acquisition of knowledge to promote continued education.
- ◆ Impart a breadth of knowledge which enables a choice of solutions to materials engineering problems.

#### *Curriculum*

The Metallurgical and Materials Engineering (MME) curriculum is organized to provide three educational components: fundamentals of materials, applications of the fundamentals, and emphasis in one of three focus areas.

**A. MME Basics:** The basic curriculum in the Metallurgical and Materials Engineering Department 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, casting and welding.
2. Design and Application of Materials: Materials selection, ferrous and nonferrous metals, ceramic materials, polymeric materials, composite materials and electronic materials.
3. Statistical Process Control and Design of Experiments: Statistical process-control, process capability- analysis and design of experiments.

**C. MME Focus Areas:** There are three Focus Areas within the Metallurgical and Materials Engineering curriculum. These are

1. Physicochemical Processing of Materials
2. Physical Metallurgy
3. Materials 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
MACS213 Calculus for Scientists & Engr's III	4		4
PHGN200 Physics II	3.5	3	4.5
SYGN202 Engineered Materials Systems	3		3
MACS260 Fortran Programming	2		2
PAGN201 Physical Education III		2	0.5
Total			17

**Sophomore Year Spring Semester**                   lec.lab. sem. hrs.

MACS315 Differential Equations	3		3
PHGN300 Modern Physics	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 Field Session**                   lec.lab. sem. hrs.

MTGN272 Field Session			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	4		4
EGGN320 Mechanics of Materials	3		3
MACS—Advanced Mathematics Elective	3		3
LAIS/EBGN H&SS Cluster Elective I	3		3
Total			19

**Junior Year Spring Semester**                   lec.lab. sem. hrs.

MTGN334 Chemical Processing of Materials	3		3
MTGN348 Microstructural Develop. of Materials	3	3	4
MTGN352 Metallurgical & Materials Kinetics	3		3
MTGN331 Particulate Materials Processing	3		3
LAIS/EBGN H&SS Cluster Elective II	3		3
Free Elective	3		3
Total			19

**Senior Year Fall Semester**                   lec.lab. sem. hrs.

MTGN445 Mechanical Behavior of Materials	3	3	4
MTGN461 Trans. Phen. & Reactor Design for Met. & Mat. Eng.	2	3	3
MTGN450 Stat Process Control & Design of Experiments	3		3
MTGN—MTGN Elective	3		3
LAIS/EBGN H&SS Cluster Elective III	3		3
Free Elective	3		3
Total			19

**Senior Year Spring Semester**                   lec.lab. sem. hrs.

MTGN466 Design, Selection & Use of Mats	1	6	3
MTGN—MTGN Elective	3		3



MTGN—MTGN Elective	3	3
DCGN381 Electric Circuits, Electronics & Power	3	3
PHGN217 Analog Electronics and Instrumentation Laboratory	3	1
Free Electives	6	6
Total		19
<b>Degree Total</b>		147.5

*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 goal 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, are outlined in an informational package "Enhanced Program for Preparation for Microelectronics" available from either 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.

## Military Science (Army ROTC-AROTC)

The Military Science Program at the Colorado School of Mines develops the qualities of citizenship and leadership in the individual which are desirable in both military and civilian enterprises. Successful completion of the four-year program qualifies the student for a commission as a Second Lieutenant in the United States Army, Army Reserve or Army National Guard. Full benefit of the program is achieved by participating in the four-year program; however, late entry may be possible by attendance at the summer Basic Camp.

**Basic Course.** (Freshman and Sophomore-level Military Science): No obligation is incurred by enrolling in any Freshman or Sophomore-level Military Science course (except by Military Science Scholarship winners). Students receive training in military skills such as drill and ceremonies, uniform wear, customs and courtesies of the service, small unit tactics, and background information on the role and organization of the Army. Freshman cadets will receive extensive training and practical experience in using a map and compass to navigate cross-country. Sophomore cadets will receive training in First Aid. Additionally, all cadets receive training, and have the opportunity to participate, in several outdoor activities.

**Advanced AROTC.** Enrollment in the last two years of AROTC is both elective and selective for nonscholarship students. Applicants must demonstrate academic proficiency, leadership ability and officer potential. The Advanced Course builds on the individual skills learned in the Basic Course. During the Junior year (MSIII) cadets receive training in small unit tactics in preparation for their attendance at the AROTC Advanced Camp (normally attended during the summer after their Junior year). Cadets also receive training in management, ethics and leadership, as well as practical experience in performing as the leader in a stressful environment. The senior level (MSIV) cadets receive training on how the Army functions at a higher level by planning and executing many of the Cadet Battalion activities.

**AROTC Credit.** Military Science credits may be applied to the free elective portion of the degree programs, or used in the Military Science minor program. **Military Supplies.** Military Science textbooks, uniforms and accessories are issued free of charge to students in the AROTC program. Students enrolled in Advanced Military Science courses also

receive a subsistence allowance of \$250 per month for freshmen, \$300 per month for sophomores, \$350 per month for juniors, and \$400 per month for seniors during the regular school year. AROTC Scholarships. The United States Government offers qualified male or female applicants

AROTC Scholarships to attend the Colorado School of Mines. AROTC Scholarships pay tuition and fees (within the limits set by the law), provides a book allowance and pay the cadets a subsistence allowance of \$200 per month during the school year for the duration of the scholarship. The student may pursue any 4-year degree program offered at CSM. Upon graduation, AROTC Scholarship cadets receive commissions and will be required to serve in the military for four years of a active duty and four years of Reserve Forces duty, for a total of eight years. Individuals interested in applying for AROTC Scholarships should contact high school guidance counselors or the Professor of Military Science, CSM, no later than the first month of the senior year in high school. There are also 2-year and 3-year AROTC Scholarships available to students already in college. A 2-year AROTC Reserve Forces Duty Scholarship is available for cadets entering the Advanced Military Science course who wish to pursue a Reserve Forces military obligation. Another option available to cadets is the Department of the Army Scientific and Engineering AROTC Cooperative Program (DASE AROTC CO-OP). DASE students are hired as Department of the Army civilians. They receive the pay, insurance, sick leave and other benefits provided DA civilian employees. In addition, upon successful completion of the program, students will have the opportunity for continued employment. Qualified students may receive financial assistance of up to \$5,000 per year to cover cost of tuition, books and living expenses.

## **Navy ROTC (NROTC) Naval Reserve Officer Training Corps**

Colorado School of Mines students may pursue a commission as a officer in the U.S. Navy or Marine Corps through a cross town agreement with the Naval ROTC Unit at the University of Colorado, Boulder. NROTC offers two-year and four-year scholarship programs and college (non-scholarship) programs. Navy scholarships may be earned through a national competition based on college board exams and high school record, or while the student is enrolled in college based on college grades and military performance. Scholarship students receive tuition and fees, books, and a \$100 per month subsistence allowance during their last two years in the program (advanced standing).

NROTC students attending Colorado School of Mines must attend a weekly drill session at the University of Colorado Boulder campus and fulfill other military responsibilities. Additionally, they must complete a series of Naval Science courses at the Boulder campus by special arrangement with the appropriate NROTC staff instructor. Navy option students must complete course work in calculus, physics, computer science, American military history or national security policy, and a foreign language. Marine Corps option students are required to complete courses in American military history or national security policy and a foreign language. Students should check with their NROTC class advisor to determine specific course offerings which fulfill the above requirements.

Commissioned Service. The mission of the NROTC program is to provide regular and reserve officers to the fleet and Marine Corps for service in the "Unrestricted Line" fields. Unrestricted Line officers specialize in one of the following: Surface ships, submarines, aviation (Pilot or Naval Flight Officer), Special Warfare (SEALs) or Special Operations (Diving, Salvage, Explosive Ordnance Disposal). Marine Corps officer commissionees enter a variety of fields including infantry, aviation, armor, and combat engineering. Regardless of the type of commission earned, regular or reserve, virtually all NROTC graduates serve on active duty after commissioning. Men and women interested in these and other programs leading to commissions in the Naval Service are encouraged to contact the NROTC Unit at 492-8287 or in person at Folsom Stadium, Gate 6, Room 241, University of Colorado, Boulder.

## **Air Force ROTC (AFROTC) Air Force Reserve Officer Training Corps**

U.S. Air Force ROTC offers several programs leading to a commission in the U.S. Air Force upon receipt of at least a baccalaureate degree.

### ***Standard Four-Year Program***

This standard 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.

### ***Modified Two-Year Program***

All undergraduate and graduate students are eligible for this program. It is offered to full-time, regularly enrolled degree students and requires at least two years of full-time college (undergraduate or graduate level, or a combination). Those selected for this program must complete a six-week field training program during the summer months as a prerequisite for entry into the Professional Officer Course the following fall semester.

### ***Leadership Lab***

All AFROTC cadets must attend Leadership Lab (1-1/2 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 junior officer.

### *Other AFROTC Programs*

Other programs are frequently available based on current Air Force needs. Any AFROTC staff member in Boulder (303 492-8351) can discuss best alternatives. Interested students should make initial contact as early as possible to create the best selection opportunity, as selection is on a competitive basis. There is no obligation until a formal contract is entered.

## **Mining Engineering**

TIBOR G. ROZGONYI, Professor and Department Head

M.U. OZBAY, Professor

LEVENT OZDEMIR, Professor and Director of Earth Mechanics Institute

BAKI YARAR, Professor

KADRI DAGDELEN, Associate Professor

MASAMI NAKAGAWA, Associate Professor

D. SCOTT KIEFFER, Assistant Professor

MARK KUCHTA, Assistant Professor

MIKLOS D. G. SALAMON, Professor Emeritus

MATTHEW J. HREBAR, III, Associate Professor Emeritus

### **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 nonmetallics, 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. 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 Goals (Bachelor of Science in Mining Engineering)*

The education goals 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 goal 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)

	lec.	lab.	sem.	hrs.
<b>Sophomore Year Fall Semester</b>				
MACS213 Calc. for Scientists & Engr's III	4			4
PHGN200 Physics II	3.5	3		4.5
EBGN201 Principles of Economics	3			3
MNGN317 Statics/Dynamics	4			4
EPIC251 Design II	2	3		3
PAGN201 Physical Education III		2		0.5
Total				19
<b>Sophomore Year Spring Semester</b>				
EGGN351 Fluid Mechanics	3			3
MACS315 Differential Equations	3			3
GEOL210 Materials of the Earth	2	3		3
MNGN210 Introductory Mining	3			3
SYGN201 Engineered Earth Systems	3			3
EGGN320 Mechanics of Materials	3			3
PAGN202 Physical Education IV		2		0.5
Total				18.5
<b>Summer Field Session</b>				
MNGN300 Summer Field Session				5
Total				5
<b>Junior Year Fall Semester</b>				
EGGN371 Engineering Thermodynamics	3			3
MNGN308 Mine Safety	1			1
MNGN309 Mine Operations Lab		8		2
MNGN312 Surface Mine Design	2	3		3
MNGN321 Introductory Rock Mechanics	2	3		3
SYGN200 Human Systems	3			3
Free Elective	3			3
Total				18
<b>Junior Year Spring Semester</b>				
DCGN381 Electrical Circuits, Elec. & Pwr	3			3
MACS323 Probability and Stat. for Engr's	3			3
LAIS/EBGN H&SS Cluster Elective I	3			3
MNGN316 Coal Mining Methods and Design	2	2		3
EBGN312 Macroeconomics	3			3
GEOL308 Structural Geology	2	3		3
Total				18
<b>Senior Year Fall Semester</b>				
MNGN314 Underground Mine Design	2	3		3
MNGN414 Mine Plant Design	2	3		3
MNGN428 Mining Eng. Design Report I	3			1
MNGN438 Introduction to Geostatistics	1	3		2

MNGN322/323 Intro. to Mineral Processing	3	3	4
LAIS/EBGN H&SS Cluster Elective II	3		3
Free Elective			3
Total			19
<b>Senior Year Spring Semester</b>	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
LAIS/EBGN H&SS Cluster Elective III	3		3
GEEN405 Mineral Deposits	2		2
Free Elective			3
Total			18
<b>DegreeTotal</b>			148.5

## Petroleum Engineering

CRAIG W. VAN KIRK, Professor and Department Head

JOHN R. FANCHI, Professor

ERDAL OZKAN, Professor

RICHARD L. CHRISTIANSEN, Associate Professor

ALFRED W. EUSTES III, Associate Professor

RAMONA M. GRAVES, Associate Professor

TURHAN YILDIZ, Associate Professor

MARK G. MILLER, Assistant Research Professor

BILLY J. MITCHELL, Professor Emeritus

HOSSEIN KAZEMI, Research Professor

### Program Description

The primary objectives of petroleum engineering are the environmentally sound exploration, development, evaluation, and recovery of oil, gas, 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 the program are in high 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 producing oil and gas fields to office jobs in small towns or large cities. Worldwide travel and overseas assignments are available for interested students. 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 a semester abroad opportunity in Austria through a formal exchange program with the Petroleum Engineering Department at the Mining University in Leoben, Austria. 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 graduate students may earn the Master of Science, Master of Engineering, and Doctor of Philosophy degrees.

A new lab wing was completed in 1993 and the existing office and classroom building was renovated in 1994 at a total project cost exceeding \$10 million. New lab equipment added during the past few years total more than \$2 million. The department has state-of-the-art laboratories in a wide range of technical areas, including the following undergraduate labs:

#### Computer Laboratory

A state-of-the-art computer laboratory is available for general use and classroom instruction. Software includes more than \$3.0 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.

#### Reservoir Characterization Laboratory

Properties of rock are measured that affect economic development of reservoir resources of oil and gas. Measured properties include permeability, porosity, and relative permeability. "Hands on" experiences with simple and sophisticated equipment are provided.

### **Drilling Fluids Laboratory**

Modern equipment 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 Field 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. 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, 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 trips 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.

It is recommended that all students considering majoring or minoring in Petroleum Engineering sign up for the elective course PEGN 102 in the spring semester. 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. See the department secretaries for the registration procedure.

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 Goals (Bachelor of Science in Petroleum Engineering)***

The Mission of the Petroleum Engineering Program has evolved naturally over time in response to the needs of the graduates; in concert with the Colorado School of Mines Institutional Mission Statement and the Profile of the Future Graduate; and in recognition of accreditation requirements specified by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology. The Mission of the Petroleum Engineering Program is:

To educate engineers for the worldwide petroleum industry at the undergraduate and graduate levels, perform research that enhances the state-of-the-art in petroleum technology, and to serve the industry and public good through professional societies and public service. This mission is achieved through proactive leadership in providing a solid foundation for both the undergraduate and graduate programs. Students are well prepared for life-long learning, an international and diverse career, further education, and public service. The program emphasizes integrated and multidisciplinary teamwork in classroom instruction and in research, and actively pursues interdisciplinary activities with many other CSM departments, particularly the Earth Science/Engineering programs.

Individuals interested in the Petroleum Engineering program goals and objectives are encouraged to contact faculty, visit the CSM campus, or visit our website: [www.mines.edu](http://www.mines.edu). The Petroleum Engineering program goals and objectives can also be found posted in the hallway outside the department office. The specific educational goals are outlined below:

#### **1. Broad education**

- 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**

- 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**

- 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**

- 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**

Integrated 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 recovery, economic evaluation of petroleum projects, environmental and safety issues, and the computer simulation of most of these topics.

The petroleum engineering student studies mathematics, computer science, chemistry, physics, general engineering, the humanities, technical communication (including 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 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, oil 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)

	lec.	lab.	sem.	hrs.
<b>Sophomore Year Fall Semester</b>				
SYGN201 Engineered Earth Systems	2	3		3
EBGN201 Principles of Economics	3			3
DCGN241 Statics	3			3
MACS213 Calculus for Scientists & Engr's III	4			4
PHGN200 Physics II	3.5	3		4.5
PAGN201 Physical Education III		2		0.5
Total				18
<b>Sophomore Year Spring Semester</b>				
EPIC251 Design II	2	3		3
DCGN209 Introduction to Thermodynamics	3			3
EGGN351 Fluid Mechanics	3			3
PEGN308 Rock Properties	2	4.5		3.5
MACS315 Differential Equations	3			3
SYGN200 Human Systems	3			3
Total				18.5
<b>Summer Field Session</b>				
PEGN315 Summer Field Session I	2			2
Total				2
<b>Junior Year Fall Semester</b>				
GEOL315 Sedimentology & Stratigraphy	2	3		3
PEGN310 Petroleum Fluid Properties	2	4.5		3.5
PEGN311 Drilling Engineering	3	3		4
EGGN320 Mechanics of Materials	3			3
PEGN419 Well Log Anal. & Formation Eval.	2	3		3
Total				16.5
<b>Junior Year Spring Semester</b>				
GEOL308 Intro. Applied Structural Geology	2	3		3
MACS323 Statistics for Geo-engineers	3			3
DCGN381 Electric Circuits, Elec. & Pwr.	3			3
PEGN361 Well Completions	3			3

PEGN411 Mechanics of Petrol. Production	3		3
Free Elective	3		3
Total			18
<b>Summer Field Session</b>	lec.	lab.	sem. hrs.
PEGN316 Summer Field Session II	2		2
Total			2
<b>Senior Year Fall Semester</b>	lec.	lab.	sem. hrs.
PEGN481 Petroleum Seminar	2		2
PEGN423 Petroleum Reservoir Eng. I	3		3
PEGN413 Gas Meas. & Formation Evaluation		6	2
PEGN426 Well Stimulation	3		3
PEGN422 Econ. & Eval. Oil & Gas Projects	3		3
LAIS/EBGN H&SS Cluster Elective I	3		3
Free Elective	3		3
Total			19
<b>Senior Year Spring Semester</b>	lec.	lab.	sem. hrs.
PEGN424 Petroleum Reservoir Eng. II	3		3
PEGN439 Multidisciplinary Team Design	2	3	3
PEGN414 Well Test Analysis and Design	3		3
LAIS/EBGN H&SS Cluster Elective II	3		3
LAIS/EBGN H&SS Cluster Elective III	3		3
Free Elective	3		3
PAGN202 Physical Education IV		2	0.5
Total			18.5
<b>Degree Total</b>			145.5

## Physical Education and Athletics

MARVIN L. KAY, Department Head, Professor and Athletic Director

JENNIFER McINTOSH, Athletics Trainer

GREG JENSEN, Assistant Trainer

DAN R. LEWIS, Associate Athletic Director

MICHELE L. HARRIS, Volleyball Coach, Senior Woman Administrator, Director of Physical Education

OSCAR BOES, Cross Country Coach

STEVE CAREY, Assistant Football Coach

VIC L. DOPERALSKI, Women's Basketball Coach

PRYOR ORSER, Men's Basketball Coach

GREG MURPHY, Sports Information Director

BOB WRITZ, Golf Coach

DAVID HUGHES, Swimming and Diving Coach

FRANK KOHLENSTEIN, Soccer Coach

MICHAEL MULVANEY, Baseball Coach

MARK ROBERTS, Softball Coach

ROBERT STITT, Football Coach

BRANDON LEIMBACH, Intramural & Club Sports Director

SCOTT VANSICKLE, Track Coach

STEVE WIMBERLY, Tennis Coach

STEVEN KIMPEL, Wrestling Coach

The Department of Physical Education and Athletics offers a four-fold physical education and athletics program which includes (a) required physical education; (b) intercollegiate athletics; (c) intramural athletics; and (d) recreational athletics.

A large number of students use the college's facilities for purely 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 swimming pool, a basketball arena, two racquetball/handball courts, wrestling room, weight training facility, locker space, and offices for the Physical Education Department.

### Steinhauer Field House

A completely renovated facility of 35,000-sq. ft., which provides for the needs of intercollegiate athletics, physical



education classes, intramurals and student recreation.

#### **Baseball Diamond**

Located west of Brooks Field and has seating accommodations for 500 spectators.

#### **Softball Field**

Located adjacent to the baseball field.

#### **Brooks Field**

Named in honor of Ralph D. Brooks, former member of the Board of Trustees of the School of Mines, Brooks Field includes a football/soccer field equipped with lights and a steel-concrete grandstand and bleachers which seat 3,500 spectators.

#### **Tennis Courts**

The Department maintains four tennis courts.

#### **Swenson Intramural Complex**

Two fields are available for intramural/recreation sports.

#### ***Required Physical Education.***

Each student at Colorado School of Mines is required to complete four separate semesters of Physical Education, beginning with PAGN101 and PAGN102. Four 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) entering students 26 years or older or 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. Students who transfer in as freshmen or sophomores without any PA credits will be required to take PAGN101 and PAGN102. 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 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 on an elective basis.

All students enrolled in physical education shall provide their own gym uniform, athletic shoes, and swimming suit. A non-refundable fee is assessed for the required locker and towel service. Towels and lockers are also available to students who are not enrolled in physical education classes for the same fee.

#### **Intercollegiate Athletics**

The School is a charter member of the Rocky Mountain Athletic Conference (RMAC) and the National Collegiate Athletic Association (NCAA). Sports offered include: football, men's and women's basketball, wrestling, men's and women's track, men's and women's cross country, baseball, men's tennis, men's golf, men's and women's swimming, men'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. 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 IM Council and CSM Sports Club Council. Current offerings may be viewed in the second floor of the Volk Gymnasium on the IM board. All activities are offered in the following categories: Independent men, organizational men, independent women, and co-ed.

The club sport program is governed by the CSM Sport Club Council. There are 29 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 Billiards, Caving, Climbing, Cheerleading, Ice Hockey, Karate, Kendo, Kayak, Judo, Lacrosse, Men's Rugby, Women's Rugby, Shooting, Ski Team, Snowboard, Women's Soccer, Men's Ultimate Frisbee, Women's Ultimate Frisbee, Volleyball, Water Polo.

## **Physics**

JAMES A. McNEIL, Professor and Department Head

F. EDWARD CECIL, Professor

REUBEN T. COLLINS, Professor

THOMAS E. FURTAK, Professor

FRANK V. KOWALSKI, Professor

FRANKLIN D. SCHOWENGERDT, Professor  
JEFF A. SQUIER, Professor  
JOHN U. TREFNY, Professor and President  
TIMOTHY R. OHNO, Associate Professor  
DAVID M. WOOD, Associate Professor  
CHARLES G. DURFEE, Assistant Professor  
UWE GREIFE, Assistant Professor  
MARIËT A. HOFSTEE, Assistant Professor  
ELI A. SUTTER, Assistant Professor  
PETER W. SUTTER, Assistant Professor  
TODD G. RUSKELL, Lecturer  
P. DAVID FLAMMER, Instructor  
BRUCE H. MEEVES, Instructor  
JAMES T. BROWN, Professor Emeritus  
DON L. WILLIAMSON, Professor Emeritus  
F. RICHARD YEATTS, Professor Emeritus  
WILLIAM B. LAW, Associate Professor Emeritus  
ARTHUR Y. SAKAKURA, Associate Professor Emeritus  
ROBERT F. HOLUB, Research Professor  
VIKTOR KAYDANOV, Research Professor  
JAMES E. BERNARD, Research Associate 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, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012, telephone (410) 347-7700. 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, 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 solid-state 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 Goals (Bachelor of Science in Engineering Physics)*

The physics department embraces the broad institutional goals as summarized in the Graduate Profile. The additional engineering physics program-specific goals are listed below.

All engineering physics graduates must have the factual knowledge and other thinking skills necessary to construct 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.

### *Five-year Combined Baccalaureate / Masters Degree Programs*

The Physics Department in collaboration with the Department of Metallurgical and Materials Engineering and with

the Engineering Division offers five-year programs in which students obtain an undergraduate degree in Engineering Physics as well as a Masters Degree in an Engineering discipline. There are three engineering tracks and three physics tracks. 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. The Applied Physics tracks are in the areas of condensed matter, applied optics, and applied nuclear physics. The programs emphasize a strong background in fundamentals of science, in addition to practical experience within an applied physics or engineering 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 appropriate engineering or applied physics graduate program.

Students in the engineering tracks must complete a report or case study during the fifth year. Students in the applied physics tracks must complete a masters thesis. 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.

Interested students can obtain additional information and detailed curricula from the Physics Department or from the participating Engineering Departments.

### *Minor and Areas of Special Interest*

The department offers a Minor and Areas of Special Interest for students not majoring in physics. The requirements are as follows:

**Area of Specialization:** 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 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 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)*

	lec.	lab.	sem. hrs.
<b>Sophomore Year Fall Semester</b>			
MACS213 Calculus for Scientists & Engr's III	4		4
PHGN200 Physics II	3.5	3	4.5
EPIC251 Design II	3		3
SYGN200 Human Systems	3		3
PAGN201 Physical Education III		2	0.5
Total			15
<b>Sophomore Year Spring Semester</b>			
MACS315 Differential Equations	3		3
SYGN201/2 Engineered Systems	3		3
PHGN300/310 Physics III-Modern Physics I	3		3
DCGN381 Electric Circuits, Electronics and Pwr.	3		3
PHGN217 Analog Circuits	3		1
EBGN201 Principles of Economics	3		3
PAGN202 Physical Education IV		2	0.5
Total			16.5
<b>Summer Field Session</b>			
PHGN384 Summer Field Session (6 weeks)			6
Total			6
<b>Junior Year Fall Semester</b>			
PHGN315 Advanced Physics Lab I (WI)	4		2
PGHN311 Introduction to Math. Physics	3		3
LAIS/EBGN H&SS Cluster Elective I	3		3
DCGN209 Introduction to Thermodynamics	3		3
PHGN317 Digital Circuits	2	3	3
PHGN350 Intermediate Mechanics	4		4

Total			18
<b>Junior Year Spring Semester</b>	lec. lab.	sem.	hrs.
PHGN361 Intermediate Electromagnetism	3		3
PHGN320 Modern Physics II	4		4
PHGN326 Advanced Physics Lab II (WI)		4	2
PHGN341 Thermal Physics	3		3
Free Elective I	3		3
Total			15
<b>Senior Year Fall Semester</b>	lec. lab.	sem.	hrs.
PHGN471 Senior Design I (WI)	1	6	3
PHGN462 Electromag. Waves & Opt. Physics	3		3
LAIS/EBGN H&SS Cluster Elective II	3		3
Free Elective II	3		3
Free Elective III	3		3
Total			15
<b>Senior Year Spring Semester</b>	lec. lab.	sem.	hrs.
PHGN472 Senior Design II (WI)	1	6	3
LAIS/EBGN H&SS Cluster Elective III	3		3
Engineering Science Elective	3		3
Free Elective III	3		3
Free Elective IV	3		3
Total			15
<b>Degree Total</b>			133.5

# Section 6 - Description of Courses

## 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	

## Student Life

CSM101. FRESHMAN SUCCESS SEMINAR is a “college adjustment” course, taught in small groups, designed to assist students with the transition from high school to CSM. Emphasis is placed on appreciation of the value of a Mines education, and the techniques and University resources that will allow freshmen to develop to their fullest potential at CSM. 8 meetings during semester; 0.5 semester hours.

## Core Areas

### Design

#### *Engineering Practices Introductory Course Sequence (EPICS)*

ROBERT D. KNECHT, Design (EPICS) Program Director and CEPR Research Professor

#### **Freshman Year**

EPIC151. Design (EPICS) I introduces a design process that includes open-ended problem solving and team work 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.

### **Sophomore Year**

EPIC251. 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. Design (EPICS) II is also offered during the first summer field session in a three week format. Prerequisite: EPIC151. 3 semester hours.

EPIC252. Leadership Design (EPICS) can be taken in lieu of EPIC251. Leadership Design (EPICS) II builds on the design process introduced in Design (EPICS) I, which focuses on open-ended problem solving in which students integrate skills in teamwork, communications, and computer software to solve engineering problems. This section, however, presents projects which require strategic planning and community interaction to expose design students to the challenges and responsibilities of leadership. 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 analyze team dynamics through weekly meetings and progress reports. The course emphasizes oral presentations and builds on written communications techniques introduced in Design (EPICS) I. In addition, these sections provide instruction and practice in team interactions (learning styles, conflict resolution), project management (case studies, seminars), and policy (multiple clients, product outcome, and impact). Prerequisite: EPIC151. 4 semester hours.

### **Systems**

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.

SYGN200. HUMAN SYSTEMS (I, II) This is a pilot course in the CSM core curriculum that articulates with LIHU100: 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: LIHU100. 3 semester hours.

SYGN201. ENGINEERED EARTH SYSTEMS (I) An introduction to Engineered Earth Systems. Aspects of appropriate earth systems and engineering practices in geological, geophysical, mining and petroleum engineering. Emphasis on complex interactions and feedback loops within and among natural and engineered systems. A case histories format provides an introduction to earth engineering fields. 2 hours lecture/seminar, 3 hours lab; 3 semester hours.

SYGN202. ENGINEERED MATERIALS SYSTEMS (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 materials in living systems. Prerequisites or concurrent: CHGN124, MACS112, PHGN100. 3 hours lecture; 3 semester hours.

### **Distributed Core**

DCGN209. INTRODUCTION TO THERMODYNAMICS (I, II) Introduction to the fundamental principles of classical thermodynamics. Application of mass and energy balances to a variety of systems. Entropy and the second law of thermodynamics. Introduction to phase equilibria and chemical reaction equilibria. Ideal and nonideal solutions. Electrochemistry. Prerequisites: CHGN121, CHGN124, MACS111, MACS112, PHGN100. 3 hours lecture; 3 semester hours.

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:

Credit or concurrent enrollment in PHGN100, MACS112, EPIC151 3 hours lecture; 3 semester hours.

DCGN381. INTRODUCTION TO ELECTRICAL CIRCUITS, ELECTRONICS AND POWER (I, II, S) This course provides an engineering science analysis of electrical circuits. The following topics are included: DC and single- and three-phase AC circuit analysis, current and charge relationships. Ohm's Law, resistors, inductors, capacitors, equivalent resistance and impedance, Kirchoff'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, effective and rms values, complex power, apparent power, power factor, balanced delta and wye line and phase currents, filters, resonance, diodes, EM work, moving charge in an electric field, relationship between EM voltage and work, Faraday's and Ampere's Laws, magnetic reluctance and ideal transformers. Prerequisite: PHGN200. 3 hours lecture; 3 semester hours.

## **Chemical Engineering**

### **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. Prerequisite: MACS112 or consent of instructor. 2 hours lecture; 2 semester hours.

ChEN201. MATERIAL AND ENERGY BALANCES Introduction to the principles of conservation of mass and energy. Applications to chemical processing systems. Relevant aspects of computer-aided process simulation. Prerequisite: MACS315 (corequisite), DCGN209, ChEN200 or equivalent (as approved by ChEN Department Head) or consent of instructor. Corequisite ChEN202. 3 hours lecture; 3 semester hours.

ChEN202. CHEMICAL PROCESS PRINCIPLES LABORATORY 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. Prerequisites: DCGN209; corequisites: ChEN201, MACS315 or consent of instructor. 3 hours laboratory; 1 credit hour.

### **Junior Year**

ChEN307. FLUID MECHANICS 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. Prerequisite: ChEN201, MACS315. 3 hours lecture; 3 semester hours.

ChEN308. HEAT TRANSFER 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. Prerequisite: ChEN201, ChEN307, MACS315, or consent of instructor. 3 hours lecture; 3 semester hours.

ChEN312/313. UNIT OPERATIONS LABORATORY Field Session (I & II) (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. Prerequisite: ChEN201, ChEN307, ChEN308, ChEN357, ChEN375 6 hours lab; 6 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. Prerequisite: consent of instructor. 1 to 3 semester hours.

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

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

ChEN357. CHEMICAL ENGINEERING THERMODYNAMICS 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. Prerequisite: DCGN209, ChEN201, MACS315, or consent of instructor. Corequisite: ChEN358. 3 hours lecture; 3 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: DCGN209, ChEN201, MACS315, or consent of instructor. Corequisite: ChEN357. 3 hours laboratory; 1 semester hour.

ChEN375. MASS TRANSFER Fundamentals of stage-wise and diffusional mass transport with applications to chemical engineering systems and processes. Relevant aspects of computer-aided process simulation. Prerequisite:

ChEN201, ChEN357, or consent of instructor. 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.

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.

### Senior Year

ChEN402. CHEMICAL ENGINEERING DESIGN (WI) Advanced computer-aided process simulation and process optimization. Prerequisite: ChEN307, ChEN308, ChEN357, ChEN375, or consent of instructor. Co-requisite: ChEN418, ChEN421. 3 hours lecture; 3 semester hours.

ChEN403. PROCESS DYNAMICS AND CONTROL Mathematical modeling and analysis of transient systems. Applications of control theory to response of dynamic chemical engineering systems and processes. Prerequisite: ChEN201, ChEN307, ChEN308, ChEN375, MACS315, or consent of instructor. 3 hours lecture; 3 semester hours.

ChEN408 NATURAL GAS PROCESSING Application of chemical engineering principles to the processing of natural gas. Emphasis on using thermodynamics and mass transfer operations to analyze existing plants. Relevant aspects of computer-aided process simulation. Prerequisites: CHGN221, ChEN201, ChEN307, ChEN308, ChEN357, ChEN375, or consent of instructor. 3 hours lecture, 3 semester hours.

ChEN409. PETROLEUM PROCESSES 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. Prerequisite: CHGN221, ChEN201, ChEN357, ChEN375, or consent of instructor. 3 hours lecture; 3 semester hours.

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: CHGN221, MACS315, 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. Prerequisite: ChEN307, MACS315, or consent of instructor. 3 hours lecture; 3 semester hours.

ChEN418. REACTION ENGINEERING (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. Prerequisite: ChEN201, ChEN307, ChEN308, ChEN357, MACS315, CHGN221, CHGN351, or consent of instructor. 3 hours lecture; 3 semester hours.

ChEN420. MATHEMATICAL METHODS IN CHEMICAL ENGINEERING Formulation and solution of chemical engineering problems using exact analytical solution methods. Set-up and solution of ordinary and partial differential equations for typical chemical engineering systems and transport processes. Prerequisite: MACS315, ChEN201, ChEN307, ChEN308, ChEN375, or consent of instructor. 3 hours lecture; 3 semester hours.

ChEN421. 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 Theory and chemical engineering applications of momentum, heat, and mass transport. Set up and solution of problems involving equations of motion and energy. Prerequisite: ChEN307, ChEN308, ChEN357, ChEN375, MACS315, or consent of instructor. 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. 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. Prerequisite: ChEN307, ChEN308,

ChEN357, ChEN375, CHGN351 and 353, CHGN221 and 222, MACS315, or consent of instructor. 3 hours lecture; 3 semester hours

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

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

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

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.

## Chemistry and Geochemistry

CHGN111. INTRODUCTORY CHEMISTRY (S) Introductory college chemistry. Elementary atomic structure and the periodic chart, chemical bonding, properties of common elements and their compounds, and stoichiometry of chemical reactions. Must not be used for elective credit. 3 hours lecture and recitation; 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 and recitation, 3 hours lab; 4 semester hours.

CHGN124. 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). Prerequisite: Credit in CHGN121. 3 hours lecture and recitation; 3 semester hours.

CHGN126. QUANTITATIVE CHEMICAL MEASUREMENTS (I,II,S) Experiments emphasizing quantitative chemical measurements. Prerequisite: Credit in or concurrent enrollment in CHGN124. 3 hours lab; 1 semester hour.

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.

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.

CHGN201. CHEMICAL THERMODYNAMICS LABORATORY (II) Experiments in determining enthalpy, entropy, free energy, equilibrium constants, reaction rates, colligative properties. Prerequisites DCGN209 or concurrent enrollment. 3 hours lab; 1 semester hour.

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: CHGN124, CHGN126. 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.

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.

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.

CHGN323. QUALITATIVE ORGANIC ANALYSIS (II) Identification, separation and purification of organic compounds including use of modern physical and instrumental methods. Prerequisite: CHGN222. 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: DCGN209, MACS112. 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: DCGN209, CHGN335. 3 hours lecture; 3 semester hours.

CHGN337. ANALYTICAL CHEMISTRY LABORATORY (I) (WI) Laboratory exercises emphasizing sample preparation and instrumental methods of analysis. Prerequisite: CHGN335, 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 (II) 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: CHGN222, 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: CHGN124, DCGN209, MACS315, PHGN200. 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.

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.

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.

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.

CHGN/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. 3 hours lab; 1 semester hour.

CHGN428. INTRODUCTORY BIOCHEMISTRY (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 permission of instructor. 3 hours lecture; 3 semester hours.

CHGN430/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 thermoplasts including elastomers. Prerequisite: CHGN221 or permission of instructor. 3 hour lecture, 3 semester hours.

CHGN462. MICROBIOLOGY AND THE ENVIRONMENT 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. Offered in alternate years.

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 field 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 6 credit hours.

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.

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.

## **Economics and Business**

### **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.

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.

### **Sophomore Year**

EBGN201. PRINCIPLES OF ECONOMICS (I, II) The basic social and economic institutions of market capitalism. Contemporary economic issues. Business organization. Price theory and market structure. Economic analysis of public policies. Discussion of inflation, unemployment, monetary policy and fiscal policy. Students may elect to satisfy the economics core requirement by taking both EBG311 and EBG312 instead of this course. Students considering a major in economics are advised to take the EBG311/312 sequence instead of EBG201. 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 consent. Variable credit; 1 to 6 credit hours.

EBGN 299. 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.

### **Junior Year**

EBGN304. PERSONAL FINANCE (II, 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 (I, 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: EBG305. 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: EBG201 or EBG311. 3 hours lecture; 3 semester hours.

**EBGN311. MICROECONOMICS (I, II, S)** How markets for goods and services work. Economic behavior of consumers, businesses, and government. Market structure and pricing. Efficiency and equity. Public policies. Students may satisfy the economics core requirement by taking the EBG311/312 sequence instead of EBG201. Students considering a major in economics are advised to skip EBG201 and begin with the EBG311/312 sequence. 3 hours lecture; 3 semester hours.

**EBGN312. MACROECONOMICS (I, II, S)** Analysis of gross domestic output and cyclical variability, plus the general level of prices and employment. The relationship between output and financial markets that affects the level of economic activity. Evaluation of government institutions and policy options for stabilization and growth. International trade and balance of payments. Students may satisfy the economics core requirement by taking the EBG311/312 sequence instead of EBG201. Students considering a major in economics are advised to skip EBG201 and begin with the EBG311/312 sequence. 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 (I)** 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: EBG311. 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: EBG311. 312 is recommended but not required. 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 analyses using expected value concepts, (4) mutually exclusive alternative analyses and service producing alternatives. 3 hours lecture; 3 semester hours.

**EBGN325. APPLICATIONS OF OPERATIONS RESEARCH/ MANAGEMENT SCIENCE (I)** Operations research methods for immediate application. Emphasis on areas of production and inventory control. Principal aim of course is to equip students to use operations research methods to cope with day-to-day problems arising in industry. Introduction to econometric modeling, break-even analysis, and elementary theory of the firm. Introductory applications of network, simulation, linear, and geometric programming methods. Prerequisite: MACS112. 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: EBG201 or EBG311. 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: EBG311. 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 consent. Variable credit; 1 to 6 credit hours.

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.

### **Senior Year**

EBGN401. HISTORY OF ECONOMIC THOUGHT (I) Study of the evolution of economic thinking since the 18th century. Topics include Adam Smith and the Classical School, Karl Marx and Socialism, Alfred Marshall and the Neoclassical School, John Maynard Keynes and the Keynesian School, and Milton Friedman and the New Classicism. Prerequisites: EBGN311 and EBGN312. 3 hours lecture; 3 semester hours.

EBGN402. FIELD SESSION (S) (WI) A capstone course for students majoring in economics. The field session may consist of either an independent research project or an internship. In either case, a student prepares an analytical research paper on a topic in the area of economics and business. Specific research issues are arranged between the student and the supervising faculty member. Prerequisite: Consent of instructor. 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 advanced work 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: MACS112, EBGN411, EBGN412, MACS323 or MACS530, or permission of instructor. 3 hours lecture; 3 semester hours.

EBGN411. INTERMEDIATE MICROECONOMICS (I, II) (WI) A second course in microeconomics. Compared to the earlier course, this course is more rigorous mathematically and quantitatively. It also places more emphasis on advanced topics such as game theory, risk and uncertainty, property rights, and external costs and benefits. Prerequisite: EBGN311 and MACS112. 3 hours lecture; 3 semester hours.

EBGN412. INTERMEDIATE MACROECONOMICS (I, II) (WI) Intermediate macroeconomics provides a foundation for analyzing the long-run and short-run effects of fiscal and monetary policy on aggregate economic performance. Special emphasis on interactions between the foreign sector and the domestic economy. Analytical models are developed from Classical, Keynesian, and New Classical schools of thought. Prerequisites: EBGN311, EBGN312 and MACS112. 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: EBGN411. 3 hours lecture; 3 semester hours. Offered alternate years.

EBGN445. INTERNATIONAL BUSINESS FINANCE (II) An introduction to financial issues of critical importance to multinational firms. Overview of international financial markets, the international monetary system, and foreign-exchange markets. International parity conditions, exchange-rate forecasting, swaps and swap markets. International investments, foreign-direct investment, corporate strategy, and the international debt crisis. Prerequisite: EBGN305, EBGN411, EBGN412. 3 hours lecture; 3 semester hours.

EBGN455. LINEAR PROGRAMMING (I) Geometric interpretation of linear programming problems, the simplex method, the revised simplex method, and the product form of the inverse, duality theory, dual simplex, and applications, sensitivity analysis, complementary slackness and applications. The emphasis is on formulation of business and economic problems as linear programs, including production planning, scheduling, staffing, blending, and product mix applications, and modeling and solving the problems on the computer. Efficiency and implementation issues are discussed, and advanced topics include decomposition methods for large-scale problems. The aim of the course is to equip students to formulate and solve real world problems as linear programs. Prerequisites: EBGN411, MACS332. 3 hours lecture; 3 semester hours.

EBGN490. ECONOMETRICS (I) (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. Prerequisite: EBGN411, MACS323, MACS332. 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: EBG411, EBG412, EBG490. 3 hours lecture; 3 semester hours.

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 consent. Variable credit; 1 to 6 credit hours.

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.

## **Engineering**

### **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.

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.

### **Sophomore Year**

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: None. 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, MACS260/261 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.

### **Junior Year**

EGGN315. DYNAMICS (I,II, S) Absolute and relative motions. Kinetics, work-energy, impulse-momentum, vibrations. Prerequisite: DCGN241 and MACS315. 3 hours lecture; 3 semester hours.

EGGN320. MECHANICS OF MATERIALS (I,II) Fundamentals of stresses and strains, material properties. Axial, torsion, bending, transverse and combined loadings. Stress at a point; stress transformations and Mohr's circle for stress. Beams and beam deflections, thin-wall pressure vessels, columns and buckling, fatigue principles, impact loading. Prerequisite: DCGN241 or MNGN317. 3 hours lecture; 3 semester hours.

EGGN 333. GEOGRAPHICAL MEASUREMENT SYSTEMS (I) The mensuration base for work in the 21st century; engineering projects with local and geodetic control using theodolites, electronic distance meters and total stations. Civil engineering applications of work in the "field" (i.e. implementation on the ground), including engineering astronomy, and computer generated designs. Relationships between and interactions of the "flat" and the "curved" earth, including the mathematics of the ellipsoids and geoid; reduction of GPS observations from the orbital geometry to receiver position and its subsequent reduction into a coordinate plane; conceptual and mathematical knowledge of applying GPS data to engineering projects. The principles and equations of projections (Mercator, Lambert, UTM, State Plane, etc.) and their relationship to the databases of (North American Datum) NAD '27, NAD '83 and (High

Accuracy Reference Network) HARN will also be studied. Prerequisites: EGGN 234. 2 hours lecture, 8-9 field work days; 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, and EGGN389. Three weeks in summer field 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, MACS323. Three weeks in summer field session, 3 semester hours.

EGGN340. 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. Credit earned in EGGN340, Cooperative Education, may be used as free elective credit hours 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 requires submission by the student to the Co-op Advisor of a "Declaration of Intent to Request Approval to Apply Co-op Credit toward Graduation Requirements" form obtained from the Career Center.

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, EGGN320. 4.5 hours lab; 1.5 semester hour.

EGGN351. FLUID MECHANICS (I,II,S) Properties of liquids, manometers, one-dimensional continuity. Bernoulli's equation, the impulse momentum principle, laminar and turbulent flow in pipes, meters, pumps, and turbines. Prerequisite: DCGN241 or MNGN317. 3 hours lecture; 3 semester hours.

EGGN/ESGN353. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I (I) 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: Junior standing or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN/ESGN354. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II (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: Junior standing 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. One-dimensional consolidation theory. Soil compressibility and settlement prediction. Shear strength of soils. Pore pressure parameters. Introduction to earth pressure and slope stability calculations. 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) Definitions, properties, temperature, phase diagrams, equations of state, steam tables, gas tables, work, heat, first and second laws of thermodynamics, entropy, ideal gas, phase changes, availability, reciprocating engines, air standard cycles, vapor cycles. Prerequisite: MACS213/223. 3 hours lecture;

3 semester hours.

EGGN382. ENGINEERING CIRCUIT ANALYSIS (I,II) Frequency response, two port networks, network analysis, application of Laplace and Fourier transforms to circuit analysis. Laboratory experience, simulation study, evaluation, application and extension of lecture concepts. Prerequisites: DCGN381 and EGGN250, co-requisite EGGN388. 1 hour lecture, 3 hours lab; 2 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 equivalent. 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: DCGN381 and EGGN250 or consent of department. 3 hours lecture, 3 hours lab; 4 semester hours.

EGGN388. INFORMATION SYSTEMS SCIENCE (I, II) The interpretation, representation and analysis of time-varying phenomena as signals which convey information and noise; a quantitative treatment on the properties of information and noise, and the degradation of signal fidelity through distortion, band limitation, interference and additive noise. Fourier, Laplace, and Z transforms. Introductory applications in the analysis of dynamic data streams emanating from mechanical, structural and electronic systems, system diagnostics, data acquisition, control and communications. Prerequisite: DCGN381 and MACS315. Corequisite: MACS348. 3 hours lecture; 3 semester hours.

EGGN389. FUNDAMENTALS OF ELECTRIC MACHINERY I (I, II) Magnetic circuit concepts and materials, transformer analysis and operation, special transformers, steady state and dynamic analysis of rotating machines, synchronous and polyphase induction motors, fractional horsepower machines, laboratory study of external characteristics of machines and transformers. Prerequisite: DCGN381, EGGN250 or consent of department. 3 hours lecture, 3 hours lab; 4 semester hours.

EGGN390/MTGN390. MATERIALS AND MANUFACTURING PROCESSES (II) This course focuses on available engineering materials and the manufacturing processes used in their conversion into a product or structure as critical considerations in design. Properties, characteristics, typical selection criteria, and applications are reviewed for ferrous and nonferrous metals, plastics and composites. The nature, features, and economics of basic shaping operations are addressed with regard to their limitations and applications and the types of processing equipment available. Related technology such as measurement and inspection procedures, numerical control systems and automated operations are introduced throughout the course. Prerequisite: EGGN320, SYGN202. 3 hours lecture; 3 semester hours.

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.

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.

### **Senior Year**

EGGN400/MNGN400. INTRODUCTION TO ROBOTICS FOR THE MINERALS AND CONSTRUCTION INDUSTRIES (II) Focuses on construction and minerals industries applications. 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: PHGN200/210. 3 hours lecture; 3 semester hours.

EGGN403. THERMODYNAMICS II (I, II) Thermodynamic relations, Maxwell's Relations, Clapeyron equation, fugacity, mixtures and solutions, thermodynamics of mixing, Gibbs function, activity coefficient, combustion processes, first and second law applied to reacting systems, third law of thermodynamics, real combustion processes, phase and chemical equilibrium, Gibbs rule, equilibrium of multicomponent systems, simultaneous chemical reaction of real combustion processes, ionization, application to real industrial problems. Prerequisite: EGGN351, EGGN371. 3 hours lecture; 3 semester hours.

EGGN407. INTRODUCTION TO FEEDBACK CONTROL SYSTEMS (I,II) System modeling through an energy flow approach is presented, and modeling of electro-mechanical and thermofluid systems are discussed. Feedback control design techniques using pole-placement, root locus, and lead-log compensators are presented. Case studies

using real-life problems are presented and analyzed. Prerequisite: EGGN388. 3 hours lecture; 3 semester hours.

EGGN411. MACHINE DESIGN (I, II) Introduction to the principles of mechanical design. Consideration of the behavior of materials under static and cyclic loading; failure considerations. Application of the basic theories of mechanics, kinematics, and mechanics of materials to the design of basic machine elements, such as shafts, keys, and coupling; journal bearings, antifriction bearings, wire rope, gearing; brakes and clutches, welded connections and other fastenings. Prerequisite: EPIC251, EGGN315, and EGGN320. 3 hours lecture, 3 hours lab; 4 semester hours.

EGGN413. COMPUTER AIDED ENGINEERING This course introduces the student to the concept of computer-aided engineering. The major objective is to provide the student with the necessary background to use the computer as a tool for engineering analysis and design. The Finite Element Analysis (FEA) method and associated computational engineering software have become significant tools in engineering analysis and design. This course is directed to learning the concepts of FEA and its application to civil and mechanical engineering analysis and design. Note that critical evaluation of the results of a FEA using classical methods (from statics and mechanics of materials) and engineering judgment is employed throughout the course. Prerequisite: EGGN320. 3 hours lecture; 3 semester hours.

EGGN422. ADVANCED MECHANICS OF MATERIALS (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.

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 how to use the American Institute of Steel Construction/Load and Resistance Factor Design (AISC/LRFD) design specifications, to develop understanding of the underlying theory, and to 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 and flexural members 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 (II) Loads on structures, design of columns, continuous beams, slabs, retaining walls, composite beams, introduction to prestressed and precast construction. Prerequisite: EGGN342. 3 hours lecture, 3 hours design lab; 3 semester hours.

EGGN450. MULTIDISCIPLINARY ENGINEERING LABORATORY III 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: DCGN381, EGGN250, EGGN352, EGGN350, EGGN351, EGGN320; concurrent enrollment in EGGN407. 3 hours lab; 1 semester hour.

EGGN451. HYDRAULIC PROBLEMS (I) Review of fundamentals, forces on submerged surfaces, buoyancy and flotation, gravity dams, weirs, steady flow in open channels, backwater curves, hydraulic machinery, elementary hydrodynamics, hydraulic structures. Prerequisite: EGGN351. 3 hours lecture; 3 semester hours.

EGGN/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: ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN/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: EGGN353, or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN/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: EGGN354. 3 hours lecture; 3 semester hours.



EGGN456. 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: EGGN353, or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN/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: EGGN354, or consent of instructor. 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: EGGN461. 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.

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: MACS315, EGGN351, EGGN371. 3 hours lecture; 3 semester hours.

EGGN473. FLUID MECHANICS II (I) Review of elementary fluid mechanics and engineering. Two-dimensional internal and external flows. Steady and unsteady flows. Fluid engineering problems. Compressible flow. Computer solutions of various practical problems for mechanical and related engineering disciplines. Prerequisite: EGGN351 or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN478. ENGINEERING DYNAMICS (I) Applications of dynamics to design, mechanisms and machine elements. Kinematics and kinetics of planar linkages. Analytical and graphical methods. Four-bar linkage, slider-crank, quick-return mechanisms, cams, and gears. Analysis of nonplanar mechanisms. Static and dynamic balancing of rotating machinery. Free and forced vibrations and vibration isolation. Prerequisite: EGGN315; concurrent enrollment in MACS315. 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: EGGN481 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 department. 3 hours lecture, 3 hours lab; 4 semester hours.

EGGN484. POWER SYSTEMS ANALYSIS (I) Power systems, three-phase circuits, per unit calculations, system components, stability criteria, network faults, system instrumentation, system grounding, load-flow, economic operation. 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.

EGGN488. RELIABILITY OF ENGINEERING SYSTEMS (I) This course addresses uncertainty modeling, reliability analysis, risk assessment, reliability-based design, predictive maintenance, optimization, and cost-effective retrofit of engineering systems such as structural, sensory, electric, pipeline, hydraulic, lifeline and environmental facilities. Topics include introduction of reliability of engineering systems, stochastic engineering system simulation, frequency

analysis of extreme events, reliability and risk evaluation of engineering systems, and optimization of engineering systems. Prerequisite: MACS323. 3 hours lecture; 3 semester hours.

EGGN491. SENIOR DESIGN I (I, II) (WI) The first of a two-semester course sequence giving the student experience in the engineering design process. Realistic, open-ended design problems are addressed at the conceptual, engineering analysis, and the synthesis stages, and include economic and ethical considerations necessary to arrive at a final design. 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. Prerequisites: Permission of Capstone Design Course Committee. 3 hours lecture; 3 hours lab; 4 semester hours.

EGGN492. SENIOR DESIGN II (I, II) (WI) This is the second of a two-semester course 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 and performing pre-planned experimental tests, wherever feasible. Prerequisite: EGGN491 1 hour lecture; 6 hours lab; 3 semester hours.

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.

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.

## Environmental Science and Engineering

### *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.

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.

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.

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.

ESGN301. ENVIRONMENTAL BIOLOGY (I) Organism structures, energy transformations, photosynthesis, respiration, reproduction, and adaptation are covered. Physiological processes of plants, animals and people are emphasized with respect to environmental issues. Examples are: mineral nutrition, water, relations, growth, and development. Prerequisites: SYGN101. 3 hours lecture; 3 semester hours.

ESGN302/CHGN403. 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, and CHGN222. 3 hours lecture; 3 semester hours.

EGGN/ESGN353. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING I (I) 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: Junior standing or consent of instructor. 3 hours lecture; 3 semester hours.

EGGN/ESGN354. FUNDAMENTALS OF ENVIRONMENTAL SCIENCE AND ENGINEERING II (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: Junior standing 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.

**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.

**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 the above. Three to four weekend field trips will be arranged during the semester. 3 hours lecture; 3 semester hours.

**ESGN440. 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: EGGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

**EGGN/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: ESGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

**EGGN/ESGN454. 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 EGGN353 or consent of instructor. 3 hours lecture; 3 semester hours.

**EGGN/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: EGGN354. 3 hours lecture; 3 semester hours.

**EGGN/ESGN456. 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 EGGN353. 3 hours lecture; 3 semester hours.

**EGGN/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. Prerequisites: EGGN354 or consent of instructor. 3 hours lecture; 3 semester hours.

**ESGN462. SOLID WASTE MINIMIZATION & 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.

**ESGN463/MTGN462. INDUSTRIAL WASTE: RECYCLING & MARKETING (II)** This offering will illustrate process technologies converting industrial waste to marketable by-products, with particular emphasis on locating and evaluation suitable consumers. Components of a waste are matched with operations using similar components as raw materials. This course focuses on identifying customer needs for by-product materials generated by recycling processes, particularly product physical and chemical specifications. Understanding user process technologies facilitates negotiation of mutually satisfactory, environmentally sound sales contracts. Prerequisites: EGGN/ESGN353, and EGGN/ESGN354 or consent of instructor. 3 hours lecture; 3 semester hours.

**ESGN490. 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: ESGN353 or ESGN354, or consent of instructor. 3 hours lecture; 3 semester hours.

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.

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.

## **Geology and Geological Engineering**

### **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.

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.

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.

### **Sophomore Year**

GEOL201. HISTORICAL GEOLOGY AND PALEONTOLOGY (II) Introduction to principles of historical geology used in understanding evolution of the Earth's lithosphere, hydrosphere, atmosphere, and biosphere through geologic time. Consideration of the historical aspects of plate tectonics, the geologic development of North America, and important events in biological evolution and the resulting fossil assemblages through time. Study of fossil morphology, classification and taxonomy, and applications in paleobiology, paleoecology, and biostratigraphy. Prerequisite: SYGN101. 3 hours lecture, 3 hours lab; 4 semester hours.

GEOL210. MATERIALS OF THE EARTH (II) Minerals, rocks and fluids in the Earth, their physical properties and economic applications. Processes of rock formation. Laboratories stress the recognition and classification of minerals and rocks and measurement of their physical properties. Prerequisite: SYGN101. 2 hours lecture, 3 hours lab; 3 semester hours.

GEOL212. MINERALOGY (II) Introduction to crystallography; crystal systems, classes. Chemical and physical properties of minerals related to structure and composition. Occurrence and associations of minerals. Identification of common minerals. Prerequisite: SYGN101, CHGN124. 2 hours lecture, 3 hours lab; 3 semester hours.

GEOL221. OPTICAL MINERALOGY (I) Petrographic analysis of behavior of light in crystalline substances. Identification of non-opaque rock-forming minerals using oil immersion media and thin-section techniques; complete treatment of crystal optics and petrogenetic significance of genetic groupings of minerals. Prerequisite: GEOL212. 2 hours lecture, 4 hours lab; 3 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.

GEGN299. INDEPENDENT STUDY IN ENGINEERING GEOLOGY OR ENGINEERING HYDROGEOLOGY (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.

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.

### **Junior Year**

**GEGN306. PETROLOGY (II)** Shares lectures and topics with GEGN307. Laboratory is presented without use of optical microscope. Prerequisite: GEOL212, GEOL314, DCGN209. 3 hours lecture, 3 hours lab; 4 semester hours.

**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: GEOL212, GEOL314, GEOL221, DCGN209. 3 hours lecture, 6 hours lab; 5 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)** 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, GEOL201 and GEOL212 or GEOL210 or GPGN210. 3 hours lecture, 3 hours lab; 4 semester hours.

**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, GEOL201. 3 hours lecture, 3 hours lab; 4 semester hours.

**GEOL315. SEDIMENTOLOGY AND STRATIGRAPHY (I)** Lecture, laboratory and field exercises on the genesis and classification of sediments, sedimentary rocks, siliciclastic and chemical depositional systems, lithostratigraphy, and biostratigraphy methods of correlation, and basin modeling. Applications of sedimentology and stratigraphy in petroleum exploration and production stressed throughout the course. Prerequisite: SYGN101. 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: GEOL201, GEOL314, GEGN306 or GEGN307, GEOL309, and GEGN317. 6 semester hours (Field 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 to GEGN316. Prerequisite: GEOL201, GEOL314, GEOL309 or GEOL308. Completion or concurrent enrollment in GEGN210 or GEOL212 or GEGN306 or GEGN307. 1 hour lecture, 8 hours field; 2 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.

**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.

**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.

**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.

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.

### **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: GEGN316 and DCGN209. 3 hours lecture, 3 hours lab; 4 semester hours.

GEGN403. MINERAL EXPLORATION DESIGN (II) 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 or concurrent enrollment. 2 hours lecture, 3 hours lab; 3 semester hours.

GEGN404. ORE MICROSCOPY/ FLUID INCLUSIONS (II) Identification of ore minerals using reflected light microscopy, micro-hardness, and reflectivity techniques. Petrographic analysis of ore textures and their significance. Guided research on the ore mineralogy and ore textures of classic ore deposits. Prerequisites: GEGN 306, GEGN401, or consent of instructor. 6 hours lab; 3 semester hours.

GEGN405. MINERAL DEPOSITS (I) Physical and chemical characteristics and geologic and geographic setting of magmatic, hydrothermal, and sedimentary metallic mineral deposits from the aspects of genesis, exploration, and mining. For non-majors. Prerequisite: GEOL210, GEOL308 or concurrent enrollment. 2 hours lecture; 2 semester hours.

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: GEOL309 and GEOL314; GEGN316 or GPGN386 or PEGN316. 3 hours lecture, 3 hours lab; 4 semester hours.

GEGN/GPGN/PEGN439. MULTI-DISCIPLINARY PETROLEUM DESIGN (II) 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: GEOL308 or GEOL309, GEGN438, GEGN316; PE majors: PEGN316, PEGN414, PEGN422, PEGN423, PEGN424 (or concurrent) GEOL308; GP Majors: GPGN302 and GPGN303. 2 hours lecture; 3 hours lab; 3 semester hours.

GEGN442. ADVANCED ENGINEERING GEOMORPHOLOGY (II) Application of quantitative geomorphic techniques to engineering problems. Map interpretation, photo interpretation, field observations, computer modeling, and GIS analysis methods. Topics include: coastal engineering, fluvial processes, river engineering, controlling water and wind erosion, permafrost engineering. Multi-week design projects and case studies. Prerequisite: GEGN342 and GEGN468, or graduate standing; GEGN475/575 recommended. 2 hours lecture, 3 hours lab; 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 differential equations, structural geology, and sedimentation/stratigraphy, or consent of instructor. 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 analyses 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) 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. 2 hours lecture, 3 hours lab; 3 semester hours.

GEGN470. GROUND-WATER ENGINEERING DESIGN (II) 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, analyses, and results, will be required. Prerequisite: GEGN467 or equivalent or consent of instructor. 2 hours lecture, 3 hours lab; 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 (I) 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.

GEGN476. DESKTOP MAPPING APPLICATIONS FOR PROJECT DATA MANAGEMENT (I,II) Conceptual overview and hands-on experience with a commercial desktop mapping system. Display, analysis, and presentation mapping functions; familiarity with the software components, including graphical user interface (GUI); methods for handling different kinds of information; organization and storage of project documents. Use of raster and vector data in an integrated environment; basic raster concepts; introduction to GIS models, such as hill shading and cost/distance analysis. Prerequisite: No previous knowledge of desktop mapping or GIS technology assumed. Some computer experience in operating within a Windows environment recommended. 1 hour lecture; 1 semester hour

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.

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.

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.

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.

## **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; Spring 2003.

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; Spring 2002.

## **Geophysics**

### **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.

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, not to exceed 6 semester hours.

GPGN210. MATERIALS OF THE EARTH (II) (WI) Introduction to the physical and chemical properties and processes in naturally occurring materials. Combination of elements to become gases, liquids and solids (minerals), and aggregation of fluids and minerals to become rocks and soils. Basic material properties that describe the occurrence of matter such as crystal structure, density, and porosity. Properties relating to simple processes of storage and transport through the diffusion equation (such as Fick’s, Ohm’s, Hooke’s, Fourier’s, and Darcy’s Laws) as exhibited in electric, magnetic, elastic, mechanical, thermal, and fluid flow properties. Coupled processes (osmosis, electromagnetic, nuclear magnetic relaxation). The necessity to statistically describe properties of rocks and soils. Multiphase mixing theories, methods of modeling and predicting properties. Inferring past processes acting on rocks from records left in material properties. Environmental influences from temperature, pressure, time and chemistry. Consequences of nonlinearity, anisotropy, heterogeneity and scale. Prerequisites: PHGN200 and MACS112, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

GPGN249. APPLIED MATHEMATICS FOR GEOPHYSICISTS (II) The course bridges the gap between skills acquired in mathematical courses and in skills required in advanced geophysical courses. Moreover, it links both to the physical phenomena they represent and their importance in geophysical applications. The course reviews mathematical topics such as vector algebra and calculus; line, surface, and volume integrals; complex variables; series; sequences; Fourier series and integrals, and gives examples of how these concepts are used for acoustic and electromagnetic wave propagation, magnetic and electrical fields, and spectral analysis. Prerequisites: MACS213, PHGN200, and concurrent enrollment in MACS315. 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.

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, not to exceed 6 semester hours.

### **Junior Year**

GPGN302. SEISMIC METHODS I: INTRODUCTION TO SEISMIC METHODS (II) (WI) This is an introductory study of seismic methods for imaging the Earth’s subsurface, with emphasis on reflection seismic exploration. Starting with the history and development of seismic exploration, the course proceeds through an overview of methods for acquisition of seismic data in land, marine, and transitional environments. Underlying theoretical concepts, including working initially with traveltimes equations for simple subsurface geometries, are used to introduce general issues in seismic data processing, as well as the nature of seismic data interpretation. The course introduces basic concepts, mathematics, and physics of seismic wave propagation (including derivation of the one-dimensional acoustic wave equation and its solution in multi-layered medium), emphasizing similarities with the equations and physics that underlie all geophysical methods. Using analysis of seismometry as a first example of linear time-invariant systems, the course brings Fourier theory and filter theory to life through demonstrations of their immense power in large-scale processing of seismic data to improve signal-to-noise ratio and ultimately the accuracy of seismic images of the Earth’s subsurface. Prerequisites: PHGN200, MACS213, MACS315, and GPGN210, GPGN249, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

GPGN303. GRAVITY AND MAGNETIC METHODS (I) Introduction to land, airborne, oceanographic, and borehole gravity and magnetic exploration. Reduction of observed gravity and magnetic values. Theory of potential-field



anomalies introduced by geologic distributions. Methods and limitations of interpretations. Prerequisites: PHGN200, MACS213, MACS315, and GPGN210, GPGN249, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

**GPGN306. LINEAR SYSTEMS (I)** Beginning with simple linear systems of coupled elements (springs and masses or electrical circuits, for instance) we study linearity, superposition, damping, resonance and normal modes. As the number of elements increases we end up with the wave equation, which leads, via separation of variables, to the first signs of Fourier series. One of the unifying mathematical themes in this course is orthogonal decomposition, which we first encounter in the comfort of finite dimensional vector spaces associated with springs and masses. But the idea extends naturally to infinite dimensional spaces where it appears as a Fourier series. The course culminates in an exposition of Fourier series, integrals and transforms, both discrete and continuous. Throughout, these ideas are motivated by and applied to current geophysical problems such as normal mode seismology, acoustic wave propagation and spectral analysis of time series. In addition to the lectures, there will be classroom and laboratory demonstrations, and all students will complete a variety of computer exercises, using packages such as Mathematica and Matlab. Prerequisites: PHGN200, MACS213, and MACS315, or consent of instructor. 3 hours lecture; 3 semester hours.

**GPGN308. INTRODUCTION TO ELECTRICAL AND ELECTROMAGNETIC METHODS (II)** This is an introductory course on electrical and electromagnetic methods for subsurface exploration. The course begins with a review of the factors influencing the electrical properties of rocks. Methods to be discussed are electrical methods with various electrode arrays for profiling and soundings, and ground and airborne electromagnetic methods using both natural (e.g. the magnetotelluric method) and man-made (e.g. the time domain method) sources for electromagnetic fields. Other techniques reviewed are self-potential, induced polarization and ground penetrating radar. The discussion of each method includes a treatise of the principles, instrumentation, procedures of data acquisition, analyses, and interpretation. These various methods are employed in geotechnical and environmental engineering and resources exploration (base and precious metals, industrial minerals, geothermal and hydrocarbons). The laboratory will focus on demonstrating various methods in the field, and working through case histories. Prerequisites: PHGN200, MACS213, MACS315, GPGN210, GPGN249, and GPGN321, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

**GPGN311. SURVEY OF EXPLORATION GEOPHYSICS (I)** The fundamentals of geophysical exploration are taught through the use of a series of computer simulations and field exercises. Students explore the physics underlying each geophysical method, design geophysical surveys, prepare and submit formal bids to clients contracting the work, and collect, process, and interpret the resulting data. Emphasis is placed on understanding the processes used in designing and interpreting the results of geophysical exploration surveys. Prior exposure to computer applications such as web browsers, spreadsheets, and word processors is helpful. Prerequisites: MACS213, PHGN200, and SYGN101. 3 hours lecture, 3 hours lab; 4 semester hours.

**GPGN315. SUPPORTING GEOPHYSICAL FIELD INVESTIGATIONS (II)** 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. Prerequisite: Concurrent enrollment in GEOL309, or consent of instructor 6 hours lab, 2 semester hours

**GPGN320. ELEMENTS OF CONTINUUM MECHANICS AND WAVE PROPAGATION (I)** Introduction to continuum mechanics and elastic wave propagation with an emphasis on principles and results important in seismology and earth sciences in general. Topics include a brief overview of elementary mechanics, stress and strain, Hooke's law, notions of geostatic pressure and isostasy, fluid flow and Navier-stokes equation. Basic discussion of the wave equation for elastic media, plane wave and their reflection/transmission at interfaces. Prerequisites: MACS213, PHGN200. 3 hours lecture; 3 semester hours.

**GPGN321. THEORY OF FIELDS I: STATIC FIELDS (I)** 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, MACS213, and MACS315, and concurrent enrollment in GPGN249 or consent of instructor. 3 hours lecture; 3 semester hours.

**GPGN322. THEORY OF FIELDS II: TIME-VARYING FIELDS (II)** 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: GPGN321, 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.

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, not to exceed 6 semester hours.

### **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: MACS213, MACS315, GPGN249, and GPGN306, or consent of instructor. Knowledge of a computer programming language is assumed. 2 hours lecture; 2 hours lab, 3 semester hours.

GPGN414. ADVANCED GRAVITY AND MAGNETIC METHODS (II) 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, II) The basics of core analyses 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: MACS315, GPGN249, GPGN302, GPGN303, GPGN308. 3 hours lecture, 2 hours lab; 3 semester hours.

GPGN422. 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: GPGN308, or consent of instructor. 3 hours lecture, 3 hours lab; 4 semester hours.

GPGN432. FORMATION EVALUATION (II) The basics of core analyses 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: MACS315, GPGN249, GPGN302, GPGN303 and GPGN308. 2 hours lecture, 2 hours lab; 3 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, GPGN303, GPGN308, 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. Course can be retaken once.

GPGN439. GEOPHYSICS PROJECT DESIGN (II) GEGN439/PEGN439. MULTI-DISCIPLINARY PETROLEUM DESIGN (II) 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 and GPGN303. GE Majors: GEOL308 or GEOL309, GEGN316, GEGN438. PE majors: PEGN316, PEGN414, PEGN422, PEGN423, PEGN424 (or concurrent). 2 hours lecture, 3 hours lab; 3 semester hours.

GPGN452. 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) interpretation techniques including curved ray methods. 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.

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: GEOL309, GEOL314, GPGN302, GPGN303, GPGN308, GPGN315 or consent of instructor. Up to 6 weeks field; up to 6 semester hours, minimum 4 hours

GPGN494. PHYSICS OF THE EARTH (II) (WI) Students will explore the fundamental observations from which physical and mathematical inferences can be made regarding the Earth's origin, structure, and evolution. These observations include traditional geophysical observations (e.g., seismic, gravity, magnetic, and radioactive) in addition to geochemical, nucleonic, and extraterrestrial observations. Emphasis is placed on not only cataloging the available data sets, but on developing and testing quantitative models to describe these disparate data sets. Prerequisites: GEOL201, GPGN249, GPGN302, GPGN303, GPGN306, GPGN308, PHGN200, and MACS315, or consent of instructor. 3 hours lecture; 3 semester hours.

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.

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, not to exceed 6 semester hours.

## **Liberal Arts and International Studies**

### *Humanities (LIHU)*

LIHU100. NATURE AND HUMAN VALUES 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 both expository and technical writing, using the disciplines and perspectives of the humanities and social sciences. 4 hours lecture/recitation; 4 semester hours.

LIHU198. SPECIAL TOPICS IN HUMANITIES (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.

LIHU298. SPECIAL TOPICS IN HUMANITIES (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.

LIHU300. THE JOURNEY MOTIF IN MODERN LITERATURE This course will explore the notion that life is a journey, be it a spiritual one to discover one's self or geographical one to discover other lands and other people. The exploration will rely on the major literary genres—drama, fiction, and poetry—and include authors such as Twain, Hurston, Kerouac, Whitman, and Cormac McCarthy. A discussion course. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LIHU301. 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: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LIHU310. HUMEN: CONNECTIONS BETWEEN HUMANITIES AND CHEMICAL ENGINEERING This course is taught in conjunction with CRGN201, 'Chemical Process Principles'(3 semester hours) and is part of an integration program known as HumEn (humanities + engineering). The combination of these two courses is designed to help CSM students make appropriate connections between humanities and their technical work, connections which will allow them to appreciate the importance of humanistic understanding in their professional pursuits and in their lives. Courses in the program are team-taught by an engineering faculty member and a humanities faculty member, each are expert in his/her own field, each knowledgeable of the other's field. In this way, students are exposed to the importance of humanistic considerations in solving complex technical problems.

Note: LIHU310, 'Connections between Humanities and Chemical Engineering,' can be take only in conjunction with CRGN201, not as a stand-alone course. Chemical engineering majors who apply and are selected to take CRGN201 in this format will satisfy one of their LAIS mid-level requirements by taking a combination of courses. Chemical engineering students interested in participating in the HumEn program should contact either the Department of Chemical Engineering and Petroleum Refining or the Division of Liberal Arts and International Studies for application procedures. Prerequisite: LIHU100 and permission from instructor. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LIHU330. WESTERN CIVILIZATION SINCE THE RENAISSANCE Major historical trends in Western civilization since the Renaissance. This course provides a broad understanding of the historical events, issues, and personalities which shaped contemporary Western civilization. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LIHU334. LITERARY HERITAGE OF THE WESTERN WORLD A study of representative works that have contributed significantly to the literary heritage of Western civilization. Selections read from various genres (drama, fiction, poetry, essay) range in time from ancient Greece to the present. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LIHU338 ART, ARCHITECTURE AND CITIES Combining history of art and architecture with social history, this course focuses on paintings, sculpture, buildings, and urban centers of the Western world, including Rome, Florence, Venice, Paris, Vienna, Munich, Berlin, and New York. Principal goals, besides enjoyment of beautiful objects and spaces, are to differentiate the social, political, and religious systems that created these objects, to recognize the values they represent, and to develop esthetic sensitivity to our contemporary world. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture; 3 credit hours.

LIHU339. MUSICAL TRADITIONS OF THE WESTERN WORLD An introduction to music of the Western world from its beginnings to the present. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LIHU350. 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: LIHU 100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LIHU360. HISTORY OF SCIENCE AND TECHNOLOGY: BEGINNING TO 1500 Topics include: technology of hunting and gathering societies, the development of agriculture, writing, metallurgy, astronomy, mathematics; Roman architecture and civil engineering, the role of technology in the development of complex societies in the Near East and Mediterranean areas, Medieval military and agricultural technology and the rise of feudalism; the movement of the economic center of Europe from the Mediterranean to the North Sea. Includes some discussion of archaeological method including excavation techniques and dating methods. Requires a 15-25 page analytical annotated bibliography or research paper, a 10-15 minute oral presentation, and a 2-hour take-home exam. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LIHU375. PATTERNS OF AMERICAN CULTURE A survey of American cultural history through an examination of significant works of literature and of social and intellectual history. Works chosen may vary from year to year, but the goal of the course will remain constant: the understanding of those cultural aspects that help to define America. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LIHU398. SPECIAL TOPICS IN HUMANITIES (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. Prerequisite or corequisite: SYGN200. Variable credit: 1 to 6 hours.

*Note: Students enrolling in 400-level courses are required to have senior standing or permission of instructor.*

**LIHU401. THE AMERICAN DREAM: ILLUSION OR REALITY?** This seminar will examine ‘that elusive phrase, the American dream,’ and ask what it meant to the pioneers in the New World, how it withered, and whether it has been revived. The concept will be critically scrutinized within cultural contexts. The study will rely on the major genres of fiction, drama, and poetry, but will venture into biography and autobiography, and will range from Thoreau’s *Walden* to Kerouac’s *On the Road* and Boyle’s *Budding Prospects*. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

**LIHU402. HEROES AND ANTIHEROES: A TRAGIC VIEW** This course features heroes and antiheroes (average folks, like most of us), but because it is difficult to be heroic unless there are one or more villains lurking in the shadows, there will have to be an Iago or Caesar or a politician or a member of the bureaucracy to overcome. Webster’s defines heroic as ‘exhibiting or marked by courage and daring.’ Courage and daring are not confined to the battlefield, of course. One can find them in surprising places—in the community (Ibsen’s *Enemy of the People*), in the psychiatric ward (Kesey’s *One Flew Over the Cuckoo’s Nest*), in the military (Heller’s *Catch-22*), on the river (Twain’s *The Adventures of Huckleberry Finn* or in a “bachelor pad” (Simon’s *Last of the Red Hot Lovers*). Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

**LIHU403. MYTHOLOGY** This course is designed to give students a familiarity with important Greek myths, especially in terms of their imaginative and dramatic appeal. Considerations regarding the nature of that appeal will provide means for addressing the social function of myth, which is a central issue for the course. The class will also examine various issues of anthropological and philosophical significance pertaining to the understanding of myth, including the issue of whether science is a form of myth. The final assignment will provide an opportunity to address either Greek or non-Greek myth. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

**LIHU404. TRANSCENDENT VISION** Imagination can take us beyond the limits imposed by conventional mechanistic thinking about life and the universe. Spiritual vision can reveal a living universe of great power, beauty, and intrinsic value. Yet people accept existence in a world supposedly built out of dead matter. To transcend ordinary experience, we must set out on an adventure, a journey into new and strange worlds. Works of imaginative literature provide gateways to new worlds in which the universe is a transcendent experience that gives full meaning to existence. This course explores ideas and images of the universe as a revelation of transcendent value. A major issue considered in the course is the implication of comparing European and Native American world views. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours

**LIHU410. ROMANTICISM TO IMPRESSIONISM** Romanticism to Impressionism is a seminar on aspects of European (primarily French) cultural history of the nineteenth century. Emphasis is on art and literature from the era of Napoleon I to that of the Third Republic. This is the age of industrial revolution, rapid growth of cities, exploitation of the working class, the beginnings of socialism, and the triumph of capitalism. Artists to be covered range from Delacroix to Monet; authors include Sir Walter Scott and Emile Zola. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

**LIHU470. BECOMING AMERICAN: LITERARY PERSPECTIVES** This course will explore the increasing heterogeneity of U.S. society by examining the immigration and assimilation experience of Americans from Europe, Africa, Latin America, and Asia as well as Native Americans. Primary sources and works of literature will provide the media for examining these phenomena. In addition, Arthur Schlesinger, Jr.’s thesis about the ‘unifying ideals and common culture’ that have allowed the United States to absorb immigrants from every corner of the globe under the umbrella of individual freedom, and the various ways in which Americans have attempted to live up to the motto ‘e pluribus unum’ will also be explored. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

**LIHU479. THE AMERICAN MILITARY EXPERIENCE** A survey of military history, with primary focus on the American military experience from 1775 to present. Emphasis is placed not only on military strategy and technology, but also on relevant political, social, and economic questions. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours. Open to ROTC students or by permission of the LAIS Division.

**LIHU480. URBAN QUALITY OF LIFE** This course is intended to engage students with the marvelous potential and appalling problems of some of the world’s cities. Primary focus will be on cultural history and the designed environment, including issues of traffic, housing, and environmental quality. Emphasis will be on the humanistic dimensions of a range of issues normally associated with urban sociology. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

**LIHU498. SPECIAL TOPICS IN HUMANITIES (1, 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. Prerequisite or corequisite: SYGN200. Variable credit: 1 to 6 semester hours.

LIHU499. INDEPENDENT STUDY (I, II) Individual research or special problem projects supervised by a faculty member. For students who have completed their LAIS requirements. Instructor consent required. Prerequisite: "Independent Study" form must be completed and submitted to the registrar. Prerequisite or corequisite: SYGN200. Variable credit: 1 to 6 hours.

### *Systems (SYGN)*

SYGN200. HUMAN SYSTEMS This is a pilot course in the CSM core curriculum that articulates with LIHU100, 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: LIHU100. 3 hours lecture/discussion; 3 semester hours.

### *Social Sciences (LISS)*

LISS198. SPECIAL TOPICS IN SOCIAL 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: Instructor consent. Variable credit: 1 to 6 semester hours.

LISS298. SPECIAL TOPICS IN SOCIAL 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: Instructor consent. Variable credit: 1 to 6 semester hours.

LISS300. CULTURAL ANTHROPOLOGY A study of the social behavior and cultural development of man. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LISS312. 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: LIHU 100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours

LISS320. THE PSYCHOLOGY OF HUMAN PROBLEM-SOLVING Introduction to, and study of, basic concepts relating to self-development, group interactions, and interpersonal skills. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LISS330. MANAGING CULTURAL DIFFERENCES Developing awareness and sensitivities of differences among cultures, their interrelationship; acquiring basic cultural literacy; acculturation processes of ethics, values, and behavior in the United States. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LISS335. 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: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LISS340. 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: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LISS342. 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: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LISS344. 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: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LISS351. THE HISTORY OF EASTERN EUROPE AND RUSSIA SINCE 1914 The course will trace the developments in Eastern Europe and Russia from 1914 to the present, with emphasis on the development of communism, World War II, the Cold War, the fall of communism, and the resulting efforts to democratize the former communist states. Countries covered will include Russia, Poland, Hungary, the Czech Republic, Slovakia, Romania, Bulgaria, Albania, Slovenia, Croatia, Bosnia, Macedonia, and Serbia/Montenegro. The course is primarily lecture, with opportunities for individual and group presentations and papers. Tests will be both objective and essay. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LISS362. SCIENCE AND TECHNOLOGY POLICY An introductory survey of current issues relating to national science and technology policy in the U.S. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LISS364. ENGINEERING, SCIENCE, AND TECHNOLOGY: SOCIAL/ENVIRONMENTAL CONTEXT Social context and social effects of engineering, science, and technology, with strong emphasis on ecological sustainability of resource use and of technological activity in general, from both social and comprehensively ecological viewpoints. Examination of the relationship between social values and technological developments, and of how engineering alternatives imply social alternatives; engineering as a means of ecological rationality. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LISS372. THE AMERICAN POLITICAL EXPERIENCE A study of key elements in the American political system (e.g., the Constitution, the Presidency, federalism, public opinion), their historical development, and how they affect policy-making on controversial issues. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LISS375. INTRODUCTION TO LAW AND LEGAL SYSTEMS Examination of different approaches to, principles of, and issues in the law in the U.S. and other societies. Prerequisite: LIHU 100. Prerequisite or corequisite: SYGN200. 3 hours lecture/discussion; 3 semester hours.

LISS398. SPECIAL TOPICS IN SOCIAL 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: Instructor consent. Prerequisite or corequisite: SYGN200. Variable credit: 1 to 6 semester hours.

LISS 410. UTOPIAS/DYSTOPIAS This course studies the relationship between society, technology, and science using fiction and film as a point of departure. A variety of science fiction novels, short stories, and films will provide the starting point for discussions. These creative works will also be concrete examples of various conceptualizations that historians, sociologists, philosophers, and other scholars have created to discuss the relationship. Prerequisite: LIHU 100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS415. THE INVISIBLE MACHINE Did an Invisible Machine build the pyramids? Was the Invisible Machine reassembled in the 17th century? Did astronomy provide the blueprint? Why was Louis XIV called the "Sun King?" Is modern technology a servant that obeys, or a mega-technical system that dominates? Is human society becoming a technological paradise, or an urban nightmare? Why have a number of movies depicted the future as a nightmare city? Using selected readings plus films such as *Metropolis* and *Blade Runner*, this course will address these and other significant questions. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS430. 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: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS431. 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: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS432. 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: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS433. GLOBAL CORPORATIONS This international political economy seminar seeks to (1) understand the history of the making of global corporations and their relationship to the state, region-markets, and region-states; and

(2) analyze the on-going changes in global, regional, and national political economies due to the presence of global corporations. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS434. 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: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS435. 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: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS437. 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.

LISS439. POLITICAL RISK ASSESSMENT RESEARCH SEMINAR This international political economy seminar must be taken concurrently with LISS435, 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: LIHU100. Prerequisite or corequisite: SYGN200. Concurrent enrollment in LISS435. 1 hour seminar; 1 semester hour.

LISS440. 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: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS441. 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. If the Free Trade Area of the Americas (FTAA) becomes a reality, it will be the largest region-market in the world with some 800 million people and a combined GNP of over US\$10 trillion. In the three other main languages of the Americas, the FTAA is known as the Area de Libre Comercio de las Américas (ALCA) (Spanish), the Area de Livre Comércio das Américas (ALCA) (Portuguese), and the Zone de libre échange des Amériques (ZLEA) (French). Negotiations for the FTAA/ALCA/ZLEA are to be concluded by 2005. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS442. 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: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS446. INTERNATIONAL POLITICAL ECONOMY OF AFRICA 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.

LISS450. AMERICAN MINING HISTORY This course asks the question, "how do we know what happened in the past?" using Western American mining history as the case study. The course will include primary texts those written at the time that the historical events occurred and secondary sources, scholars' and popularizers' reconstructions. We will look at several approaches: scholarly studies, such as labor, technology, quantitative, and social history. Oral history



will be approached through song and video material. We will study industrial archaeology by visiting the Western Mining Museum in Colorado Springs. The movie "Matewan" illustrates how Americans make myths out of history. Students unfamiliar with mining can earn extra credit by a visit to the CSM experimental mine. In all these cases, we will discuss the standpoint of the authors of primary sources and scholarly accounts. We will discuss how we represent all different historical viewpoints and discuss how we know what is historically true—what really happened. Prerequisite: LIHU 100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS455. JAPANESE HISTORY AND CULTURE Japanese History and Culture is a senior seminar taught in Japanese that covers Japan's historical and cultural foundations from earliest times through the modern period. It is designed to allow students who have had three semesters of Japanese language instruction (or the equivalent) to apply their knowledge of Japanese in a social science-based course. Major themes will include: cultural roots; forms of social organization; the development of writing systems; the development of religious institutions; the evolution of legal institutions; literary roots; and clan structure. Students will engage in activities that enhance their reading proficiency, active vocabulary, translation skills, and expository writing abilities. Text is in Japanese. Prerequisites: LIHU 100; three semesters of college-level Japanese or permission of instructor. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS460. TECHNOLOGY AND WILDERNESS A seminar on the values of wild nature in comparison to technological values with a view to the impact on environmental management policies. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS461. TECHNOLOGY AND GENDER: ISSUES This course focuses on how women and men relate to technology. Several traditional disciplines will be used: philosophy, history, sociology, literature, and a brief look at theory. The class will begin discussing some basic concepts such as gender and sex and the essential and/or social construction of gender, for example. We will then focus on topical and historical issues. We will look at modern engineering using sociological studies that focus on women in engineering. We will look at some specific topics including military technologies, ecology, and reproductive technologies. Prerequisite: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS474. 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: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS480. 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: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS482. 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: LIHU100. Prerequisite or corequisite: SYGN200. 3 hours seminar; 3 semester hours.

LISS498. SPECIAL TOPICS IN SOCIAL 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: Instructor consent. Prerequisite or corequisite: SYGN200. Variable credit: 1 to 6 semester hours.

LISS499. INDEPENDENT STUDY (I, II) Individual research or special problem projects supervised by a faculty member. For students who have completed their LAIS requirements. Instructor consent required. Prerequisite: "Independent Study" form must be completed and submitted to the registrar. Prerequisite or corequisite: SYGN200. Variable credit: 1 to 6 hours.

### *Foreign Languages (LIFL)*

A variety of foreign languages is available 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.** Proficiency tests may be used to determine at what level a student should be enrolled, but a student cannot receive course credit by taking these tests.

### **Foreign Language Policy**

Students will not receive credit toward their LAIS or Free Elective graduation requirements for taking a foreign language in which they have had previous courses as per the following formula:

If a student has taken one year in high school or one semester in college, he/she will not receive graduation credit for the first semester in a CSM foreign language course. Likewise, if a student has taken two years in high school or two semesters in college, he/she will not receive graduation credit for the second semester, and if a student has taken three years in high school or three semesters in college, he/she will not receive graduation credit for the third semester.

LIFL198. SPECIAL TOPICS IN A FOREIGN LANGUAGE (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.

LIFL221. 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.

LIFL321. 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.

LIFL421. SPANISH III Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and Spanish American culture. 3 semester hours.

LIFL222. 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.

LIFL322. 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.

LIFL422. ARABIC III Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and culture of Arabic-speaking societies. 3 semester hours.

LIFL223. GERMAN I Fundamentals of spoken and written German with an emphasis on vocabulary, idiomatic expressions of daily conversation, and German culture. 3 semester hours.

LIFL323. 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.

LIFL423. GERMAN III Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and German culture. 3 semester hours.

LIFL224. RUSSIAN I Fundamentals of spoken and written Russian with an emphasis on vocabulary, idiomatic expressions of daily conversation, and Russian culture. 3 semester hours.

LIFL324. RUSSIAN II Continuation of Russian I with an emphasis on acquiring conversational skills as well as further study of grammar, vocabulary, and Russian culture. 3 semester hours.

LIFL424. RUSSIAN III Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and Russian culture. 3 semester hours.

LIFL225. FRENCH I Fundamentals of spoken and written French with an emphasis on vocabulary, idiomatic expressions of daily conversation, and French-speaking societies. 3 semester hours.

LIFL325. FRENCH II Continuation of French I with an emphasis on acquiring conversational skills as well as further study of grammar, vocabulary, and French-speaking societies. 3 semester hours.

LIFL425. FRENCH III Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and French-speaking societies. 3 semester hours.

LIFL226. PORTUGUESE I Fundamentals of spoken and written Portuguese with an emphasis on vocabulary, idiomatic expressions of daily conversation, and Brazilian culture. 3 semester hours.

LIFL326. PORTUGUESE II Continuation of Portuguese I with an emphasis on acquiring conversational skills as well as further study of grammar, vocabulary, and Brazilian culture. 3 semester hours.

LIFL426. PORTUGUESE III Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and Brazilian culture. 3 semester hours.

LIFL227. CHINESE I Fundamentals of spoken and written Chinese with an emphasis on vocabulary, idiomatic expressions of daily conversation, and Chinese culture. 3 semester hours.

LIFL327. CHINESE II Continuation of Chinese I with an emphasis on acquiring conversational skills as well as further study of grammar, vocabulary, and Chinese culture. 3 semester hours.

LIFL427. CHINESE III Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and Chinese culture. 3 semester hours.

LIFL228. INDONESIAN I Fundamentals of spoken and written Indonesian with an emphasis on vocabulary, idiomatic expressions of daily conversation, and Indonesian culture. 3 semester hours.

LIFL328. INDONESIAN II Continuation of Indonesian I with an emphasis on acquiring conversational skills as well as further study of grammar, vocabulary, and Indonesian culture. 3 semester hours.

LIFL428. INDONESIAN III Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and Indonesian culture. 3 semester hours.

LIFL229. JAPANESE I Fundamentals of spoken and written Japanese with an emphasis on vocabulary, idiomatic expressions of daily conversation, and Japanese culture. 3 semester hours.

LIFL329. JAPANESE II Continuation of Japanese I with an emphasis on acquiring conversational skills as well as further study of grammar, vocabulary, and Japanese culture. 3 semester hours.

LIFL429. JAPANESE III Emphasis on furthering conversational skills and a continuing study of grammar, vocabulary, and Japanese culture. 3 semester hours.

LIFL298. SPECIAL TOPICS IN A FOREIGN LANGUAGE (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.

LIFL299. INDEPENDENT STUDY (I, II) Individual independent study in a given foreign language. Prerequisite: "Independent Study" form must be completed and submitted to the registrar. Variable credit: 1 to 6 hours.

LIFL398. SPECIAL TOPICS IN A FOREIGN LANGUAGE (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.

LIFL399. 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.

LIFL498. SPECIAL TOPICS IN A FOREIGN LANGUAGE (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.

LIFL499. INDEPENDENT STUDY (I, II) Individual research or special problem projects supervised by a faculty member. For students who have completed their LAIS requirements. Instructor consent required. Prerequisite: "Independent Study" form must be completed and submitted to the registrar. Variable credit: 1 to 6 hours.

### ***Communication (LICM)***

Courses in communication do not count toward the LAIS restricted elective requirement but may be taken for free elective credit and to complete a communications minor or Area of Special Interest (ASI).

LICM301. \ORAL COMMUNICATION A five-week course which teaches the fundamentals of effectively preparing and presenting messages. "Hands-on" course emphasizing short (5- and 10-minute) weekly presentations made in small groups to simulate professional and corporate communications. Students are encouraged to make formal presentations which relate to their academic or professional fields. Extensive instruction in the use of visuals. Presentations are rehearsed in class two days prior to the formal presentations, all of which are video-taped and carefully evaluated. 1 hour lecture/lab; 1 semester hour.

LICM304. PRACTICUM IN TUTORING Designed to provide an intensive training program for students who will serve as peer tutors in the LAIS Writing Center. Course emphasis will be on theoretical bases of tutoring as well as practice. Prerequisite: Permission of the instructor. 1-3 hours lecture/lab; 1-3 semester hours.

LICM 306. SELECTED TOPICS IN WRITTEN COMMUNICATION Information on courses designated by this number may be obtained from the LAIS Division. Prerequisite: Will depend on the level of the specific course. 1 - 3 hours lecture/lab; 1-3 semester hours.

### ***Music (LIMU)***

A cultural opportunity for students with music skills to continue study in music for a richer personal development. Free elective hours required by degree-granting departments may be satisfied by a maximum of 3 semester hours total of concert band (i.e., spring semester), chorus, or physical education and athletics.

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.

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.

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: LIHU 339 or consent of instructor. 3 hours lecture/discussion; 3 semester hours.

(See also LIHU339. MUSICAL TRADITIONS OF THE WESTERN WORLD in preceding list of LAIS courses.)

## **Materials Science**

### *(Interdisciplinary Program)*

The interdisciplinary Materials Science Program is administered jointly by the Departments of Chemical Engineering and Petroleum Refining, Chemistry and Geochemistry, Metallurgical and Materials 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.

Listed below are 400-level undergraduate courses which are cross-listed with 500-level Materials Science courses. Additional courses offered by the Program Departments, not listed here, may also satisfy the course-requirements towards a graduate degree in this Program. Consult the Materials Science Program Guidelines for Graduate Students and the Program Departments course-listings. It should be noted that the course requirement for graduate-level registration for a MLGN<sup>500</sup>-level course which is cross-listed with a 400-level course-number, will include an additional course-component above that required for 400-level credit.

MLGN502/PHGN440. SOLID STATE PHYSICS (II) An elementary study of the properties of solids including crystalline structure and its determination, lattice vibrations, electrons in metals, and semiconductors. Prerequisite: PHGN300 or PHGN325 and MACS315. 3 hours lecture; 3 semester hours.

MLGN505\*/MTGN445. MECHANICAL PROPERTIES OF MATERIALS (I) Mechanical properties and relationships. Plastic deformation of crystalline materials. Relationships of microstructures to mechanical strength. Fracture, creep, and fatigue. Prerequisite: MTGN348. 3 hours lecture; 3 hours lab; 3<sup>3</sup>/<sub>4</sub> semester hours. \* This is a 3 hour-credit graduate-course in the Materials Science Program and a 4 hour-credit undergraduate-course in the MTGN program.

MLGN510/CHGN410 SURFACE CHEMISTRY (I) 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.

MLGN512/MTGN412. CERAMIC ENGINEERING (II) 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.

MLGN515/MTGN415. 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 will be discussed, along with functions, performance requirements, and testing methods of materials for each type of circuit component. The general topics covered are conductors, resistors, insulators, capacitors, energy convertors, magnetic materials, and integrated circuits. Prerequisites: PHGN200/210, MTGN311 or MLGN501, MTGN412/MLGN512, or consent of instructor. 3 hours lecture; 3 semester hours.

MLGN516/MTGN416 PROPERTIES OF CERAMICS (II) A 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 multi-phase ceramics, including composites, are covered. Prerequisites: PHGN200/210, MTGN311 or MLGN501, MTGN412/MLGN512 or consent of instructor. 3 hours lecture; 3 semester hours

MLGN517/EGGN422 SOLID MECHANICS OF MATERIALS (I) Review mechanics of materials. Introduction to elastic and non-linear continua. Cartesian tensors and stresses and strains. Analytical solution of elasticity problems.

Develop basic concepts of fracture mechanics. Prerequisite: EGGN320 or equivalent, MACS315 or equivalent. 3 hours lecture; e semester hours. Semester to be offered: Spring

MLGN519/MTGN419. NON-CRYSTALLINE MATERIALS(II) An 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.

MLGN522/PHGN441. SOLID STATE PHYSICS APPLICATIONS AND PHENOMENA Continuation of MLGN502/PHGN440 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 cannot receive credit for MLGN522, only PHGN441. Prerequisite: MLGN502/PHGN440. 3 hours lecture; 3 semester hours. Those receiving graduate credit will be required to submit a term paper, in addition to satisfying all of the other requirements of the course.

MLGN530/CHGN430/CRGN415. 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 thermoplasts including elastomers. Prerequisite: CHGN327 or consent of instructor. 3 hours lecture; 3 semester hours.

MLGN531/CRGN416. INTRODUCTION TO POLYMER ENGINEERING (II) This class provides a background in polymer fluid mechanics, polymer rheological response and polymer shape forming. The class begins with a discussion of the definition and measurement of material properties. Interrelationships among the material response functions are elucidated and relevant correlations between experimental data and material response in real flow situations are given. Processing operations for polymeric materials will then be addressed. These include the flow of polymers through circular, slit, and complex dies. Fiber spinning, film blowing, extrusion and coextrusion will be covered as will injection molding. Graduate students are required to write a term paper and take separate examinations which are at a more advanced level. Prerequisite: CHEN307, EGGN351 or equivalent. 3 hours lecture; 3 semester hours.

MLGN544/MTGN414 PROCESSING OF CERAMICS (II) A description of the principles of ceramic processing and the relationship between processing and microstructure. Raw materials and raw material 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 are included. Prerequisites: MTGN311, MTGN331, and MTGN412/MLGN512 or consent of instructor. 3 hours lecture; 3 semester hours.

MLGN550/MLGN450. STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS(II) An introduction to statistical process control, process capability analysis and experimental design techniques. Statistical process control theory and techniques will be developed and applied to control charts for variables and attributes involved in process control and evaluation. Process capability concepts will be developed and applied for the evaluation of manufacturing processes. The theory and application of designed experiments will be developed and applied for full factorial experiments, fractional factorial experiments, screening experiments, multilevel experiments and mixture experiments. Analysis of designed experiments will be carried out by graphical and statistical techniques. Computer software will be utilized for statistical process control and for the design and analysis of experiments. Prerequisite: Consent of Instructor. 3 hours lecture, 3 semester hours

## **Mathematical and Computer Sciences**

### **Freshman Year**

MACS100. 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. Prerequisite: Consent of Instructor. 1 semester hour.

MACS 111. CALCULUS FOR SCIENTISTS AND ENGINEERS I (I,II,S) First course in the calculus sequence, including elements of plane geometry. Functions, limits, continuity, and derivatives and their application. Definite and indefinite integrals; applications and numerical approximations. Prerequisite: precalculus. 4 hours lecture; 4 semester hours.

MACS 112. CALCULUS FOR SCIENTISTS AND ENGINEERS II (I,II,S) Vectors, computational linear algebra, and multivariable calculus. Prerequisite: MACS111 or Advanced Placement credit in Calculus AB or BC. 4 hours lecture; 4

semester hours.

MACS122. CALCULUS FOR SCIENTISTS AND ENGINEERS II HONORS (I) Same topics as those covered in MACS112 but with additional material and problems. Prerequisite: Consent of Department. 4 hours lecture; 4 semester hours.

MACS198. 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.

MACS199. 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.

### **Sophomore Year**

MACS213. CALCULUS FOR SCIENTISTS AND ENGINEERS III (I,II,S) Vector fields, line and surface integrals, techniques of integration and infinite series as they apply to solutions of differential equations. Prerequisite: MACS112 or MACS 122. 4 hours lecture; 4 semester hours.

MACS223. CALCULUS FOR SCIENTISTS AND ENGINEERS III HONORS (II) Same topics as those covered in MACS213 but with additional material and problems. Prerequisite: Consent of Department Head. 4 hours lecture; 4 semester hours.

MACS224. CALCULUS FOR SCIENTISTS AND ENGINEERS III HONORS(AP) (I) Early introduction of vectors, linear algebra, multivariable calculus with an introduction to Mathematica. Vector fields, line and surface integrals. Prerequisite: Consent of Department Head. 4 hours lecture; 4 semester hours.

MACS260 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.

MACS261 PROGRAMMING CONCEPTS (I,II,S) Computer Programming in a contemporary language such as C++, 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.

MACS262 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: MACS261. 3 hours lecture; 3 semester hours.

MACS298. 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.

MACS299. 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.

### **Junior Year**

MACS306. 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: MACS262. 3 hours lecture; 3 semester hours.

MACS315. 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. Prerequisite: MACS213 or MACS223. 3 hours lecture; 3 semester hours.

MACS323. 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: MACS112 or MACS122. 3 hours lecture; 3 semester hours.

MACS324. PROBABILITY AND STATISTICS FOR ENGINEERS II (II) Continuation of MACS323. Multiple regression analysis, analysis of variance, basic experimental design, and distribution-free methods. Applications

emphasized. Prerequisite: MACS323 or consent of instructor. 3 hours lecture; 3 semester hours.

MACS325. DIFFERENTIAL EQUATIONS WITH HONORS (II) Same topics as those covered in MACS315 but with additional material and problems. Prerequisite: Consent of department. 3 hours lecture; 3 semester hours.

MACS332. LINEAR ALGEBRA (I,II) Systems of linear equations, matrices, determinants and eigen- values. Linear operators. Abstract vector spaces. Applications selected from linear programming, physics, graph theory, and other fields. Prerequisite: MACS213 or MACS223. 3 hours lecture; 3 semester hours.

MACS 333. INTRODUCTION TO MATHEMATICAL MODELING. (II) This course gives students the opportunity to build mathematical models of real-world phenomena. It considers several practical problems drawn from engineering and the sciences. For each, the problem is defined and then the student discovers how the underlying principles lead to a mathematical model. The course concentrates on difference and differential equation models. In each case, the student solves the model and analyzes how the model and its solutions are useful in understanding the original problem. Prerequisites: MACS 315 or consent of instructor. 3 hours lecture; 3 semester hours.

MACS340. 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.

MACS341. MACHINE ORGANIZATION AND ASSEMBLY LANGUAGE PROGRAMMING (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: MACS261. 3 hours lecture; 3 semester hours.

MACS348. 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 MACS elective by MACS majors. Prerequisite: MACS315. 3 hours lecture; 3 semester hours.

MACS358. DISCRETE MATHEMATICS & ALGEBRAIC STRUCTURES (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: MACS213 or MACS223. 3 hours lecture; 3 semester hours.

MACS370. FIELD COURSE (S) This is the department'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 MACS306 and Mathematics students should have coursework through MACS 323 and 332. Prerequisite: Consent of Instructor. 6-week summer field session; 6 semester hours.

MACS398. 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.

MACS399. 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.

### **Senior Year**

MACS400. 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: MACS262. 3 hours lecture; 3 semester hours.

MACS401 REAL 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: MACS213 or MACS223 and MACS332. 3 hours lecture; 3 semester hours.

MACS403. DATA BASE MANAGEMENT (I,II) 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: MACS262. 3 hours lecture; 3 semester hours.

MACS404. 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: MACS262, MACS358. 3 hours lecture; 3 semester hours.

MACS406. DESIGN AND ANALYSIS OF 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: MACS262, MACS213,MACS358. 3 hours lecture; 3 semester hours.

MACS407. 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. Code development using C/C++/Java. Emphasis is on problem solving using efficient numerical methods in scientific computing. Prerequisite: MACS315 and knowledge of computer programming. 3 hours lecture; 3 semester hours.

MACS411. 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: MACS 262, MACS358. 3 hours lecture; 3 semester hours.

MACS428. APPLIED PROBABILITY (II) Basic probability. Probabilistic modeling. Discrete and continuous probability models and their application to engineering and scientific problems. Empirical distributions, probability plotting, and testing of distributional assumptions. Prerequisite: MACS213 or MACS223. 3 hours lecture; 3 semester hours.

MACS433/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, 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: MACS 315. 3 hours lecture, 3 semester hours.

MACS434. 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: MACS 213 or 223. 3 hours lecture, 3 semester hours.

MACS 435: 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: MACS 434 3 hours lecture, 3 semester hours

MACS 440. PARALLEL COMPUTING FOR SCIENTISTS AND ENGINEERS (I) 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.

MACS441. COMPUTER GRAPHICS (I,II) 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: MACS 262. 3 hours lecture, 3 semester hours.

MACS442. 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: MACS262, MACS 341. 3 hours lecture; 3 semester hours.

MACS443. 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: MACS 261, MACS 262. 3 hours lecture, 3 semester hours

MACS454. COMPLEX ANALYSIS (I) The complex plane. Analytic functions, harmonic functions. Mapping by elementary functions. Complex integration, power series, calculus of residues. Conformal mapping. Prerequisite: MACS 315. 3 hours lecture, 3 semester hours.

MACS455. PARTIAL DIFFERENTIAL EQUATIONS (II) 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: MACS315. 3 hours lecture; 3 semester hours.

MACS461. SENIOR SEMINAR I (I) Students present topics orally and write research papers using undergraduate mathematical and computer sciences techniques, emphasizing critical analysis of assumptions and models. Prerequisite: Consent of Department Head. 1 hour seminar; 1 semester hour.

MACS462. SENIOR SEMINAR II (II) Students present topics orally and write research papers using undergraduate mathematical and computer sciences techniques, emphasizing critical analysis of assumptions and models. Prerequisite: Consent of Department Head. 1 hour seminar; 1 semester hour.

MACS471. COMPUTER NETWORKS (I,II) This introduction to computer networks covers the fundamentals of computer communications, using TCP/IP standardized protocols as the main case study. Topics include physical topologies, switching, error detection and correction, routing, congestion control, and connection management for global networks (such as the Internet) and local area networks (such as the Ethernet). In addition, network programming and applications are considered. Prerequisite: MACS442 or permission of instructor. 3 hours lecture, 3 semester hours.

MACS491. UNDERGRADUATE RESEARCH (I) Individual investigation under the direction of a department faculty member. Written report required for credit. Prerequisite: Consent of Department Head. 1 to 3 semester hours, no more than 6 in a degree program.

MACS492. UNDERGRADUATE RESEARCH (II) Individual investigation under the direction of a department faculty member. Written report required for credit. Prerequisite: Consent of Department Head. 1 to 3 semester hours, no more than 6 in a degree program.

MACS498. 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.

MACS499. 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.

## **The Guy T. McBride, Jr. Honors Program in Public Affairs for Engineers**

HNRS101A. PARADOXES OF THE HUMAN CONDITION (II) Study of the paradoxes in the human condition expressed in significant texts in classics, literature, moral philosophy, and history (HNRS101A); drama and music, both classical and contemporary (HNRS101B); or history, biography, and fiction (HNRS101C). The seminar will encourage a value-oriented approach to the texts. Prerequisite: Freshman status in the McBride Honors Program. 3 hours seminar; 3 semester hours.

HNRS200A. 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: Sophomore status in the McBride Honors Program. 3 hours seminar; 3 semester hours.

HNRS201A. COMPARATIVE POLITICAL AND ECONOMIC SYSTEMS (II) 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. Prerequisites: Sophomore status in the McBride Honors Program; HNRS101, HNRS200 or permission of instructor. 3 hours seminar; 3 semester hours.

HNRS300A. 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. Prerequisites: EBGN201, HNRS201. 3 hours seminar; 3 semester hours.

HNRS300B. TECHNOLOGY AND SOCIO-ECONOMIC CHANGE (I) 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. 3 hours seminar; 3 semester hours.

HNRS301A. 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 analyses of public policy, and will understand the process and how they may become involved in it. Students may spend spring break in Washington, D.C., as part of this seminar. 3 hours seminar; 3 semester hours.

HNRS301B FOREIGN AREA STUDY (II) 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 to be studied will be 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 will be expected to take a brief intensive language course before departure. 3 hours seminar; 3 semester hours.

HNRS400A. MCBRIDE PRACTICUM (SUMMER) 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 Principal Tutor. All students completing a practicum are expected to keep an extensive journal and write a professional report detailing, analyzing, and evaluating their experiences. 3 hours seminar; 3 semester hours.

HNRS401A. STUDY OF LEADERSHIP AND POWER (I) 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. 3 hours seminar; 3 semester hours.

HNRS402A. SCIENCE, TECHNOLOGY, AND ETHICS (II) 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. Literature is used as case studies to illustrate these themes and to bring them home personally to students. 3 hours seminar; 3 semester hours.

## **Metallurgical and Materials Engineering**

### **Freshman Year**

MTGN198. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS 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. 1 to 3 semester hours.

MTGN199. INDEPENDENT STUDY (I, II) 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.

### **Sophomore Year**

MTGN272. MATERIALS ENGINEERING (S) Field session. Relationship of atomic structure and bonding to mechanical, thermal, electrical and magnetic properties of organic, ceramic, polycrystalline rock and metallic materials. Materials selection and applications to a variety of engineering problems. Some laboratory work and industry visits will be included. Prerequisites: DCGN209 and PHGN200/210. 3 weeks; 3 semester hours.

MTGN298. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING (I, II) 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: Instructor consent. 1 to 3 semester hours.

MTGN299. INDEPENDENT STUDY (I, II) 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.

### **Junior Year**

MTGN300. FOUNDRY METALLURGY (II) Design and metallurgical aspects of casting, patterns, molding materials and processes, solidification processes, risering 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. 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 MTGN272 or MTGN212. 3 hours lecture, 3 hours lab; 4 semester hours.

MTGN331. PARTICULATE MATERIALS PROCESSING (I) Characterization and production of particles. Physical and interfacial phenomena involved in particulate processes. Applications to metal and ceramic powder processing. Prerequisite: DCGN209. 3 hours lecture; 3 semester hours.

MTGN334. 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 will be presented within the framework of a formalism which will examine the necessary physical chemistry, thermodynamics, reaction mechanisms, and kinetics inherent to a wide selection of chemical-processing systems. Since the formalism is general the course will develop the knowledge required for its application to other systems not specifically covered in the course. Prerequisite: MTGN351. 3 hours lecture; 3 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.

MTGN348. MICROSTRUCTURAL DEVELOPMENT (II) (WI) An 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 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. Predictions of phase stabilities. Thermodynamic principles of phase diagrams in material systems, defect equilibrium and interactions. Prerequisite: DCGN209. 4 hours lecture; 4 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. 2hours lecture; 2 semester hours.

MTGN390/EGGN390. MATERIALS AND MANUFACTURING PROCESSES (I,II,S) 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 and MTGN212. 3 hours lecture; 3 semester hours.

MTGN398. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING (I, II) 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.

MTGN399. INDEPENDENT STUDY (I, II) 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.

#### **Senior Year**

MTGN403. SENIOR THESIS (I,II) Two semester individual research under the direction of members of the Metallurgical and Materials Engineering staff. 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 the Head of Department. 6 semester hours (3 hours per semester).

MTGN412/MLGN512. CERAMIC ENGINEERING (II) Application of engineering principles to nonmetallic and ceramic materials. Processing of raw materials and production of ceramic bodies, glazes, glasses, enamels, and cermets. 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 are included. Prerequisites: MTGN 311, MTGN 331, and MTGN 412/MLGN 512 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 convertors, magnetic materials and integrated circuits. Prerequisites: PHGN200, MTGN311 or MLGN501, MTGN412/MLGN512, 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 to explain 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) An 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: MTGN331. 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. Prerequisite: MTGN422 or consent of instructor. 3 hours lab; 1 semester hour.

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) Physical and chemical principles involved in 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, MTGN433 or consent of instructor. 2 hours lecture; 2 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 considerations. Prerequisite: MTGN334. 3 hours lecture; 3 semester hours.

MTGN433. HYDRO- AND ELECTRO-METALLURGY LABORATORY (I) Experiments designed to supplement the lectures in MTGN431. Co-requisite: MTGN431 or consent of instructor. 3 hours lab; 1 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. Prerequisite: MTGN436 or consent of instructor. 3 hours lab; 1 semester hour.

MTGN442. ALLOYING AND PHASE STABILITY (II) Phase equilibrium of solid solutions, primary and intermediate phases, binary and ternary phase equilibrium diagrams, multi-component systems. Phase transformations in ferrous alloys, hardenability, heat treatment, surface modification, alloying of steel, precipitation alloys and alloy design for cast irons, stainless steels, and tool steels. 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 hour-credit graduate-course in the Materials Science Program (ML) and a 4 hour-credit undergraduate-course in the MTGN program.

MTGN450/MLGN550. STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS(I) An introduction to statistical process control, process capability analysis and experimental design techniques. Statistical process control theory and techniques will be developed and applied to control charts for variables and attributes involved in process control and evaluation. Process capability concepts will be developed and applied for the evaluation of manufacturing processes. The theory and application of designed experiments will be developed and applied for full factorial experiments, fractional factorial experiments, screening experiments, multilevel experiments and mixture experiments. Analysis of designed experiments will be carried out by graphical and statistical techniques. Computer software will be utilized 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 protection 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 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: MTGN311, MTGN331,

MTGN348, MTGN351. 3 hours lecture; 3 semester hours

**MTGN453. PRINCIPLES OF INTEGRATED CIRCUIT PROCESSING (I)** An 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: MACS315, MTGN351 and MTGN352. 2 hours lecture, 3 hours lab; 3 semester hours.

**MTGN463. POLYMER ENGINEERING (I)** Introduction to the structure and properties of polymeric materials, their deformation and failure mechanisms, and the design and fabrication of polymeric end items. Molecular and crystallographic structures of polymers will be developed and related to the elastic, viscoelastic, yield and fracture properties of polymeric solids and reinforced polymer composites. Emphasis on forming and joining techniques for end-item fabrication including: extrusion, injection molding, reaction injection molding, thermoforming, and blow molding. The design of end-items in relation to: materials selection, manufacturing engineering, properties, and applications. Prerequisite: Consent of instructor. 3 hours lecture; 3 semester hours.

**MTGN464. FORGING AND FORMING (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 EGGN390. 2 hours lecture; 3 hours lab, 3 semester hours

**MTGN466. MATERIALS DESIGN: SYNTHESIS, CHARACTERIZATION AND SELECTION (II) (WI)** The application of fundamental materials engineering principles to the design of systems for extraction and synthesis, and to the selection of materials. Systems covered may range from those used for metallurgical processing to those used for processing of emerging materials. Microstructural design, characterization and properties evaluation will link the synthesis to applications. Selection criteria may include 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 may include mature and emerging metallic, ceramic and composite systems used in the manufacturing and fabrication industries. Design activities will be conducted by teams of students. Oral and written reports will be required. Prerequisite: MTGN331, MTGN334, and MTGN348. 1 hour lecture, 6 hours lab; 3 semester hours.

**MTGN475. METALLURGY OF WELDING (I)** Introduction to welding processes thermal aspects; metallurgical evaluation of resulting microstructures; attendant phase transformations; selection of filler metals; stresses; stress relief and annealing; preheating and post heating; distortion and defects; welding ferrous and nonferrous alloys; 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. Prerequisite: MTGN475. 3 hours lab; 1 semester hour.

**MTGN498. SPECIAL TOPICS IN METALLURGICAL AND MATERIALS ENGINEERING (I, II)** 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.

**MTGN499. INDEPENDENT STUDY (I, II)** Independent advanced-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.

## **Military Science (AROTC)**

### **Freshman Year**

\*Indicates courses that may be used to satisfy PAGN semester requirements.

\*MSGN103. ADVENTURES IN LEADERSHIP I (I) Development of individual skills necessary to become an effective small group leader. Training is challenging and encompasses a wide variety of skills. A major emphasis is placed on map reading and land navigation principals, including use of the lensatic compass, terrain interpretation, intersection, resection, and magnetic declination. Cadets also receive training in marksmanship, physical training (PT), and military drill, and the Army organization. Lab Fee. 1 hour lecture, 2 hours lab, 1 hour PT, and 80 hours field training; 2 semester hours.

\*MSGN104. ADVENTURES IN LEADERSHIP II (II) Continuation of MSGN103 training with increased emphasis on leadership. Training also includes small unit tactics, and First Aid training. Lab Fee. 1 hour lecture, 2 hours lab, 1 hour PT, and 80 hours field training; 2 semester hours.

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: Instructor consent. Variable credit; 1 to 6 credit hours.

MSGN199. 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.

### **Sophomore Year**

\*MSGN203. ADVENTURES IN LEADERSHIP III (I) Continues the development of those individual skills taught in MSGN103 and 104. Increased emphasis on the role of the Leader/Trainer. Cadets receive training in First Aid. As with MSGN103, the majority of the training is in the field. Lab Fee. 1 hour lecture, 2 hours lab and 80 hours field training; 2 semester hours.

\*MSGN204. ADVENTURES IN LEADERSHIP IV (II) In this course emphasis is on development of leadership skills necessary in a small group environment. Students are trained in the mechanics of small unit tactics, the required to perform in various leadership positions. Cadets take an increased role in the planning and execution of cadet activities. Lab Fee. 1 hour lecture, 2 hours lab, 1 hour PT, and 80 hours field training; 2 semester hours.

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: Instructor consent. Variable credit; 1 to 6 credit hours.

### **Junior Year**

MSGN301. APPLIED PRINCIPLES OF LEADERSHIP AND COMMAND I (I) An introduction to the organization of the U.S. Army in the field. Application of leadership principles in the command environment emphasizing motivation, performance counseling, group development, ethics, and attention to detail. Lab Fee. Prerequisite: Enrollment in the AROTC Advanced Course or consent of department. 3 hours lecture; 3 semester hours.

MSGN302. APPLIED PRINCIPLES OF LEADERSHIP AND COMMAND II (II) The theory and practice of small unit tactical operations to include small unit tactics, military problems analysis, communications techniques, and troop leading procedures. Prerequisite: Enrollment in the AROTC Advanced Course or consent of department. Lab Fee. 3 hours lecture; 3 semester hours.

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: Enrollment in the AROTC Advanced Course or consent of department. Lab Fee. 2 hours lab, 1 hour PT, 80 hours field training; .5 semester hour.

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: Enrollment in the ROTC Advanced Course or consent of department. Lab Fee. 2 hours lab, 1 hour PT, 80 hours field training; .5 semester hour.

ADVANCED CAMP (Fort Lewis, WA) A six (6) week Advanced Camp is required for completion of the AROTC

program. The camp should be attended between the junior and senior year. The emphasis at Advanced Camp 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 camp period. The U.S. Army reimburses students for travel to and from Advanced Camp. In addition, students receive approximately \$600.00 pay while attending camp. Prerequisite: Enrollment in the AROTC Advanced Course and successful 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: Instructor consent. Variable credit; 1 to 6 credit hours.

MSGN399. 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.

### **Senior Year**

MSGN401. ETHICS, PROFESSIONALISM, AND MILITARY JUSTICE (I) An introduction to military ethics and professionalism with emphasis on the code of the officer. A study of military justice and its application to military life. Orientation to Army administrative, training, and logistics systems. Pre-commissioning orientation. Prerequisite: Enrollment in the AROTC Advanced Course or consent of department. 3 hours lecture; 3 semester hours.

MSGN402. THE AMERICAN MILITARY EXPERIENCE (II) A study of the history of the United States military in order to better understand the role played by the armed forces in American society today through a study of the origins and development of military policy, organization and technology; relating these to political, social and economic development during this period.

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. Lab Fee. Prerequisite: Enrollment in the AROTC Advanced Course or consent of department. 2 hours lab, 1 hour PT, and 80 hours field training; .5 semester hour.

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: Enrollment in the AROTC Advanced Course or consent of department. Lab Fee. 2 hours lab, 1 hour PT, and 80 hours field training; .5 semester hour.

MSGN497. SPECIAL STUDIES IN LEADERSHIP AND 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: Instructor consent. Variable credit; 1 to 6 credit hours.

MSGN499. 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.

### **(AFROTC)**

AFAS100. AFROTC P/T .5 hours

AFAS101. THE AIR FORCE TODAY I This course deals with the US Air Force in the contemporary world through a study of the total force structure, strategic offensive and defensive forces, general purpose forces, aerospace support forces, and the development of communicative skills. 1 hour lecture, 1.5 hours lab; 1.5 semester hour.

AFAS102. THE AIR FORCE TODAY II A continuation of The Air Force Today I. 1 hour lecture, 1.5 hours lab; 1.5 semester hour.

AFAS103. DEVELOPMENT OF AIR POWER I One 1-hour lecture and one 1.5 hour lab per week. This course is designed to examine general aspects of air and space power through a historical perspective. Utilizing this perspective, the course covers a time period from the first balloons and dirigibles to the space-age global positioning systems of the Persian Gulf War. Historical examples are provided to extrapolate the development of Air Force capabilities (competencies), and missions (functions) to demonstrate the evolution of what has become today's USAF air and space power. Furthermore, the course examines several fundamental truths associated with war in the third dimension: e.g.,



Principles of War and Tenets of Air and Space Power. As a whole, this course provides the students with a knowledge level understanding for the general element and employment of air and space power, from an institutional doctrinal and historical perspective. In addition, the students will continue to discuss the importance of the Air Force Core Values with the use of operational examples and historical Air Force leaders and will continue to develop their communication skills. Leadership Laboratory is mandatory for AFROTC cadets and complements this course by providing cadets with followership experiences. 1 hour lecture, 1.5 hours lab; 1.5 semester hours.

AFAS104. DEVELOPMENT OF AIR POWER II A continuation of DEVELOPMENT OF AIR POWER I. One 1-hour lecture and one 1.5 hour lab per week; 1.5 semester hours.

AFAS105. AIR FORCE MANAGEMENT AND LEADERSHIP I Two 1.5 hour seminars and one 1.5 hour lab per week. This course is a study of leadership, management fundamentals, professional knowledge, Air Force personnel and evaluation systems, leadership ethics, and communication skills required of an Air Force junior officer. Case studies are used to examine Air Force leadership and management situations as a means of demonstrating and exercising practical application of the concepts being studied. A mandatory Leadership Laboratory complements this course by providing advanced leadership experiences in officer-type activities, giving students the opportunity to apply leadership and management principles of this course. 3 hours lecture, 1.5 hours lab; 3.5 semester hours.

AFAS106. AIR FORCE MANAGEMENT AND LEADERSHIP II A continuation of AIR FORCE MANAGEMENT AND LEADERSHIP I. Two 1.5 hour seminars and 1.5 hour lab per week. 3 hours lecture, 1.5 hours lab; 3.5 semester hours.

AFAS107. NATIONAL SECURITY FORCES IN CONTEMPORARY AMERICAN SOCIETY I. Two 1.5 hour seminars and one 1.5 hour lab per week. This course examines the national security process, regional studies, advanced leadership ethics, and Air Force doctrine. Special topics of interest focus on the military as a profession, officership, military justice, civilian control of the military, preparation for active duty, and current issues affecting military professionalism. Within this structure, continued emphasis is given to refining communication skills. A mandatory Leadership Laboratory complements this course by providing advanced leadership and management principles of this course. 3 hours lecture, 1.5 hours lab; 3.5 semester hours.

## **Mining Engineering**

### **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.

MNGN199. 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.

### **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.

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.

MNGN300. SUMMER FIELD SESSION (S) Introduction to and use of the department's computing system, as well as the application of various computer-aided mine design software packages incorporated in upper-division mining courses. Classroom and field instruction in the theory and practice of surface and underground mine surveying. First, third and fifth weeks of the course are taught in the department's computing laboratory on the CSM campus. Second and fourth weeks of the course are taught at the CSM Experimental Mine located in Idaho Springs, CO (20 miles west of Golden). The course begins with the start of the first field session and continues for five weeks. Prerequisite: Completion of Sophomore Year; Duration: First five weeks of summer term. 5 semester hours.

MNGN317. STATICS/DYNAMICS (I) For non-Engineering Division majors only. Forces, moments, couples, equilibrium, centroids, moments of inertia and friction. Absolute and relative motions, kinetics, work-energy, impulse-momentum and angular impulse-momentum. Prerequisite: PHGN100/110 Corequisite: MACS213/223. 4 hours lecture; 4 semester hours.

### **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. Should be taken concurrently with MNGN309.

MNGN309. MINING ENGINEERING LABORATORY (I) 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. 2 semester hours. Should be taken concurrently with MNGN308.

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 and sequencing and 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; layout of auxiliary systems such as ventilation and haulage; 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, 2 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.

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.

MNGN399. 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.

### **Senior Year**

MNGN314. UNDERGROUND MINE DESIGN (I) Selection, design, and development of most suitable underground mining methods based upon the physical and the geological properties of mineral deposits (metallics and nonmetallics), conservation considerations, and associated environmental impacts. Reserve estimates, development and production planning, engineering drawings for development and extraction, underground haulage systems, and cost estimates. Prerequisite: MNGN210 and MNGN300. 2 hours lecture, 3 hours lab; 3 semester hours.

MNGN322. INTRODUCTION TO MINERAL PROCESSING (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, MACS213/223. 3 hours lecture; 3 semester hours.

MNGN323. INTRODUCTORY MINERAL PROCESSING LABORATORY (I) Experiments and assignments to accompany MTGN322. Hands-on experience includes crushing, grinding, sizing, particle-size-determination, magnetic separation, gravity concentration, coal analysis, flotation and circuit analysis. Prerequisite: MTGN322 or concurrent enrollment. 3 hours lab; 1 semester hour.

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: MNGN210, MNGN314. 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: EGGN320 or concurrent enrollment. 3 hours lecture; 3 semester hours. Offered in odd years.

**MNGN414. MINE PLANT DESIGN (I)** Analysis of mine plant elements with emphasis on design. Materials handling systems, dewatering, hoisting, compressed air, and other power systems. Prerequisite: EGGN351 and DCGN381. 2 hours lecture, 3 hours lab; 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: SYGN101, credit or concurrent enrollment in EGGN320. 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. Corequisite: MNGN421 or consent of instructor. 3 hours lab; 1 semester hour.

**MNGN424. MINE VENTILATION (II)** Fundamentals of mine ventilation, including control of gas, dust, temperature, and humidity; stressing analysis and design of systems. Prerequisite: EGGN351, EGGN371 and MNGN314. 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 consent of instructor. 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. 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 and evaluation. 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: consent of instructor. 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: MACS323 or equivalent course in statistics; 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 consent of instructor. 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 consent of instructor permitted. 3 hours lecture, 3 hours lab; 3 semester hours.

MNGN438. INTRODUCTION TO GEOSTATISTICS(I) Introduction to the application and theory of geostatistics in the mining industry. Review of elementary statistics and traditional estimations techniques. Variograms, estimation variance, block variance, kriging, and geostatistical concepts are presented. Prerequisite: MACS323 or equivalent. 1 hour lecture, 3 hours lab; 2 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.

MNGN445. OPEN PIT SLOPE DESIGN (II) Introduction to the analysis and design of optimal pit slopes. Topics include: economic aspects of slope angles, rock mass classification and strength determinations, geologic structural parameters, properties of fracture sets, data collection techniques, hydrologic factors, methods of analysis, macrofab analysis, wedge intersections, monitoring and maintenance of final pit slopes, classification of slides. Prerequisite: MNGN321, GEOL308 or 309. 2 hours lecture; 2 semester hours.

MNGN446. SLOPE DESIGN LABORATORY (II) Laboratory and field exercise in slope analysis and design. Collection of data and specimens in the field for laboratory determination of physical properties for determination of slope angle stability. Application of computer software to slope stability determination for hard and soft rock environments. Prerequisite: MNGN321 and credit or concurrent registration in MNGN445. 3 hours lab; 1 semester hour.

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, MNGN318, MNGN322, MNGN323, or consent of instructor. 3 hours lecture; 3 semester hours. Offered in spring.

MNGN482. MINE MANAGEMENT (II) Basic principles of successful mine management, supervision, administrative policies, industrial and human engineering. Prerequisite: Senior or graduate status or consent of instructor. 2 hours lecture; 2 semester hours. Offered in odd years.

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 consent. Variable credit; 1 to 6 credit hours.

MNGN499. 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.

## **Petroleum Engineering**

### **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. 2 hours lecture; 2 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.

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.

### **Sophomore Year**

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.

PEGN308. RESERVOIR ROCK PROPERTIES (II) (WI) Introduction to basic reservoir rock and fluid properties and their measurements. Topics include fluid flow in porous media, capillary pressure, compressibility, phase behavior of multi-component hydrocarbon systems, and pressure-volume-temperature calculations of reservoir fluids. Prerequisites: DCGN241. 2 hours lecture, 4.5 hours lab; 3.5 semester hours.

### **Junior Year**

PEGN310. RESERVOIR FLUID PROPERTIES (I) Properties of fluids encountered in petroleum engineering. Phase behavior, density, viscosity, interfacial tension, composition of oil, gas, and brine systems. Interpret lab data for engineering applications. Flash calculations with k-values and equations of state. Introduction to reservoir simulation software. Prerequisites: DCGN209, PEGN308. 2 hours lecture; 4.5 hours lab; 3.5 semester hours.

PEGN311. DRILLING ENGINEERING (I) (WI) Study of drilling fluid design, rig hydraulics, drilling contracts, rig selection, rotary system, blowout control, bit selection, drill string design, directional drilling, and casing seat selection. Prerequisite: PEGN315, DCGN241, EGGN351. 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. Prerequisites: PEGN308. 2 semester hours.

PEGN316. SUMMER FIELD SESSION II (S) This two-week course is taken after the completion of the junior year. An intensive on-site study of the Rangely Oil Field is undertaken. Emphasis is placed on the multidisciplinary nature of reservoir management. Field trips in the area provide the opportunity to study eolian, fluvial, lacustrine, near shore, and marine depositional systems. These field trips provide the setting for understanding the complexity of each system in the context of reservoir development and management. Petroleum systems including the source, maturity, and trapping of hydrocarbons are studied in the context of petroleum exploration and development. Geologic methods incorporating both surface and subsurface data are used extensively. Prerequisite: PEGN315, PEGN361, PEGN411, PEGN419 and GEOL308, 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.

PEGN361. COMPLETION ENGINEERING (II) This class is a continuation from drilling in PEGN311 into completion operations. Topics are casing design, cement planning, completion techniques and equipment, tubing design, wellhead selection, and sand control, and perforation procedures. Surface facility design for oil and gas systems include separator design, dehydration, and compression. Prerequisite: PEGN311, 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.

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.

PEGN408/EGES408. INTRODUCTION TO OFFSHORE TECHNOLOGY (II) Introduction to offshore technology for exploration drilling, production and transportation of petroleum in the ocean. Practical analysis methods for determining environmental forces, structural response, and pipe flow for the design of platforms, risers, subsea completion and pipeline systems, including environment-hydrodynamic-structure interactions. System design parameters. Industrial practice and state-of-the-art technology for deep ocean drilling. Prerequisite: MACS315 or consent of instructor. 3 hours lecture; 3 semester hours.

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. Prerequisite: PEGN308, PEGN310, PEGN311, and

EGGN351. 3 hours lecture; 3 semester hours.

PEGN419. 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, 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. Prerequisites: PEGN308, PEGN310, PEGN419. 6 hours lab; 2 semester hours.

PEGN414. WELL TEST ANALYSIS AND DESIGN (II) 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. 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, state and local taxes, federal income taxes, expected value concept, decision trees, gambler's ruin, and monte carlo simulation techniques. Prerequisite: MACS323. 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. Prerequisite: PEGN316, PEGN419 and MACS315 (MACS315 only for non PEGN 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. Perforating, sand control, skin damage associated with completions, and well productivity. Fluid types and properties; characterizations of compatibilities. Stimulation techniques; acidizing and fracturing. Selection of proppants and fluids; types, placement and compatibilities. Estimation of rates, volumes and fracture dimensions. Reservoir considerations in fracture propagation and design. Prerequisite: PEGN311, PEGN361, PEGN411 and MACS315. 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. Prerequisite: PEGN311, PEGN361. 3 hours lecture; 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. Prerequisite: PE Majors: GEOL308, PEGN316, PEGN422, PEGN423. Concurrent enrollment in PEGN414 and PEGN424; GE Majors: GEOL308 or GEOL309, GEGN438, GEGN316; GP Majors: GPGN302 and GPGN303. 2 hours lecture; 3 hours lab; 3 semester hours.

PEGN481. PETROLEUM SEMINAR (I) (WI) Written and oral presentations by each student on current petroleum topics. Prerequisite: Consent of instructor. 2 hours lecture; 2 semester hours.

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.

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.

## Physical Education and Athletics

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 provide 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 one of several special activities listed below. Approved transfer credit may be substituted for the following classes:

PAGN205 through PAGN236. (Students enrolling in these courses may be required to furnish their own equipment.) Prerequisite: PAGN101 or PAGN102 or consent of Department Head. 2 hours activity; .5 semester hour.

PAGN205A. MARTIAL ARTS  
PAGN205B&C. YOGA  
PAGN209. BEGINNING GOLF (I)  
PAGN210. BEGINNING GOLF (II)  
PAGN211A. WOMEN'S RACQUETBALL  
PAGN211B. BEGINNING RACQUETBALL  
PAGN215. TENNIS (I)  
PAGN216. TENNIS (II)  
PAGN217. CO-ED WEIGHT TRAINING (I)  
PAGN218. CO-ED WEIGHT TRAINING (II)  
PAGN221. BADMINTON (I)  
PAGN235. AEROBICS (I)  
PAGN236. AEROBICS (II)  
PAGN301A INTERMEDIATE BASKETBALL  
PAGN301B INTERMEDIATE VOLLEYBALL

### *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. Note: All courses shown below, numbered 151 to 182 inclusive are likewise offered as junior, and senior courses. For freshmen and sophomores, they are numbered 151 to 182; juniors and seniors, 351 to 382. Odd numbered courses are offered in the fall, even numbered courses in the spring.

PAGN151. BASEBALL (I)  
PAGN152. BASEBALL (II)  
PAGN153. BASKETBALL (I) A-men; B-women  
PAGN154. BASKETBALL (II) A-men; B-women  
PAGN157. CROSS COUNTRY (I)  
PAGN159. FOOTBALL (I)  
PAGN160. FOOTBALL (II)  
PAGN161. GOLF (I)  
PAGN162. GOLF (II)  
PAGN167. SOCCER (I)  
PAGN168. SOCCER (II)  
PAGN169. SWIMMING (I)  
PAGN170. SWIMMING (II)  
PAGN171. TENNIS (I)  
PAGN172. TENNIS (II)  
PAGN173. TRACK (I)  
PAGN174. TRACK (II)  
PAGN175. WRESTLING (I)  
PAGN176. WRESTLING (II)  
PAGN177. VOLLEYBALL (I)  
PAGN178. VOLLEYBALL (II)

PAGN179. SOFTBALL (I)

PAGN180. SOFTBALL (II)

Prerequisite: Consent of department. 1 semester hour.

## 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: MACS111 and concurrent enrollment in MACS112/122 or consent of instructor. 2 hours lecture; 4 hours studio; 4.5 semester hours.

PHGN110. HONORS PHYSICS I - MECHANICS (I, II) A course parallel to Physics 100 but in which the subject matter is treated in greater depth. Registration is restricted to students who are particularly interested in physics and can be expected to show above-average ability. Usually an A or B grade in MACS111/121 is expected. Prerequisite: MACS111 and concurrent enrollment in MACS112/122 or consent of instructor. 2 hours lecture; 4 hours studio; 4.5 semester hours.

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.

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.

### 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: PHGN100/110, concurrent enrollment in MACS213/223. 3 hours lecture; 1 hours recitation; 1.5 hours lab; 4.5 semester hours.

PHGN210. HONORS PHYSICS II-ELECTROMAGNETISM AND OPTICS (I, II) A course parallel to PHGN200 but in which the subject matter is treated in greater depth. Registration is restricted to students who show particular interest and ability in the subject of physics. Usually an A or B grade in PHGN110 or an A grade in PHGN100 is expected.

Prerequisite: PHGN100/110, concurrent enrollment in MACS213/223. 3 hours lecture; 1 hour recitation; 1.5 hours lab; 4.5 semester hours.

PHGN217 ANALOG ELECTRONICS AND INSTRUMENTATION LABORATORY (II) Introduction to methods of electronic measurements, particularly the application of oscilloscopes and computer based data acquisition. Laboratory experiences in the use of basic electronic devices for physical measurements. Topics covered include diodes, transistors (FET and BJT), operational amplifiers, filters, transducers, and integrated circuits. Emphasis on practical knowledge, including prototyping, troubleshooting, and laboratory notebook style. Prerequisite: DCGN381 or concurrent enrollment. 3 hours lab; 1 semester hour.

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.

### Junior Year

PHGN300. PHYSICS III-MODERN PHYSICS I (I, II, S) The third course in introductory physics for scientists and engineers including an introduction to the special theory of relativity, wave-particle duality, the Schroedinger equation, electrons in solids, nuclear structure and transmutations. Prerequisite: PHGN200/210; Concurrent enrollment in MACS315. 3 hours lecture; 3 semester hours.

PHGN310. HONORS PHYSICS III-MODERN PHYSICS (II) A course parallel to PHGN300 but in which the subject matter is treated in greater depth. Registration is strongly recommended for physics majors or those considering the physics option, but is not required. Prerequisite: PHGN200/210 and concurrent enrollment in MACS315 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, MACS315, and PHGN384 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. 3 hours lab; 1 semester hour.



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: DCGN381 and PHGN217 or EGGN250, or consent of instructor. 2 hours lecture, 3 hours lab; 3 semester hours.

PHGN320 MODERN PHYSICS II: BASICS OF QUANTUM MECHANICS (II) Introduction to the Schrodinger theory of quantum mechanics. Topics include Schrodinger'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 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: PHGN200/210. 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. 3 hours lab; 1 semester hour.

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.

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 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: PHGN200/210. 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: PHGN200/210 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, DCGN381 and PHGN217 or EGGN250. Available in 4 or 6 credit hour blocks in the summer field 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.

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.

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.

### Senior Year

PHGN402. GREAT PHYSICISTS (II) The lives, times, and scientific contributions of key, historical physicists are explored in an informal seminar format. Each week a member of the faculty will lead discussions about one or more different scientists who have figured significantly in the development of the discipline. Prerequisite: None. 1 hour lecture; 1 semester hour.

PHGN404. PHYSICS OF THE ENVIRONMENT (II) An examination of several environmental issues in terms of the fundamental underlying principles of physics including energy conservation, conversion and generation; solar energy; nuclear power and weapons, radioactivity and radiation effects; aspects of air, noise and thermal pollution. Prerequisite: PHGN200/210 or consent of instructor. 3 hours lecture; 3 semester hours.

PHGN412. MATHEMATICAL PHYSICS (I) Mathematical techniques applied to the equations of physics; complex variables, partial differential equations, special functions, finite and infinite- dimensional vector spaces. Green's functions. Transforms; computer algebra. Prerequisite: PHGN311. 3 hours lecture; 3 semester hours.

PHGN419. PRINCIPLES OF SOLAR ENERGY SYSTEMS(II) Theory and techniques of insolation measurement. Absorptive and radiative properties of surfaces. Optical properties of materials and surfaces. Principles of photovoltaic devices. Optics of collector systems. Solar energy conversion techniques: heating and cooling of buildings, solar thermal (power and process heat), wind energy, ocean thermal, and photovoltaic. Prerequisite: PHGN300/310 and MACS315.

PHGN420. QUANTUM MECHANICS (I) Schroedinger equation, uncertainty, change of representation, one-dimensional problems, axioms for state vectors and operators, matrix mechanics, uncertainty relations, time-independent perturbation theory, time-dependent perturbations, harmonic oscillator, angular momentum. Prerequisite: PHGN320 and PHGN350. 3 hours lecture; 3 semester hours.

PHGN421. ATOMIC PHYSICS (II) Introduction to the fundamental properties and structure of atoms. Applications to hydrogen-like atoms, fine-structure multielectron atoms, and atomic spectra. Prerequisite: PHGN320. 3 hours lecture; 3 semester hours.

PHGN422. NUCLEAR PHYSICS (II) 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: PHGN320. 3 hours lecture; 3 semester hours.

PHGN423. DIRECT ENERGY CONVERSION (I) Review of basic physical principles; types of power generation treated include fission, fusion, magnetohydrodynamic, thermoelectric, thermionic, fuel cells, photovoltaic, electrohydrodynamic piezoelectrics. Prerequisite: PHGN300/310. 3 hours lecture; 3 semester hours.

PHGN424. ASTROPHYSICS (I) 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: PHGN320. 3 hours lecture; 3 semester hours.

PHGN435/ChEN435. 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, CRGN, MTGN, or EGGN. Consent of instructor. 1.5 hours lecture, 4 hours lab; 3 semester hours.

PHGN440/MLGN502. SOLID STATE PHYSICS (I) 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: PH320. 3 hours lecture; 3 semester hours.

PHGN441/MLGN522. SOLID STATE PHYSICS APPLICATIONS AND PHENOMENA (II) 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/MLGN502, or equivalent by instructor's permission. 3 hours lecture; 3 semester hours.

PHGN450. COMPUTATIONAL PHYSICS (I) 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.

PHGN460. PLASMA PHYSICS Review of Maxwell's equations; charged-particle orbit in given electromagnetic fields; macroscopic behavior of plasma, distribution functions; diffusion theory; kinetic equations of plasma; plasma oscillations and waves, conductivity, magnetohydrodynamics, stability theory; Alven waves, plasma confinement. Prerequisite: PHGN300/310. 3 hours lecture; 3 semester hours.

PHGN462. ELECTROMAGNETIC WAVES AND OPTICAL PHYSICS 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 waveguides. 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 (I) (WI) The first of a two-semester program covering the full spectrum of experimental

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 course coordinator and the faculty supervisor. 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, block-diagram electronics, computer data acquisition and/or analysis, sample materials, and measurement and/or analysis sequences. The course culminates in a senior thesis. Supplementary lectures are given on techniques of physics research and experimental design.

Prerequisite: PHGN384 and PHGN326. 1 hour lecture, 6 hours lab; 3 semester hours.

PHGN472. SENIOR DESIGN (II) (WI) Continuation of PHGN471. Prerequisite: PHGN384 and PHGN326. 1 hour lecture, 6 hours lab; 3 semester hours.

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.

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.

## *Section 7 - Centers and Institutes*

### **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 materials. The laboratory is supported by an industrial consortium that holds semi-annual meetings 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 National Science Foundation (NSF), 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 with special emphasis on the advanced/intelligent control and power quality in the generation, transmission, distribution, and utilization; using such research as a means of advancing graduate education.

Center research projects focus on the development of an intelligent energy system that will employ advanced power electronics, enhanced computer and communications systems, new smart sensor and actuators, and smart interactive utility/customer interface systems. Examples include development of intelligent substations, impact of highly varying loads, e.g. arc furnaces, on power quality, localized and adaptive monitoring systems for transmission and distribution networks, and intelligent automatic generation control for transient loads.

Due to the strong interest shown by other institutions and national and international utilities, ACEPS has been transformed into an NSF Mega-Center which includes twelve other universities and more than thirty industrial members. With this expansion, and given the electric power deregulation phase, the power center has become a key national resource for the Research & Development (R&D) needs of this major industrial sector.

### **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.

### **Center for Automation, Robotics and Distributed Intelligence**

The Center for Automation, Robotics and Distributed Intelligence (CARDI) focuses on the study and application of advanced engineering and computer science research in neural networks, robotics, data mining, image processing, signal processing, sensor fusion, information technology, distributed networks, sensor and actuator development and artificial intelligence to problems in environment, energy, natural resources, materials, transportation, information, communications and medicine. CARDI 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. The systems require closed loop controllers that incorporate artificial intelligence and machine learning techniques to reason autonomously or in cooperation with a human supervisor.

Established in 1994, CARDI includes faculty from the Division of Engineering, departments of Mathematical and Computer Science, Geophysics, Metallurgical and Materials Engineering, and Environmental Science and Engineering. 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 robotics and intelligent systems.

### **Center for Combustion and Environmental Research**

The Center for Combustion and Environmental Research (CCER) is an interdisciplinary research and educational unit specializing in the chemistry and physics of exothermic reacting flows. Specific research projects are varied, but they fall into five core areas: detailed combustion chemical kinetic modeling and experiment; combustion flow-field modeling and experiment; combustion spray and aerosol modeling and experiment; optical sensing techniques in combustion; and combustion emissions remediation.

Collaborative projects involve CSM's Engineering Division and Chemical Engineering and Petroleum Refining Department, and often include faculty and students from other universities. Interaction with federal and industrial sponsors not only helps to guide the Center's program, but offers students opportunities after graduation.

### **Center for Commercial Applications of Combustion in Space**

The Center for Commercial Applications of Combustion in Space (CCACS) is a NASA/Industry/ University space commercialization center based at the Colorado School of Mines. The mission of the Center is to assist industry in developing commercial products by conducting combustion research which takes advantage of the unique properties of space.

The Center operates under the auspices of NASA's Office of Space Product Development (OSPD), whose mission is to provide access to space for commercial research and development activities by private industry. The focus of CCACS is on products and processes in which combustion plays a key role and which can benefit from knowledge to be gained through experiments conducted in space. Examples include combustors, fire suppression and safety, combustion synthesis of advanced materials and sensors and controls. The Center involves faculty and students from the departments of Chemical Engineering, Engineering, Metallurgical and Materials Engineering, and Physics. For further information, contact CCACS Director F.D. Schowengerdt, Physics Department, CSM, (303) 384-2091.

### **Center for Engineering Education**

The CSM Center for Engineering Education marries educational research with assessment, outreach and teaching. The Center serves as a focal point for educational research conducted by CSM faculty. Successfully educating tomorrow's scientists and engineers 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 educational research, informed by the principles of cognitive and educational psychology, along with the application of that research, and teaching, are linked and interrelated.

The primary goals of the Center for Engineering Education are

- ◆ To conduct world-class research on teaching and learning in science and engineering.
- ◆ To use the results of that research to continually improve 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 and Petroleum Refining, Environmental Sciences and Engineering, Chemistry and Geochemistry, Economics and Business, Mathematics and Computer Science, and Geology and Geological Engineering.

### **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, Rocky Mountain Musculoskeletal Research Laboratories (RMMRL), University of Colorado Health Sciences Center and the Colorado VA Research Center. Established at CSM as a National Science Foundation (NSF) Industry/University Cooperative Research Center, IBDMS is also supported by industry and State organizations.

IBDMS has become an international center for the development of Bionic Orthopaedics, sports medicine, human sensory augmentation, and smart orthoses. Through the efforts of this center, new major and minor programs in bioengineering and biotechnology are being established at both the CSM graduate and undergraduate levels.

With its Industrial Advisory Board (IAB), IBDMS seeks to establish educational programs, 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**

The Center for Research on Hydrates and Other Solids is sponsored by a consortium of fifteen industrial and government entities. The center focuses on research and education involving solids in hydrocarbon and aqueous fluids which affect exploration, production and processing of gas and oil.

Involving over twenty students and faculty from five departments, the center provides a unique combination of expertise that has enabled CSM to achieve international prominence in the area of solids. CSM participants interact on an on-going basis with sponsors, including frequent visits to their facilities. For students, this interaction often continues beyond graduation, with opportunities for employment at sponsoring industries.

### **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 the area of electronic materials for solar and related applications. CSEM facilitates interdisciplinary collaborations across the CSM campus; fosters interactions with national laboratories, industries, public utilities, and other universities; and serves to guide and strengthen the electronic materials curriculum.

CSEM draws from expertise in the departments of Physics, Metallurgical and Materials Engineering, Chemical Engineering, Chemistry and Geochemistry, and from the Division of Engineering. The largest research activity is directed at the photovoltaic industry. CSEM also supports research in thin film materials, polymeric devices, electrophotography, encapsulants, electronic materials processing, and systems issues associated with electronic materials and devices.

Graduate students in materials science and the above-mentioned departments can pursue research on center-related projects. Undergraduates are involved through engineering design courses and summer research. 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 attempt to solve real world problems. External contacts also provide guidance in targeting the educational curriculum toward the needs of the electronic materials industry.

### **Center for Wave Phenomena**

With sponsorship for its research by 28 companies in the worldwide oil exploration industry, this interdisciplinary program, including faculty and students from the Mathematical and Computer Sciences and Geophysics Departments, is engaged in a coordinated and integrated program of research in inverse problems and problems of seismic data processing and inversion. Its methods have applications to seismic exploration, global seismology, ocean sound-speed profiling, and nondestructive testing and evaluation, among other areas. Extensive use is made of analytical techniques, especially asymptotic methods and computational techniques. Methodology is developed through computer implementation, based on the philosophy that the ultimate test of an inverse method is its application to field or experimental data. Thus, the group starts from a physical problem, develops a mathematical model that adequately represents the physics, derives an approximate solution technique, generates a computer code to implement the method, tests on synthetic data, and, finally, tests 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 and the Engineering Division. The goal of CWJCR is to promote 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 in the projects that constitute the Center's research program.

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.

## **Colorado Advanced Materials Institute**

With a mission to coordinate and foster research in materials science and engineering leading to economic development, CAMI was established in 1984 by the State of Colorado at CSM. Located at CSM, the Institute functions as a consortium of state government, research universities (CSM, CU, CSU, and DU), and private industries.

CAMI is funded by the Colorado Commission on Higher Education and has several programs aimed at promoting effective partnerships between Colorado industry and universities. CAMI's Seed Grant program provides grants to faculty for exploratory work on materials technology problems of interest to industry in the state. These seed grants enable investigators to develop subsequent proposals for additional funding from federal and industry sources, thus leveraging the state investment.

The Institute also sponsored an Entrepreneur's Technology Assistance Program that enabled start-up technology-based companies to use the unique expertise and equipment available at the research universities. These grants to university/small business teams were designed to help the entrepreneur develop his new technology into a commercial product or service. Currently CAMI has a similar program, the Colorado Tire Recycle Technology Assistance (Tire-Tap), which promotes development of new technologies focused on recycling the huge amount of scrap tires rapidly accumulating in the state.

CAMI grants are solicited annually with a Request For Proposals (RFP) and subsequently awarded on a competitive basis with reviews from a board of experts from Colorado Corporations, small business, academia, venture capitalists, business incubators and government leaders. These programs all provide an excellent opportunity for undergraduate and graduate students to work on real problems of immediate concern to industry.

## **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 porous ceramics and metals for filters; nano-scale powder preparation and mechanics; ceramic-metal composites; fuel cell, solar cell and battery materials; high temperature gas and plasma corrosion; glass fiber forming; and mechanical properties of thin films. Current projects are supported by both industry and government and several students are performing their research through a collaboration with the National Renewable Energy Laboratory located in Golden. Each project involves research leading to a graduate thesis of a student.

## **Colorado Institute for Fuels and Energy Research**

The Colorado Institute for Fuels and Energy Research (CIFER) is an interdisciplinary research institute involving faculty and students from several academic departments at the Colorado School of Mines. CIFER originally was formed to assist industry, State and Federal governments in developing and implementing clean air policy for the benefit of the U.S. and particularly for high altitude communities through the development of newer, cleaner burning fuels and the technology to properly use fuels.

The overall objective of CIFER is to enhance air quality through research, development and education. Its specific strengths are in fuels science, catalysis, materials, combustion science, thermodynamics and analytical chemistry.

## **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.

## **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.

## **International Ground Water Modeling Center**

The International Ground Water Modeling Center (IGWMC) is an information, education, and research center for ground-water 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 ground-water 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. In support of its information and training activities, IGWMC conducts a program of applied research and development in ground-water modeling.

## **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.

## **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.

### **W.J. Kroll Institute for Extractive Metallurgy**

A grant from the late W.J. Kroll, the inventor of the Kroll Process for the production of Titanium and Zirconium, enabled the establishment of an Institute for Extractive Metallurgy in the Department of Metallurgical and Materials Engineering. Today the primary focus of the Institute is the development of new technologies for the physical-chemical processing of materials. This includes the production and refining of metals, the processing of wastes and hazardous materials, the recycling of materials, and the synthesis of advanced materials. The Institute supports the education of students through the awarding of Fellowships and Research Assistantships, provides opportunities for Visiting Scholars, arranges for the teaching of short courses in subjects related to the mission of the Institute, and undertakes a wide range of sponsored research projects.

## *Section 8 - Services*

### **Arthur Lakes Library**

Arthur Lakes Library is a regional information center for engineering, energy, minerals and materials science, and associated engineering and science fields. The library provides educational and research resources to support and enhance the academic mission of CSM. The library staff is committed to excellence in supporting the information needs of the CSM community and providing access to information for library users.

The library collections include more than 500,000 volumes; approximately 1800 serial titles; over 188,000 maps; archival materials on western mining history and mineral fields; and several special collections. The library is a selective U.S. and Colorado state depository with over 600,000 government publications, including selected NTIS publications.

Access to CSM collections is provided by Catalyst, the on-line public access catalog and a computerized circulation system. Students and faculty also have access to nearly all of the library's electronic resources from any computer on the campus network, including those in networked CSM residential facilities. Dial-up and Internet access is also available from on and off-campus. The library's web page at <http://www.mines.edu/library/> has more information and links to the electronic resources.

Reference resources include specialized printed indexes and several hundred electronic databases. Reference librarians provide instruction and personal help as needed, conduct library research sessions for classes, and provide e-mail and telephone reference service and computer-aided research services.

In addition to material that can be checked out from the CSM library and other associated Colorado libraries, interlibrary loan service provides for efficient use of materials from regional and world-wide libraries.

### **Computing and Networking**

The Computing Center, which is housed on the second floor of the Green Center, provides computing and networking services to meet instructional and research needs and to support the academic mission of the Colorado School of Mines. Computer accounts and services are available to registered students and current faculty members and staff.

Information about services including activation of new accounts and the hours during which the Computing Center is open is available in a brochure which may be picked up at the Front Desk in Room 231 (303-273-3431) and on the Computing Center's web page at <http://www.mines.edu-Academic/computer/>. Problem reports can be made at the Front Desk or emailed to [support@mines.edu](mailto:support@mines.edu).

The campus network provides access to campus computing resources and to the Internet, including email and the World Wide Web. Centrally managed resources include Unix systems which are available 24 hours per day except for occasional maintenance.

Workrooms in the Computing Center contain networked PCs and workstations. Also available are printers, scanners, and digitizers. Academic departments which support specialized applications manage access to computer labs in their buildings. The Arthur Lakes Library has a computer cluster on the main floor of the building. Network



access is also provided in residence halls and Mines Park for students who bring their own computers to campus and modem pools provide access to the network for off-campus residents.

It is important for all users of the Colorado School of Mines computing resources to observe the CSM Policies for Resource Usage (available on the web page or at the Front Desk) and all legal and ethical guidelines for use of those services.

## **Copy Center**

Located on the first floor of Guggenheim Hall, the Copy Center offers on-line binding, printed tabs, and halftones. Printing can be done on all paper sizes from odd-sized originals. Some of the other services offered are GBC and Velo Binding, folding, sorting and 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**

(CSMAA) The Mines Alumni Association has served the Colorado School of Mines and its alumni since 1895. Services and benefits of membership include:

*Mines*, a quarterly publication covering campus and alumni news; an annual directory of all Mines alumni; career counseling and on-line job listings; section activities providing a connection to the campus and other Mines alumni around the world for both social and networking purposes; connections to Mines through invitations to local and annual alumni meetings, reunions, golf tournaments and other special events; awards, including the opportunity to nominate fellow alumni and be nominated yourself; CSM library privileges to Colorado residents; and e-mail forwarding services.

Benefits for the Colorado School of Mines and current students are student grants; the Student Financial Assistance Program; recognition banquets for graduating seniors/graduate students; assistance and support of School events such as Homecoming; alumni volunteer assistance in student recruiting; and programs enabling alumni input in school programming.

For further information, call 303 273-3295, FAX 303 273-3583, e-mail [csmaa@mines.edu](mailto:csmaa@mines.edu), or write Mines Alumni Association, 1600 Arapahoe Street, P.O. Box 1410, Golden, CO 80402-1410.

## **Environmental Health and Safety**

The Environmental Health and Safety (EHS) Department is located in Chauvenet Hall. Five full-time employees in the EHS Department provide a wide variety of services to students, staff and faculty members. Functions of the EHS Department include: hazardous waste collection and disposal; chemical procurement and distribution; assessment of air and water quality; fire safety; general industrial safety; industrial hygiene; health physics; and recycling. The staff of the EHS Department is ready to respond to requests for information and services from parents and students. Please call 303 273-3316.

## **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 700 persons can be accommodated at tables for banquets or dinners. Auditorium seating can be arranged for up to 550 people.

Petroleum Hall and Metals Hall are lecture rooms seating 125 and 330, respectively. Each room has audio visual equipment. In addition, the Green Center houses the modern Computing Center and the Department of Geophysics.

## **INTERLINK Language Center (ESL)**

The INTERLINK Language program at CSM combines intensive English language instruction (ESL) with academic training and cultural orientation. Designed for international students planning to attend CSM or other American universities, the program prepares students for a successful transition to academic work. The curriculum focuses on individual student needs and utilizes hands-on, experiential learning. A special emphasis on English for Engineering and Technology is especially beneficial to prospective CSM students.

Instruction is offered in nine-week sessions at live levels of proficiency. Upon completion of the program, students should be ready for the rigorous demands of undergraduate or graduate study. Successful completion of the program may entitle qualified students to begin their academic studies without a TOEFL score.

The program is open to adults who have completed secondary school in good standing (grade point average of C+ or above) and are able to meet their educational and living expenses. Spouses of CSM students are welcome to apply for admission. For further information contact INTERLINK Language Center (ESL) at

INTERLINK Language Center (ESL)

Colorado School of Mines, Golden, CO 30401  
<http://www.eslus.com>  
<http://www.mines.edu/Outreach/interlink>  
Tele: 303-273-3516  
Fax: 303-273-3529  
Email: [interlinkcsm@mines.edu](mailto:interlinkcsm@mines.edu)

## **LAIS Writing Center**

The LAIS Writing Center, located in room 311 Stratton Hall (phone: 303 273-3085), 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 writers and professional writing instructors. The Center assists students 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.

## **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.

The office works with the departments and divisions of the School to: (1) help develop and facilitate study abroad opportunities for CSM undergraduates and serve as an informational and advising resource for them; (2) assist in attracting new international students to CSM; (3) serve as an information resource for faculty and scholars of the CSM community, promoting faculty exchanges 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, help promote the internationalization of CSM's curricular programs and activities.

OIP is located in 109 Stratton Hall. For more specific information about study abroad and other international programs, contact OIP at 384-2121 or visit the OIP web page.

## **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 and preserve ownership of CSM's intellectual property, and contribute to Colorado's and the nation's economic growth. OTT reports directly to the CSM president, and the office works closely with the Dean of Graduate Studies and Research and the School's Office of Legal Services to coordinate activities. Through its internal technical review team and external business communications 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) Generate a new source of revenue for CSM to expand the school's quality research and education.

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

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 Women in Science, Engineering and Mathematics, Colorado School of Mines, 1500 Illinois, Golden, CO 80401-1869, or call (303) 273-3097; [dlasich@mines.edu](mailto:dlasich@mines.edu) or [www.mines.edu/Academic/affairs/wisem](http://www.mines.edu/Academic/affairs/wisem)

## **Public Affairs**

The Office of Public Affairs is a strategic resource for the School, advising the administration and the academic departments on marketing and communications issues.

The department also has responsibility for media relations and numerous official campus publications, including:  
*Mines*, a quarterly magazine featuring campus and alumni news published jointly by CSM and the CSM Alumni Association  
*Update*, a research newsletter published each semester and once during the summer  
Undergraduate and graduate bulletins, published each summer  
Midyear and spring commencement programs

Academic Calendar, published on the Web

*In the Mines Tradition*, a pocket guide to the campus, published each fall

*Campus in Brief*, a weekly email newsletter for faculty and staff.

To ensure quality and consistency, all publications produced on campus are required to adhere to official campus publications guidelines, which can be found on the Public Affairs Web pages at [www.mines.edu/All\\_about/public](http://www.mines.edu/All_about/public). The guidelines contain a list of vendors that departments may use for publications services, such as writing, editing, design, photography, production, printing and distribution.

Also included on the Public Affairs Web pages are the Experts Database and official CSM press releases.

In other areas, the Office of Public Affairs plans special events for the campus and maintains media and community relations. The CSM president has delegated to Public Affairs the responsibility of speaking for the institution in the day-to-day conduct of business.

Through committee participation, Public Affairs staff members provide expertise to the campus in the areas of the World Wide Web site, student publications, and emergency response and crisis communications.

In addition, the Director of Public Affairs co-chairs the campus World Wide Committee and is a member of the Emergency Planning core group. The Director and Public Affairs staff members serve as official campus spokespersons in the day-to-day conduct of business, as well as in the event of a crisis.

For more information, call 303-273-3326.

## Research Development

Under the direction of the Dean of Graduate Studies and Research, the Office of Research Development (ORD) is responsible for nurturing and expanding CSM's research experience and expertise to reflect the continually changing internal and external environment in which we live and work.

The office teams with the Office of Research Services (ORS) and the Office of Technology Transfer (OTT) in developing and implementing training programs for faculty, student, and staff development, as well as providing pre- and post-award support for individual researchers, at all levels, junior through senior, group and interdisciplinary research entities. The ORD also helps identify, provides information to, and encourages collaboration with external sponsors, including industry, state and federal governments, other academic institutions, and nonprofit entities.

As part of this role, ORD also provides start-up support and equipment matching funds for new initiatives.

## Research Services

The Office of Research Services (ORS), under the Vice President for Finance and Operations, provides administrative support in proposal preparation, contract and grant administration, both negotiation and 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.csmis5.mines.edu/ors](http://www.csmis5.mines.edu/ors).

## Special Programs and Continuing Education (SPACE)

The SPACE Office offers 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, *the Denver Earth Science Project*, *the National Science Academy*, and *Summer Investigations for Middle/High Schoolers*. The Office also coordinates educational programs for international corporations and governments through the *International Institute for Professional Advancement* and hosts the Mine Safety and Health Training Program. The SPACE Office also offers a variety of web-based distance delivery courses for off-campus audiences through *Mines On-line*. A separate bulletin lists the educational programs offered by the SPACE Office, CSM, 1600 Arapahoe St., Golden, CO 80401. Phone: 303 273-3321; FAX 303 273-3314; email [space@mines.edu](mailto:space@mines.edu); website [www.mines.edu/Outreach/Cont\\_Ed](http://www.mines.edu/Outreach/Cont_Ed).

## Telecommunications

The Telecommunications Office is located at the west end of the Plant Facilities building, and provides telephone and voicemail services to the Campus, Residence Halls, Sigma Nu house, Fiji house, and the Mines Park housing areas. The Telecommunications Office also maintains a CSM Campus Directory in conjunction with the Information Services department available anytime to faculty, staff, and students on the Web at [www.mines.edu/directory](http://www.mines.edu/directory).

Local telephone service is provided, as part of the housing rates (optional for Mines Park residence). The Telecommunications Office provides maintenance for telephone lines and services.

A voicemail/calling ID (CLID) package is available as an optional service by subscription. The fee is \$22.50 per semester, and subscription cards are available in the Housing Office, Telecommunications Office, or the Web: <http://csmis5.mines.edu/telecomm/Students/Voicemails/signup.html>. The voicemail/CLID fee is nonrefundable, except in the case of departure from the campus (refunded at a decreased, monthly prorated rate).

The Telecommunications Office provides long distance services for the Residence Halls, Sigma Nu house, Fiji house, and Mines Park housing areas through individual account codes. Long distance rates for domestic calling are 0.08 cents per minute, 24 hours a day, seven days a week. International rates are available at the Telecommunications Office or through the Web at <http://csmis5.mines.edu/telecomm/Students/LongDistanceRates.html>. Accounts are issued at the beginning of the fall semester, or by request at any time. Monthly long distance charges are assessed to the student accounts by the 5th of each month for calls made the prior month, and invoices are mailed directly to students at their campus address. Questions and requests for information for the above services should be directed to the Telecommunications Office by calling (303) 273-3000 or 1-800-446-9488 and saying Telecommunications, or via the Web at <http://csmis5.mines.edu/telecomm/Students/students.html>.

# *Directory of the School*

## **BOARD OF TRUSTEES**

JOHN K. COORS CoorsTek, Inc., 16000 Table Mountain Parkway, Golden, CO 80403

HUGH W. EVANS 768 Rockway Place, Boulder, CO 80303

KAREN OSTRANDER-KRUG Denton Wilde Sapte, Almaty 273 Furmanova, Almaty, Kazakhstan

F. STEVEN MOONEY Thompson Creek Metals Co., 945 W. Kenyon Ave., Englewood, CO 80110

MICHAEL S. NYIKOS 2285 El Rio Drive, Grand Junction, CO 81503

TERRANCE G. TSCHATSCHULA Aspen Petroleum Products, 5925 E. Evans Avenue, Suite 102B, Denver, CO 80222

DAVID. J. WAGNER David Wagner & Associates, P.C., 8400 E. Prentice Ave., Englewood, CO 80111

JUSTIN CARLSON Student Representative

## **EMERITUS MEMBERS OF BOT**

Ms. Sally Vance Allen

Mr. Leo N. Bradley

Mr. Joseph Coors, Sr.

Mr. Joseph Coors, Jr.

Mr. William K. Coors

Mr. Frank Erisman

Mr. Kenneth R. Fenwick

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Mr. Charles E. Stott, Jr.

Dr. John W Vanderwilt\*

Mr. J. N. Warren

Mr. James C. Wilson

Mr. Russell L. Wood\*

## **ADMINISTRATION**

JOHN U. TREFNY, 1977-B.S., Fordham College; Ph.D., Rutgers University; President, Professor of Physics

NIGEL T. MIDDLETON, 1990-B.Sc., Ph.D., University of the Witwatersrand, Johannesburg; Vice President for Academic Affairs and Dean of Faculty; Professor of Engineering, P.E., S. Africa

HAROLD R. CHEUVRONT, 1976-84, 1985-B.S., M.A., West Virginia University; Ph.D., University of Northern Colorado; Vice President for Student Life and Dean of Students

ROBERT G. MOORE, 1995 -B.S., Northern Arizona University; M.P.A., University of Colorado; Vice President for Finance and Operations

PETER HAN, 1993-A.B., University of Chicago; M.B.A., University of Colorado; Vice President for Institutional Advancement

PHILLIP R. ROMIG, 1969-B.S., University of Notre Dame; M.S., Ph.D., Colorado School of Mines; Dean of the Office of Graduate Studies and Research, and Professor of Geophysics

BARBARA M. OLDS, 1982-B.A., Stanford University; M.A., Ph.D., University of Denver; Associate Vice President for Academic Affairs and Professor of Liberal Arts and International Studies

LINDA J. BALDWIN, 1994-B.S., Iowa State University; Continuing Education Program Coordinator

PAUL BARTOS, 2000-B.S., Wayne State University; M.S., Stanford University; Geology Museum Curator

GARY L. BAUGHMAN, 1984-B.S.Ch.E., Ohio University; M.S., Ph.D., Colorado School of Mines; Director of Special Programs and Continuing Education and Associate Research Professor

DAVID G. BEAUSANG, 1993-B.S., Colorado State University; Computing Support Specialist

JUDI A. BONACQUISTI, 1997-B.S., Colorado State University; Minority Engineering Program Director

RICHARD M. BOYD, 2000-B.S., Regis University; Director of Public Safety

STEVEN L. BRIDGEMAN, 1995-B.S., Colorado State University; Controller

ERLING A. BROSTUEN, 1990-Ph.B., University of North Dakota; Continuing Education Program Coordinator, Director of the Energy and Minerals Field Institute, and Director of the International Institute for Professional Advancement.

RONALD L. BRUMMETT, 1993-B.A., Metropolitan State College; M.A., University of Northern Colorado; M.B.A., University of Colorado Denver; Director of CSM Career Center and the Office for Student Development and Academic Services

TIMOTHY W. CAKE, 1994-B.S., Colorado State University; M.S., Regis University; Director of Plant Facilities

CAROL R. CHAPMAN, 1999-B.A., Wells College; M.P.A., University of Colorado; Special Assistant to the President

JULIE COAKLEY, 2001-B.S., University of Toledo; M.S., University of Toledo; Executive Assistant to the Vice President for Academic Affairs

KATHLEEN CONNER, 1996-B.S., Indiana State University; M.A., University of Colorado at Boulder; Director of Outdoor Recreation

HILLE L. DAIS, 1999-B.A., M.A., University of Minnesota; B.S., Metropolitan State College of Denver; Associate Vice President for Finance and Operations

MARY C. DALE, 1984-B.A., Southwestern College; M.A., University of Denver; Assistant for Collaborative Information Development and Support

MARY DAVIS, 1998-B.S., Metropolitan State College; M.Ed., University of Colorado; Associate Director of Financial Aid

THERESE DEEGAN-YOUNG, 1987-B.A., St. Louis University; M.A., University of Colorado; Student Development Center Counselor

LOUISA DULEY, 2000-B.S., Western State College; Internship Development Coordinator

RHONDA L. DVORNAK, 1994-B.S., Colorado School of Mines; Continuing Education Program Coordinator

ROBERT FERRITER, 1999-A.S., Pueblo Junior College; B.S., M.S., Colorado School of Mines; Director, Mine Safety and Health Program

MELODY A. FRANCISCO, 1988-89, 1991-B.S., Montana State University; Continuing Education Program Coordinator

ROBERT A. FRANCISCO, 1988-B.S., Montana State University; Director of Student Life

GEORGE FUNKEY, 1991-M.S., Michigan Technological University; Director of Information Services

LISA GOBERIS, 1998-B.S., University of Northern Colorado; Assistant Director of the Student Center

KATHLEEN GODEL-GENGENBACH, 1998-B.A., M.A., University of Denver; Ph.D., University of Colorado;

Director, Office of International Programs

BRUCE P. GOETZ, 1980-84, 1987- B.A., Norwich University; M.S., M.B.A., Florida Institute of Technology; Director of Admissions

SHARON HART, 1999-B.S., Colorado School of Mines; M.A., University of Colorado; Director of Institutional Research

MICHAEL HAVILAND, 1961-B.A., Athenaeum of Ohio; M.A., University of Pittsburgh; Ph.D., University of Massachusetts; Director of the Office of International Programs

EVELYN JORDAL, 2001-Assistant to the Vice President for Student Life

MELVIN L. KIRK, 1995-B.S., M.A., University of Northern Colorado; Student Development Center Counselor

ROBERT KNECHT, 1977-P.E., M.S., Ph.D., Colorado School of Mines; Director of EPICS

ROGER A. KOESTER, 1989-B.A., Grinnell College; M.B.A., Drake University; Director of Financial Aid

DEBBY PAGE LANE, 1993-A.A.S. Front Range Community College; B.S., Metropolitan State College; M.P.A., University of Colorado Denver; Director of Human Resources

DAVID LARUE, 1998-Computer Support Specialist

DEBRA K. LASICH, 1999-B.S., Kearney State College; M.A., University of Nebraska; Executive Director of the Women in Science, Engineering, and Mathematics (WISEM) Program

VIRGINIA LEE, 1996-B.A., M.A., Ph.D., University of California at Irvine; Web Administrator

EDWARD R. LIBERATORE, 1991-B.A., Georgetown University; J.D., Washington College of Law; Director of Legal Services

CAIRN A. LINDLOFF, 1994-B.S., University of Nevada at Reno; M.Ed., University of South Carolina; Director of Student Activities and Greek Advisor

ROBERT A. MacPHERSON, 1988-B.S., United States Naval Academy; Radiation Safety Officer

A. EDWARD MANTZ, 1994-B.S., Colorado School of Mines; Director of Green Center

MICHAEL McGUIRE, 1999-Engineer of Mines, Colorado School of Mines; Program Coordinator, SPACE

LEAH K. McNEILL, 1997-B.A., University of Mississippi; M.A. University of South Carolina; Director of Public Relations

MARY MITTAG-MILLER, 1998-Director of the Office of Research Services

BARBARA MORGAN, 2001-B.S., Montana State University; M.S., University of Wyoming; Director of Residence Life

TRICIA DOUTHIT PAULSON, 1998-B.S., Colorado School of Mines; Assistant Director of Admissions

ROGER PIERCE, 2000-B.S., Wisconsin Institute of Technology; SPACE Program Coordinator

MARY POTT, 1983-B.S., Colorado School of Mines; Assistant Director of Admissions and Alumni Association Coordinator

JAMES L. PROUD, 1994-B.S., University of Wisconsin, Whitewater; M.A., California State Polytechnic University; Continuing Education Program Coordinator

CAROLYN L. REED, 1980-B.A., Regis University; Director of Marketing

MARIAN E. ROHRER, R,N, 1998-Director, Student Health Center

PHILLIP ROMIG III, 1999-B.A., Nebraska Wesleyan University; M.S., University of Nebraska; Network Engineer and Security Specialist

SYDNEY SANDROCK, 1995-Assistant to the Vice President for Finance and Operations

JAHI SIMBAL, 2000-B.S., M.B.A., University of Colorado at Boulder; Associate Director of Minority Engineering Program

SUSAN A. SMITH, 1995-B.S., Oklahoma State University; M.A., University of Tulsa; Registrar

RUTH A. STREVELER, 1994-B.A., Indiana University; M.S., Ohio State University; Ph.D., University of Hawaii Manoa; Director of Academic Services

ANNE STARK WALKER, 1999-B.S., Northwestern University; J.D., University of Denver; Staff Attorney

CAROL L. WARD, 1993-B.S., Ohio State University; M.A., Denver University; Computer Support Engineer

DEREK J. WILSON, 1982-B.S., University of Montana; Director of the Computing Center

A. WILLIAM YOUNG, 1974-B.S., North Carolina State University; M.S., University of Denver; Director of Enrollment Management and Associate Vice President for Student Life

EDWARD A. ZITT, 1991-Manager of Financial Computing

## **EMERITI**

GEORGE S. ANSELL, B.S., M.S., Ph.D., Rensselaer Polytechnic Institute; Emeritus President and Professor of Metallurgical Engineering, P.E.

THEODORE A. BICKART, B.E.S., M.S.E., D.Eng., The Johns Hopkins University; Emeritus President and Professor of Engineering

GUY T. McBRIDE, JR. B.S., University of Texas; D.Sc., Massachusetts Institute of Technology; Emeritus President, P.E.

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R. BRUCE ALLISON, B.S., State University of New York at Cortland; M.S., State University of New York at Albany; Emeritus Professor of Physical Education and Athletics

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JOHN A. CORDES, B.A., J.D., M.A., University of Iowa; Ph.D., Colorado State University; Emeritus Associate Professor of Economics and Business

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DONALD I. DICKINSON, B.A., Colorado State University; M.A., University of New Mexico; Emeritus Professor of Liberal Arts and International Studies

J. PATRICK DYER, B.P.E., Purdue University; Emeritus Associate Professor of Physical Education and Athletics

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# *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.

## **Colorado School of Mines Unlawful Discrimination Policy and Complaint Procedure**

### *1. 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. (1998) in order to set forth a policy concerning unlawful discrimination at CSM. This policy shall supersede any previously promulgated CSM policy which is in conflict herewith.

## *II. Unlawful Discrimination Policy*

Attendance and employment at CSM are based solely on merit and fairness. Discrimination on the basis of age, gender, race, ethnicity, religion, national origin, disability, and military veteran status is prohibited. No discrimination in admission, application of academic standards, financial aid, scholastic awards, promotion, salary, benefits, transfers, reductions in force, terminations, re-employment, professional development, or conditions of employment shall be permitted. The remainder of this policy shall contain a complaint procedure outlining a method for reporting alleged violations of this policy and a review mechanism for the impartial determination of the merits of complaints alleging unlawful discrimination.

## *III. Persons Who May File an Unlawful Discrimination Complaint*

An unlawful discrimination complaint may be filed by any individual described in one of the categories below:

A. Any member of the CSM community, including classified staff, exempt employees, and students as well as any applicant for employment or admission, who believes that he or she has been discriminated against by CSM, a branch of CSM, or another member of the CSM community on account of age, gender, race, ethnicity, religion, national origin, disability, or military veteran status;

B. Any person who believes that he or she has been threatened with or subjected to duress or retaliation by CSM, a branch of CSM, or a member of the CSM community as a result of (1) opposing any unlawful discriminatory practice; (2) filing a complaint hereunder; (3) representing a Complainant hereunder; or (4) testifying, assisting, or participating in any manner in an investigation, proceeding, hearing, or lawsuit involving unlawful discrimination; or

C. The Human Resources Director or an attorney from the Office of Legal Services, if any of these individuals deem it to be in the best interest of CSM to do so.

## *IV. Informal Complaint Resolution Process*

At the written request of an individual who has come forward with a complaint alleging unlawful discrimination, hereinafter the "Complainant," the Human Resources Director shall assist in an attempt to resolve the complaint in an informal manner. The informal unlawful discrimination complaint resolution process shall consist of an informal discussion between the Complainant and the individual or a representative of the entity accused of unlawful discrimination, hereinafter the "Respondent." The Human Resources Director shall act as a mediator during this process, which shall be calculated to bring the complaint to the attention of the Respondent and elicit the voluntary cooperation of the Respondent in settling the matter. By attempting to resolve the unlawful discrimination complaint in an informal manner pursuant to the terms of this section, the Complainant shall not waive any rights to subsequently pursue the complaint through the formal complaint procedure set forth below.

## *V. Formal Complaint Procedure*

### **A. Purpose**

The purpose of the formal unlawful discrimination complaint procedure is to provide a formal mechanism for the prompt and fair internal resolution of complaints alleging unlawful discrimination. The procedure outlined below shall be the exclusive forum for the internal resolution of such complaints at CSM.

### **B. Where to file a Complaint**

All complaints by non-students alleging unlawful discrimination or retaliation shall be filed in writing at the Office of Human Resources located on the second floor of Guggenheim Hall. Complaints by students alleging unlawful discrimination or retaliation may be submitted to the Human Resources Office, the Student Development Center, the Dean of Students, any faculty member, or any Resident Assistant. Any recipient of such a student complaint shall promptly forward the complaint to the Director of Human Resources for handling in accordance with the provisions set forth below.

### **C. Time Limits**

All complaints alleging unlawful discrimination or retaliation must be filed within ninety days from the date upon which the incident, occurrence, or other action alleged to constitute unlawful discrimination or retaliation occurred. However, if the alleged discrimination or retaliation is of a continuing nature, a complaint may be filed at any time.

### **D. Contents of Complaint**

A complaint alleging unlawful discrimination or retaliation must be signed by the Complainant and set forth specific factual matters believed to constitute unlawful discrimination or retaliation. The complaint shall name as Respondent the individual or entity whom the Complainant believes to have committed, participated in, or encouraged the discrimination or retaliation. The complaint shall also include a brief statement describing the relief requested by the Complainant.

### **E. Fulfillment of Complaint Prerequisites**

As soon as practicable after receipt of a complaint, the Human Resources Director shall submit the complaint to an attorney from the Office of Legal Services, who shall examine it and determine if the prerequisites outlined above have been fulfilled. If the prerequisites have not been fulfilled, the attorney shall inform the Complainant of the specifics of

such determination in writing. Unless the time limitations set forth above have lapsed prior to the initial filing of the complaint, the Complainant shall have the opportunity to correct any deficiencies and re-file the complaint. If the prerequisites have been fulfilled, the complaint will be handled as set forth below.

#### **F. Choice of Remedies**

No Complainant shall be permitted to simultaneously file an unlawful discrimination claim under the CSM Unlawful Discrimination Policy and Complaint Procedure and a sexual harassment claim under the CSM Sexual Harassment Policy and Complaint Procedure against the same individual arising out of an identical set of facts. In such a situation, a Complainant shall be entitled to file his or her claim under either, but not both, of the above-mentioned policies.

### **VI. Pre-Hearing Procedures**

#### **A. Notification to Proceed**

As soon as practicable after a determination has been made that the complaint is sufficient pursuant to subsection V.E above, the reviewing attorney shall inform the Director of Human Resources of that fact and the Director of Human Resources shall proceed with the notifications specified in subsection B below.

#### **B. Acknowledgment of Complaint and Notification of Respondent**

As soon as practicable, the Director of Human Resources shall send a letter to the Complainant acknowledging receipt of the complaint. At the same time, the Director shall provide the Respondent with a copy of the complaint and notify the Respondent in writing of the requirements set forth in subsection C below.

#### **C. Response to Complaint**

Within ten days from the date of receipt of a copy of the complaint, the Respondent shall file with the Director of Human Resources a response in which the allegations contained in the complaint are admitted or denied. The Director shall provide the Complainant with a copy of the response as soon as practicable. If the response contains a denial of one or more of the allegations contained in the complaint, the process shall proceed with the selection of a hearing panel as set forth in subsection D below. If no timely response is received, or if the response admits the allegations in their entirety, the matter shall be submitted to the President, who shall then issue a decision in accordance with subsection IX.D below.

#### **D. Selection of Hearing Panel**

An initial hearing panel of ten individuals shall be selected at random in the following manner. Five initial panel members shall be selected from the CSM group of which the Complainant is a member, i.e., classified staff, exempt employees, undergraduate students, or graduate students, and the five remaining initial panel members shall be selected from the CSM group of which the Respondent is a member. The Complainant and the Respondent shall each disqualify two of the initial panel members. The disqualifications exercised by the parties shall proceed in an alternate fashion beginning with the Complainant. Of the remaining initial panel members, the one chosen last shall serve as an alternate hearing panel member. The other five initial panel members shall constitute the hearing panel for the appeal. Prospective panel members may be excused on account of conflict of interest, health, or unavoidable absence from campus. An excused initial panel member shall be replaced by another initial panel member chosen in a random drawing prior to the exercise of any disqualifications by either party.

#### **E. Selection of Chief Panel Member**

After a hearing panel has been chosen, the panel members shall elect a chief panel member from their number who shall preside throughout the remainder of the case.

##### **1. Authority of Chief Panel Member**

The chief panel member shall have the authority to (a) issue orders to compel discovery; (b) make rulings on evidentiary objections; and (c) issue any other orders necessary to control the conduct of the hearing and prohibit abusive treatment of witnesses, including removal of disruptive individuals from the hearing room.

##### **2. Role of Alternate Hearing Panel Member**

The alternate hearing panel member shall observe, but not actively participate in, all of the proceedings in the case and be prepared to substitute for a panel member who becomes unavailable during any stage of the case due to death, illness, or emergency.

#### **F. Setting of Hearing Date**

After a chief panel member has been chosen, a hearing date shall be set with reasonable consideration given to the schedules of the participants. The chief panel member shall set a date for the hearing, which shall occur no more than ninety days after the date upon which the formal complaint was filed with the Director of Human Resources. Once set, the hearing date may be rescheduled only with the concurrence of the Complainant, the Respondent, and the hearing panel.

#### **G. Participation of Attorneys**

Either party may engage the services of an attorney to assist in document preparation or case preparation. However,

an attorney may not enter an appearance or formally participate in the case on behalf of either party.

#### **H. Legal Advice for Hearing Panel**

If the hearing panel desires legal advice at any time during the case, the chief panel member shall request such advice from the Office of Legal Services. An attorney from the Office of Legal Services shall provide the requested advice unless all such attorneys are actively involved in the case on behalf of one of the parties. In such event, the chief panel member shall request the desired legal advice from the Assistant Attorney General assigned to CSM, whose name and telephone number shall be provided to the chief panel member by the legal office.

#### **I. Pre-Hearing Discovery**

Informal discovery, or the exchange between the parties of information relevant to the case, is encouraged. If the parties cannot resolve such issues informally, either party may request the chief panel member up to ten days prior to the hearing date to enter an order compelling discovery upon a showing of the relevance of the requested information and the necessity of such information to case preparation. The other party may oppose such request by showing that the requested information is irrelevant, unnecessary to the requesting party's case preparation, or privileged according to law.

### ***VII. Pre-Hearing Statements***

#### **A. Contents of Pre-Hearing Statements**

Each party shall file a pre-hearing statement containing the following components:

1. Summary of the Argument: A concise statement summarizing the case from the position of the submitting party;
2. List of Issues: A list of the issues which the submitting party wishes the hearing panel to resolve;
3. List of Witnesses: A list of witnesses to be presented at the hearing along with a summary of the anticipated testimony of each witness; and
4. Photocopies of Exhibits: Photocopies of each exhibit to be presented at the hearing.

#### **B. Deadlines for Pre-Hearing Statements**

The Complainant shall file a pre-hearing statement with the hearing panel and provide a copy to the opposing party no later than ten days prior to the hearing date. The Respondent shall file a pre-hearing statement with the hearing panel and provide a copy to the opposing party no later than five days prior to the hearing date. If the hearing date is rescheduled, these time limits shall apply to the rescheduled hearing date.

#### **C. Limitations Imposed by Pre-Hearing Statements**

Neither party shall make an argument during the hearing which is inconsistent with the arguments set forth in the summary of the argument section of his or her pre-hearing statement. Neither party shall introduce any witnesses or exhibits at the hearing which are not listed in his or her pre-hearing statement. All exhibits listed in the pre-hearing statements shall be deemed genuine and admissible unless successfully challenged prior to the hearing.

#### **D. List of Hearing Issues**

After examining the pre-hearing statements of both parties, the hearing panel shall prepare a list of issues to be resolved through the hearing and distribute such list to the parties no later than two days prior to the hearing date. The panel may list issues contained in the pre-hearing statement of either party or relevant issues not contained in the pre-hearing statement of either party. However, since the jurisdiction of the hearing panel is limited to hearing claims of unlawful discrimination, only issues directly related to the Complainant's claim of unlawful discrimination may be placed on the list of issues. The list of issues generated pursuant to this subparagraph shall be binding upon the subsequent hearing and shall form the standard against which all relevancy arguments shall be weighed.

#### **E. Amendments to Pre-Hearing Statements**

Up to two days prior to the hearing date, either party may request the chief panel member to permit amendments to his or her pre-hearing statement upon a showing of good cause and lack of prejudice to the opposing party. Any party filing an amended pre-hearing statement shall provide a copy thereof to the opposing party no later than the filing deadline imposed by the order granting leave to amend.

### ***VIII. Hearing Procedures***

#### **A. Burden and Standard of Proof**

The Complainant shall bear the burden of proof throughout the case. The standard of proof which the Complainant must meet to sustain the burden of proof shall be the preponderance of the evidence standard. The preponderance of the evidence standard shall be deemed met if the panel believes that it is more likely than not that the facts at issue occurred. The facts at issue shall include all facts which are required to be proven by the party bearing the burden of proof in order for such party to prevail.

#### **B. Order of Presentation**

Since the Complainant bears the burden of proof, that party shall present his or her case first. After the Complainant has finished, the Respondent shall present his or her case.

### **C. Outline of Hearing**

The hearing shall proceed according to the following general outline:

1. Complainant's Opening Statement
2. Respondent's Opening Statement (unless reserved)
3. Complainant's Case
4. Respondent's Opening Statement (if reserved)
5. Respondent's Case
6. Complaint's Rebuttal Case (unless waived)
7. Respondent's Rebuttal Case (only if Complainant presents a rebuttal case and unless waived)
8. Complainant's Closing Argument
9. Respondent's Closing Argument
10. Complainant's Rebuttal Argument (unless waived)

### **D. Inapplicability of Strict Evidentiary Rules**

Strict legal evidentiary rules shall not apply during the hearing. The chief panel member shall rule on the admissibility of disputed evidence with primary consideration given to the relevance, reliability, and probative value of proffered evidence.

### **E. Witness Examination Procedure**

Each witness shall be directly examined by the party on whose behalf the witness has appeared to testify. Upon the conclusion of the direct examination of each witness, the opposing party shall be permitted the right of cross-examination. The chief panel member may permit re-direct and re-cross examination. However, an identical examination procedure shall be utilized for all witnesses testifying in a given hearing. Hearing panel members may interject questions at any time during the direct, cross, re-direct, or re-cross examinations.

## ***IX. Post-Hearing Procedure***

### **A. Recommendation of the Hearing Panel**

Within a reasonable time after the conclusion of the hearing, the hearing panel shall confer among themselves and vote upon a recommended course of action. The panel members holding a majority point of view shall designate one of their number to write a recommendation reflecting their opinion. The panel members holding a minority point of view, if any, may issue a dissenting recommendation in a similar fashion.

### **B. Contents of Recommendation**

The recommendation of the hearing panel shall include the following components:

1. Statement Regarding Burden of Proof: A statement regarding whether or not the hearing panel believes that the burden of proof borne by the Complainant has been sustained;
2. Findings of Fact: A list of the relevant facts found by the hearing panel upon which the recommendation is based;
3. Legal Conclusions: A list of the legal conclusions of the hearing panel upon which the determination of the issue of unlawful discrimination is based; and
4. Recommended Action: A statement regarding the relief for the Complainant, if any, that is being recommended by the hearing panel.

### **C. Issuance of Recommendation**

The recommendation of the hearing panel shall be issued to the parties and delivered to the President along with the case file within fifteen days after the conclusion of the hearing.

### **D. Decision of President**

The President shall examine the case file, consider the recommendation of the hearing panel, and issue a final written decision in the matter. The President shall possess the authority to affirm, reverse, or modify the recommendation of the hearing panel or to remand the matter to the panel for further proceedings or consideration. In the decision, the President may provide appropriate relief to the Complainant and may impose appropriate disciplinary action upon the Respondent. The decision of the President shall be delivered to the parties and the hearing panel within fifteen days from the date of the President's receipt of the recommendation and case file from the hearing panel, unless the President is unavailable for a significant amount of time during this period.

### **E. Presidential Unavailability**

The term "unavailable," as utilized in this subsection and subsection X.D above, shall be defined to mean out of town, medically incapacitated, or engaged in important CSM business to the extent that sufficient time cannot be devoted to decision making hereunder. If the President is unavailable for a significant period of time during the decision making period, a letter shall be sent to the parties advising them of that fact as well as the anticipated date of

presidential availability. In such event, the decision shall be due fifteen days from the date upon which the President becomes available. The President shall be the sole judge of presidential unavailability hereunder.

#### **F. Appeal of Presidential Decision**

There shall be no internal appeal from the final decision of the President. A party aggrieved by the decision of the President may file a complaint with the appropriate equal opportunity enforcement agency or pursue other available legal remedies.

*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**

### ***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 sexual harassment at CSM. This policy shall supersede any previously promulgated CSM policy which is in conflict herewith.

### ***II. Sexual Harassment Policy***

#### **A. Definition of Sexual Harassment**

Sexual harassment consists of unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature when (1) submission to such conduct is made either explicitly or implicitly a term or condition of an individual's employment or scholastic endeavors; (2) submission to or rejection of such conduct by an individual is used as the basis for employment or academic decisions affecting the individual; or (3) such conduct has the purpose or effect of unreasonably interfering with an individual's work or school performance, or creating an intimidating, hostile, or offensive working or studying environment.

#### **B. Policy Statement**

CSM wishes to foster an environment for its students and employees which is free from all forms of sexual harassment, sexual intimidation, and sexual exploitation. Accordingly, CSM will not tolerate sexual harassment and will take all necessary measures to deter such misconduct and discipline violators of this policy with appropriate sanctions. Furthermore, retaliation in any form against an individual for reporting sexual harassment or cooperating in a sexual harassment investigation is strictly prohibited. Such retaliation shall be dealt with as a separate instance of sexual harassment. The remainder of this policy shall contain a complaint procedure outlining a method for reporting alleged violations of this policy and a review mechanism for the impartial determination of the merits of complaints alleging sexual harassment.

#### **C. Sanctions for Sexual Harassment**

Appropriate sanctions may be imposed upon an employee or student who has sexually harassed another. The term Perpetrator shall be utilized herein to refer to such a person. The sanctions may include one or more of the following: verbal reprimand and warning, written reprimand and warning, student probation, suspension from registration, monetary fine, suspension without pay, expulsion, or termination. In determining appropriate sanctions for the offense, the decision maker shall consider the severity of the offense, aggravating and mitigating factors, and the Perpetrator's previous history of sexual harassment offenses. If the decision maker concludes that a lack of comprehension of the concept of sexual harassment is a factor in the offense, the Perpetrator can also be required to attend a sexual harassment seminar or workshop.

### ***III. Persons Who May File a Complaint***

A sexual harassment complaint may be filed by an individual described in one of the categories below:

A. Any person who believes that he or she has been sexually harassed by a member of the CSM community, including classified staff, exempt employees, and students;

B. Any person who believes that he or she has been threatened with or subjected to duress or retaliation by a member of the CSM community as a result of (1) opposing any perceived sexual harassment; (2) filing a complaint hereunder; (3) representing a Complainant hereunder; or (4) testifying, assisting, or participating in any manner in an investigation, proceeding, hearing, or lawsuit involving sexual harassment; or

C. The Human Resources Director or an attorney from the Office of Legal Services, if any of these individuals deem it to be in the best interest of CSM to do so.

### ***IV. Informal Complaint Resolution Process***

At the request of an individual who has come forward with a sexual harassment complaint, hereinafter the "Complainant," the Director of Human Resources shall assist in an attempt to resolve the complaint in an informal manner. Although verbal requests to proceed with the informal complaint resolution process will be honored, complainants are strongly encouraged to put such requests in writing. The informal sexual harassment complaint resolution process shall consist of an informal discussion between the Complainant and the individual accused of



sexual harassment, hereinafter the "Respondent." The Director of Human Resources shall act as a mediator during this process, which shall be calculated to bring the complaint to the attention of the Respondent and elicit the voluntary cooperation of the Respondent in settling the matter. By attempting to resolve the sexual harassment complaint in an informal manner pursuant to the terms of this section, the Complainant shall not waive any rights to subsequently pursue the complaint through the formal sexual harassment complaint procedure set forth below.

## ***V. Formal Complaint Procedure***

### **A. Purpose**

The purpose of the formal sexual harassment complaint procedure is to provide a formal mechanism for the prompt and fair internal resolution of complaints alleging sexual harassment. The procedure outlined below shall be the exclusive forum for the internal resolution of sexual harassment complaints at CSM.

### **B. Where to file a Complaint**

All complaints by non-students alleging sexual harassment or retaliation shall be lodged with the Human Resources Office located on the second floor of Guggenheim Hall. Complaints by students alleging sexual harassment or retaliation may be submitted to the Human Resources Office, the Student Development Center, the Dean of Students, any faculty member, or any Resident Assistant. Any recipient of a student sexual harassment or retaliation complaint shall promptly forward such complaint to the Director of Human Resources for handling in accordance with the provisions set forth below.

### **C. Time Limits**

A complaint may be lodged at any time, but CSM strongly encourages individuals who feel they have been victims of sexual harassment to come forward as soon as possible after the occurrence of the incident, event, or other action alleged to constitute sexual harassment or retaliation.

### **D. Contents of Complaint**

Although a verbal sexual harassment complaint will be investigated, complainants are strongly encouraged to submit sexual harassment complaints in writing. Written complaints must be signed and must set forth specific factual matters believed to constitute sexual harassment or retaliation. The Complaint shall name as Respondent each individual whom the Complainant believes to have committed, participated in, or encouraged the sexual harassment or retaliation. The complaint shall also include a brief statement describing the relief requested by the Complainant.

### **E. Fulfillment of Complaint Prerequisites**

As soon as practicable after receipt of the complaint, the Director of Human Resources shall submit the complaint to an attorney from the Office of Legal Services, who shall determine if the prerequisites outlined above have been fulfilled. If the prerequisites have not been fulfilled, the reviewing attorney shall inform the Complainant of the specifics of such determination in writing. The Complainant shall have the opportunity to correct any deficiencies and re-file the complaint. If the prerequisites have been fulfilled, the complaint will be handled as set forth below.

### **F. Choice of Remedies**

No Complainant shall be permitted to simultaneously file an unlawful discrimination claim under the CSM Unlawful Discrimination Policy and Complaint Procedure and a sexual harassment claim under the CSM Sexual Harassment Policy and Complaint Procedure against the same individual arising out of an identical set of facts. In such a situation, a Complainant shall be entitled to file his or her claim under either, but not both, of the above-mentioned policies.

### **G. Notification of CSM Management Personnel**

As soon as practicable after a determination has been made that the complaint is sufficient pursuant to subsection V.E above, the Office of Legal Services shall notify CSM Management Personnel of the complaint and provide them with a copy thereof. For the purpose this policy, the term CSM Management Personnel shall refer to the President, the vice president in whose area the Respondent is employed or enrolled, and, if applicable, the Respondent's immediate supervisor. However, if the President is the Respondent, the term CSM Management Personnel shall refer to the Board of Trustees, and if the Respondent is a vice president, the term "CSM Management Personnel" shall refer to the President.

### **H. Acknowledgment of Complaint and Notification of Respondent**

As soon as practicable after being informed of the complaint pursuant to subsection V.G above, the vice president shall send a letter to the Complainant acknowledging receipt of the complaint. At the same time, the vice president shall notify the Respondent of the complaint in writing, and if the complaint has been reduced to writing, the vice president shall provide the Respondent with a copy thereof. If the President is the Respondent, the President of the Board of Trustees shall perform the above duties. If the Respondent is a vice president, the President shall perform these duties.

### **I. Investigation Authorization Form**

Unless the complaint is initiated by an attorney from the Office of Legal Services or the Director of Human Resources pursuant to subsection III.C above, the Complainant shall be required to execute a Sexual Harassment

Complaint Investigation Authorization Form prior to any investigation of the complaint.

#### **J. Investigation of Complaint**

An attorney from the Office of Legal Services and the Director of Human Resources shall jointly investigate the complaint by examining relevant documents, if any, and interviewing witnesses and other individuals designated by either party. The investigators will strive to conduct the investigation in a discrete and expeditious manner with due regard to thoroughness and fairness to both parties.

#### **K. Confidentiality of Investigative Materials**

All materials and documents prepared or compiled by the investigators during the course of investigating a sexual harassment complaint hereunder shall be kept confidential to the fullest extent of the law in order to protect interviewees and promote candor.

#### **L. Alternate Investigators**

If either an attorney from the Office of Legal Services or the Director of Human Resources is the Complainant or the Respondent hereunder, or is otherwise unavailable, the President shall appoint an alternate investigator.

#### **M. Report of Findings and Confidential Recommendation**

As soon as practicable after the conclusion of the investigation, the investigating attorney shall prepare and submit a report of findings and a confidential recommendation to CSM Management Personnel and the Director of Human Resources. The report of findings shall be provided to the Complainant and Respondent within a reasonable time following the issuance of a decision pursuant to subsection V.N below. The confidential recommendation shall not be released to the Complainant or the Respondent without written authorization from the President. The Director of Human Resources shall submit a separate recommendation to CSM Management Personnel which contains a statement of agreement or disagreement with the findings and recommendation of the investigating attorney.

#### **N. Resolution of the Complaint**

Following consultations with the President, the investigating attorney, and the Director of Human Resources, the vice president shall issue a final written decision regarding the complaint. The decision shall be addressed to the Complainant and shall contain a statement of whether or not sexual harassment was found to have occurred, the remedies to be provided to the Complainant, if any, and the sanctions to be imposed upon the Respondent, if any. At approximately the same time, the decision shall be communicated to the Respondent in writing. If sanctions are to be imposed upon the Respondent, the vice president shall also notify the Respondent of that aspect of the decision in writing. If the President is the Respondent, the President of the Board of Trustees shall perform the above duties. If the Respondent is a vice president, the President shall perform these duties.

#### **O. Appeal of Final Decision**

There shall be no internal appeal from the final decision rendered pursuant to subsection V.N above. A party aggrieved by the decision may file a complaint with the appropriate administrative agency or pursue other available legal remedies.

*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)

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