

2011-12  
Undergraduate  
and Graduate Catalog

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SOUTH DAKOTA

**M**

SCHOOL OF MINES  
& TECHNOLOGY

*Invent Tomorrow*

# Academic Calendar

## Fall Semester 2011

Registration	August 29
Classes that meet on Mondays with a class start time of 4:00 p.m. or later begin	August 29
All other classes begin	August 30
Labor Day Holiday	September 5
Last day to add or drop a course and to adjust fees	September 7
Last day to submit a graduation application for fall 2011	September 7
Native American Day Holiday	October 10
Midterm (first half of semester ends)	October 20
Midterm deficiencies grades due by midnight	October 25
Early Registration Weeks (Tentative)	October 31-Nov 18
Last day to drop classes	November 10
Veterans Day Holiday	November 11
Thanksgiving Holiday begins at end of class day	November 22
Classes resume	November 28
Final examinations	December 12-16
Semester ends	December 16
Fall Graduation	December 17
Final grades are due by midnight	December 21

## Spring Semester 2012

Registration	January 11
Classes that meet on Wednesdays with a class start time of 4:00 p.m. or later begin	January 11
All other classes begin	January 12
Martin Luther King Jr. Day	January 16
Last day to add or drop a course and adjust fees	January 20
Last day to submit a graduation application for spring/summer 2012	January 20
Presidents' Day Holiday	February 20
Spring vacation begins at end of class day	March 2
Classes resume	March 12
Midterm (First half of semester ends)	March 12
Midterm deficiencies grades due by midnight	March 15
Early Registration Weeks (Tentative)	March 22-April 16
Last day to drop classes	April 2
Easter Break begins at end of class day	April 5
Classes resume	April 10
Final examinations	April 30-May 4
Semester ends	May 4
Spring Graduation	May 5
Final grades are due by midnight	May 9

This calendar conforms to guidelines established by the Board of Regents but is subject to change at its discretion.

## Reservation of Rights

The information contained in this catalog is the most accurate available at the time of publication, but changes may become effective before the next catalog is printed. It is ultimately the student's responsibility to stay abreast of current regulations, curricula, and the status of specific programs being offered. Further, please note that the university reserves the right to change graduation or other academic requirements where changes are necessary to comply with Board of Regents policy directives, to meet external demands relating to accountability or accreditation standards, to reflect curriculum changes or substitutions, or to implement evolving discipline requirements in major fields.

*South Dakota School of Mines and Technology does not discriminate on the basis of race, color, national origin, military status, gender, religion, age, sexual orientation, political preference, or disability in employment or the provision of service.*



*Mines Matters:* The relationships students make at the School of Mines are as important as the world-class education they receive. Students come from 40 states and 27 countries.

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## Degree Abbreviations

- A.A. -Associate of Arts
- B.S. -Bachelor of Science
- M.S. -Master of Science
- Ph.D. -Doctor of Philosophy

## **MISSION, VISION AND STRATEGIC PRIORITIES**

The South Dakota School of Mines and Technology serves the people of South Dakota as their technological university. Its mission is to provide a well-rounded education that prepares students for leadership roles in engineering and science; to advance the state of knowledge and application of this knowledge through research and scholarship; and to benefit the state, region, and nation through collaborative efforts in education and economic development.

The School of Mines is dedicated to being the technological university of choice for undergraduate and graduate education of engineers and scientists with the leadership and professional skills to advance society.

### **STRATEGIC PRIORITIES**

1. Meet the increasing demand for high quality scientists and engineers through expanded enrollment, retention, and graduation of a diverse undergraduate and graduate student body.
2. Increase the quality of educational outcomes for students while advancing knowledge in science and engineering through directed research efforts.
3. Invest in human capital to move the institution forward.
4. Focus on continuing quality improvement that assures the highest academic standards in education and research.
5. Partner to achieve financial resources that bring the vision of the institution to life.

## University Information

### South Dakota Board of Regents

Mr. Terry D. Baloun, Highmore  
Dr. James O. Hansen, Pierre  
Mr. Harvey C. Jewett, Aberdeen  
Dr. Kathryn O. Johnson, Hill City  
Mr. Dean M. Krogman, Brookings  
Mr. Randall K. Morris, Spearfish  
Ms. Carole Pagones, Sioux Falls  
Mr. Randy Schaefer, Madison  
Mr. Patrick Weber, Montrose

### **Officers of the Board**

President: Dr. Kathryn O. Johnson  
Vice President: Mr. Dean Krogman  
Secretary: Mr. Randy Schaefer

### **Executive Director**

Dr. Jack R. Warner

### South Dakota Public Higher Education Institutions

Black Hills State University, Spearfish;  
Dakota State University, Madison;  
Northern State University, Aberdeen;  
South Dakota School of Mines and  
Technology, Rapid City;  
South Dakota State University, Brookings;  
University of South Dakota, Vermillion

### Degrees

The following degrees are offered at the South Dakota School of Mines and Technology in the designated fields of study.

### **Associate of Arts**

General Studies

### **Bachelor of Science**

Chemical Engineering  
Chemistry  
Civil Engineering  
Computer Engineering  
Computer Science  
Electrical Engineering  
Environmental Engineering

Geological Engineering  
Geology  
Industrial Engineering and Engineering  
Management  
Interdisciplinary Sciences

#### Areas of Specialization:

1. Atmospheric Sciences
2. Pre-Professional Health Sciences
3. Science, Technology, and Society

Mathematics, Applied and Computational  
Metallurgical Engineering  
Mechanical Engineering  
Mining Engineering  
Physics

### **Master of Science**

Atmospheric Sciences  
Biomedical Engineering  
Chemical Engineering  
Civil Engineering  
Construction Management  
Electrical Engineering  
Engineering Management  
Geology and Geological Engineering  
Materials Engineering and Science  
Mechanical Engineering  
Paleontology  
Physics  
Robotics and Intelligent Autonomous Systems

### **Doctor of Philosophy**

Atmospheric and Environmental Sciences  
Biomedical Engineering  
Chemical and Biological Engineering  
Geology and Geological Engineering  
Materials Engineering and Science  
Mechanical Engineering  
Nanoscience and Nanoengineering

Further information concerning the engineering and science curricula leading to the engineering and science degrees may be found in the individual program sections of this catalog.

## **Accreditation**

The South Dakota School of Mines and Technology is accredited by the Higher Learning Commission of the North Central Association of Colleges and Secondary Schools, the recognized accrediting agency for the north central states, through the Academic Quality Improvement Program (AQIP) process. For more information call (800) 621-7440 or visit:

[www.ncahigherlearningcommission.org](http://www.ncahigherlearningcommission.org).

In addition, the curriculum in chemistry is approved by the American Chemical Society. All engineering programs are accredited by the by the Engineering Accreditation Commission of ABET, <http://www.abet.org>. The computer science program is accredited by the Computing Accreditation Commission of ABET, Inc.

## **Equal Opportunity Policy**

South Dakota School of Mines and Technology is committed to the policy that all persons shall have equal access to its programs, facilities, and employment without regard to race, color, creed, national origin, ancestry, religion, gender, age, sexual orientation, marital status, pregnancy, military/Veteran's status, or disability. In adhering to this policy, South Dakota School of Mines and Technology abides by all federal and state statutes and regulations for the protection of employees against discrimination. Inquiries regarding compliance may be directed to the Director of Human Resources, South Dakota School of Mines and Technology, 501 East Saint Joseph St., Rapid City, SD 57701, (605) 394-1203.

## Admissions

### Authorization for Individual Institutional Policies

Each university may adopt specific admission regulations, consistent with law and the requirements set by the Board of Regents, as may be required for each school or program to assure acceptable student preparation and enrollment levels. A copy of such regulations and any subsequent amendments shall be filed with the Executive Director and shall be subject to review by the Board of Regents.

### Admissions Requirements

The Board of Regents (BOR) requires that all students meet the minimum course requirements for admission to the South Dakota School of Mines and Technology. These are described below under South Dakota Board of Regents Minimum Undergraduate Admissions Requirements.

In addition, The Board of Regents approved the following requirements for admission to the School of Mines:

School of Mines will **automatically accept** for admission students who:

- obtain an ACT composite score of at least 25 AND obtain an ACT math subscore of at least 25 (or SAT-I equivalent score)

**OR**

- obtain a high school GPA of at least 3.50 on a 4.0 scale AND have taken four years of higher-level mathematics (i.e., algebra, geometry, trigonometry, calculus)

School of Mines will **review and consider for acceptance** students who meet BOR requirements

**AND**

- obtain an ACT composite score of at least 21 (or equivalent SAT-I score)

**OR**

- obtain an ACT math subscore of at least 21 (or equivalent SAT-I score)

**OR**

- achieve a high school GPA of at least 2.75 on a 4.0 scale.

All applicants not meeting automatic admission requirements will be reviewed by the Admissions Committee. The committee considers high school curriculum (special consideration is given to math and science coursework), grades, and test scores.

### South Dakota Board of Regents Minimum Undergraduate Admissions Requirements

A. Baccalaureate Degree Admissions for High School Graduates

For admission to baccalaureate degree programs, high school graduates must:

- meet the minimum course requirements with an average grade of C (2.0 on a 4.0 scale);

**OR**

- demonstrate appropriate competencies in discipline areas where course requirements have not been met;

**AND**

- rank in the top 60 percent of their high school graduating class;

**OR**

- obtain an ACT composite score of 18 (SAT-I score of 870) or above;

**OR**

- obtain a high school GPA of at least 2.6 on a 4.0 scale.

School of Mines ACT CODE - 3922

School of Mines SAT CODE – 6652

#### 1. Minimum Course Requirements

All baccalaureate or general studies students under twenty four (24) years of age, including students transferring with fewer than twenty-four (24) credit hours, must meet the following minimum high school course requirements:

a. Four years of English - Courses with major emphasis upon grammar, composition, or literary

analysis. One year of debate instruction may be included to meet this requirement.

b. Three years of advanced mathematics - algebra, geometry, trigonometry or other advanced mathematics including accelerated or honors mathematics (algebra) provided at the 8th grade level; not included are arithmetic, business, consumer, or general mathematics or other similar courses.

c. Three years of laboratory science — Courses in biology, chemistry, or physics in which at least one (1) regular laboratory period is scheduled each week. Accelerated or honors science (biology, physics, or chemistry) provided in the 8th grade shall be accepted. Qualifying physical science or earth science courses (with lab) shall be decided on a case-by-case basis.

d. Three years of social studies — History, economics, sociology, geography, government — including U.S. and South Dakota, American Problems, etc.

e. At the time of admission to a South Dakota Board of Regents university, it is expected that students will have basic keyboarding skills and have had experience in using computer word processing, database and spreadsheet packages, and in using the Internet or other wide-area networks. These expectations may be met by high school coursework or demonstrated by some other means. Incoming students that are assessed and found deficient in this area may be required to complete specific computer skills courses.

f. One year of fine arts for students graduating from South Dakota high schools – Art, theatre, or music (appreciation, analysis, or performance). Documented evidence of high school level noncredit fine arts activity will be accepted for students graduating from high schools in states that do not require completion of courses in fine arts for graduation.

## **2. Alternate Criteria for Minimum Course Requirements**

- a. Students who do not successfully complete four years of English may meet minimum course requirements through one of the following:
- i. An ACT subtest score of 18 or above;

- ii. An Advanced Placement Language and Composition or Literature and Composition score of 3 or above.
- b. Students who do not successfully complete three years of advanced mathematics may meet minimum course requirements through one of the following:
- i. An ACT mathematics subtest score of 20 or above;
  - ii. An Advanced Placement Calculus AB or Calculus BC score of 3 or above.
- c. Students who do not successfully complete three years of laboratory science may meet minimum course requirements through one of the following:
- i. An ACT science reasoning subtest score of seventeen (17) or above;
  - ii. An Advanced Placement Biology, Chemistry, or Physics B score of 3 or above.
- d. Students who do not successfully complete three years of social studies may meet minimum course requirements through one of the following:
- i. An ACT Social Studies/Reading subtest score of seventeen (17) or above;
  - ii. An Advanced Placement Microeconomics, Macroeconomics, Comparative or United States Government and Policies, European or United States History, or Psychology score of 3 or above.
- e. Students graduating from South Dakota high schools that do not successfully complete one year of fine arts may demonstrate fine arts knowledge or competency through the following:
- i. An Advanced Placement History of Art, Studio Art drawing, or general portfolio or Music Theory score of 3 or above.

## **Non-Traditional Students**

For purposes of admission, a degree seeking student who has attained the age of 24 and has not previously attended any post-secondary institution is classified as a non-traditional student. Non-traditional students who are high school graduates or have completed the general equivalency diploma (GED) will be admitted.

### **Non-High School Graduates**

- Students who are not high school graduates and have obtained an ACT composite score of 21, ACT English sub-test score of at least 21, mathematics sub-test score of at least 21, and social studies/reading and science reasoning sub-test scores of at least 21, and meet any university determined requirements for admission will be admitted.

OR

- Students who are not high school graduates and have completed the general equivalency diploma (GED) with total cumulative standard test scores for all five test items totaling 2250 with all test scores in the upper 50<sup>th</sup> percentile.

- Non-traditional students who do not fit within the above categories will be considered for admission based on life experience and other evidence of success. Applications will be reviewed by the SDSM&T Admissions Committee. An applicant accepted under this section will be placed on a one semester probationary status. The Admissions Committee reserves the right to impose additional conditions.

### **Regents Scholars**

South Dakota high school graduates completing the following high school courses with no final grade below a “C” (2.0 on a 4.0 scale) and an average grade of “B” (3.0 on a 4.0 scale) shall be designated as Regents Scholars and shall be eligible to receive a Regents Scholar Diploma upon request by a high school administrator to the Department of Education and Cultural Affairs. High school graduates designated as Regents Scholars automatically are admitted to all six public universities. (Regent Scholars still need to submit the admission application.)

- **4 units of English**: Courses with major emphasis upon grammar, composition, or literary analysis; one year of debate instruction may be included to meet this requirement.

- **4 units of algebra** or higher mathematics: algebra, geometry, trigonometry, or other advanced mathematics including accelerated or

honors mathematics (algebra) provided at the eighth grade level; not included are arithmetic, business, consumer or general mathematics, or other similar courses.

- **4 units of science including 3 units of approved laboratory science**: Courses in biology, chemistry, or physics in which at least one (1) regular laboratory period is scheduled each week. Accelerated or honors science (biology, physics, or chemistry) provided in the eighth grade shall be accepted. Qualifying physical science or earth science courses (with lab) shall be decided on a case-by-case basis.

- **3 units of social studies**: History, economics, sociology, geography, government—including U.S. and South Dakota, American Problems, and so on.

- **2 units of a modern (including American Sign Language) or classical language**

- **1 unit of fine arts**: Effective fall 2002 for students graduating from South Dakota high schools in: Art, theatre, or music appreciation, analysis, or performance.

- **1/2 unit of computer science**: Students will have basic keyboarding skills and have had experience in using computer word processing, database and spreadsheet packages, and in using the Internet or other wide-area networks.

### **Readmission Procedures**

A student who has interrupted attendance by two (2) or more semesters must submit an application for readmission and pay the application fee. Any student not under academic or disciplinary suspension will be automatically readmitted. Applications from students to have their academic or disciplinary suspension overturned or terminated early must be forwarded to the university’s Academic Appeals Committee.

## **Undergraduate Transfer Admission**

### **A. Transfers to Baccalaureate Programs**

Students under twenty-four (24) years of age transferring into baccalaureate degree programs with fewer than twenty-four (24) transfer credit hours must meet the baccalaureate degree admission requirements. Students with twenty-four (24) or more transfer credit hours with a GPA of at least 2.75 are automatically accepted into baccalaureate degree programs. Transfer students with GPAs less than 2.75 will be considered on a case-by-case basis by the SDSM&T Admissions Committee. If students are applying for federal financial aid, they must meet federal guidelines for transfer students.

### **Technical Institute and Community College Credits**

Technical Institute courses are designed to prepare students to enter the workforce for careers requiring less than a baccalaureate degree. Acceptance of these courses for credit at the South Dakota public universities is strictly the function of the receiving institution. Students who wish to transfer credits to a South Dakota public university for programs other than the Bachelor of Applied Technical Science degree not available through the School of Mines should contact the Admissions Office of that desired university for an evaluation of their program objectives and technical institute transcript. An individual evaluation of course credits will be made by the receiving public university in accordance with institutional and Board of Regents' policy.

Total transfer credit for work at a junior, community college (2 year), and/or two-year technical college may not exceed one-half of the hours required for completion of the baccalaureate degree at the accepting institution. Students who have completed more than the acceptable semester hours of junior, community, or technical college work may apply completed, transferable courses to specific course requirements and thereby may not be required to repeat the courses. The semester hours of credit for those additional courses may not be applied toward the minimum credit hours required for the degree.

### **B. Students who Transfer to Associate Programs**

Students younger than twenty-four (24) years of age transferring into associate degree programs with fewer than 12 transfer credit hours must meet the associate degree admission requirements. Students with 12 or more transfer credit hours with a GPA of at least 2.0 may transfer into associate degree programs. If students are applying for federal financial aid, they must meet federal guidelines for transfer students.

### **C. Students from Accredited Colleges or Universities**

At the discretion of each university, students may be accepted by transfer from other colleges within or outside of the state; preferential consideration shall be given to applicants from institutions which are accredited by their respective regional accrediting association. Advanced standing shall be allowed within the framework of existing rules in each college.

### **D. Students from Non-Accredited Colleges**

A university may refuse to recognize credits from a non-accredited college or may admit the applicant on a provisional basis and provide a means for the evaluation of some or all of the credits. The validation period shall be no less than one (1) semester and no longer than one (1) academic year.

An applicant for admission to the South Dakota School of Mines and Technology is considered a transfer applicant if he/she has enrolled for any college level work, full or part-time, since graduation from high school. The applicant must be in good standing and eligible to return to all colleges/universities attended. In general, a 2.75 or greater GPA in courses attempted at other institutions is expected. Applicants from accredited institutions ordinarily are granted credit toward their degree for work satisfactorily completed at the previous institutions, provided such courses are equivalent or comparable to those required in the program an applicant is considering at School of Mines. Credits from institutions which are not accredited by a regional accrediting association will be

provisional and subject to validation. No credit is allowed for remedial courses.

### **E. Former Students**

A student returning to the institution or a student who has attended another higher education institution in the Board of Regents system is required to pay the application fee and, he or she must also submit an application for readmission and other required documents if he or she has interrupted attendance by two (2) or more semesters. A former student shall be considered as a transfer student if he or she has attended another institution during the period of interruption of attendance.

### **F. Suspended Students**

A transfer applicant under academic suspension from the last college attended shall not be considered for admission during the period of suspension or, if suspended for an indefinite period, until one (1) semester has passed since the last date of attendance at the previous school. A system transfer student must first be reinstated to their previous institution prior to seeking admission to the School of Mines.

### **G. Disciplined Students**

A transfer applicant under disciplinary suspension shall not be considered for admission until a clearance and a statement of the reason for suspension is filed from the previous institution. The university shall take into account the fact of the previous suspension in considering the application.

### **Special (Non-degree Seeking) Students**

A prospective student at South Dakota School of Mines and Technology who wishes to be classified as a special student must complete the Application for Non-degree Seeking Students. Non-degree seeking students are ineligible for all federal financial aid programs. Non-degree seeking students must submit an official copy of their previous college transcript(s) if necessary to verify prerequisites.

### **Nursing at the School of Mines**

South Dakota School of Mines and Technology offers courses that meet requirements for nursing at South Dakota State University (4-year baccalaureate degree B.S.N.) and the University of South Dakota (2-year associate degree A.D.N.).

Students interested in earning a nursing degree from SDSU or USD need to apply to the degree granting university. For more information visit: <http://sdmines.sdsmt.edu/nursing>.

### **Dual Enrollment of High School Students**

A high school student wishing to take courses at School of Mines should begin by contacting the Admissions Office at School of Mines and then the Principal's Office or Guidance Office at the high school he or she currently attends to receive the high school's approval to participate. This approval should accompany the School of Mines Admissions Application. Please refer to the legislative SDCL 13-28-37, enacted by the South Dakota Legislature in 1990. This bill states the following: "Postsecondary enrollment—Responsibility for cost—Failing grade eliminates eligibility. Any student in grades ten, eleven and twelve may apply to an institution of higher education or a postsecondary vocational education institution as a special student in a course or courses offered at the institution of higher education or postsecondary vocational education institution. The student shall obtain the school district's approval of the post-secondary course or courses prior to enrolling. If approved, the student shall receive full credit toward high school graduation as well as post-secondary credit for each postsecondary course. The resident school district may pay all or part of the tuition and fees for a course approved for credit toward high school graduation in accordance with this section. The student is responsible for any tuition and fees not paid by the resident school district and for any other costs involved with attending a postsecondary institution. If a failing grade is received in a postsecondary course under this section, the student receiving the failure is no

longer eligible to enroll for post-secondary courses under this section.”

### **Additional Admissions Policies and Practices**

Institutions authorized by the Board of Regents to offer graduate study programs may admit students selected according to regulations established by each faculty. A graduate student will be defined as one who has been accepted into a graduate school.

All entering students seeking an associate or baccalaureate degree must provide valid Enhanced ACT scores or must take the ACT COMPASS examination in the areas of writing skills, mathematics, and reading. All non-degree seeking students enrolling in English and mathematics courses must provide Enhanced ACT scores or must take the ACT COMPASS examination in the areas of writing skills and mathematics.

Students transferring within the South Dakota Board of Regents system will be allowed to transfer their placement test scores and continue their sequence of courses in English and/or mathematics.

The placement process will be consistent for all Regental institutions.

### **Applications and Procedures**

#### **A. Application for Tuition and Fee Reductions and Scholarships Established by the Legislature**

Students should contact the Admissions Office for information on eligibility for tuition and fee reductions and scholarships established by the Legislature.

#### **B. Application Submission**

An applicant for admission must submit the required application for admission and the necessary official transcript or transcripts and other required documents to the Office of Admissions (501 E. Saint Joseph Street, Rapid City, SD 57701).

#### **C. Records Required**

Applicants who are twenty-one (21) years of age or younger must submit Enhanced ACT (or SAT-I) results, an official high school transcript, if a high school graduate, or proof of GED and an official transcript for all previous college work as part of their application. Applicants who are older than twenty-one (21) years of age and who do not have valid ACT / SAT-I exam results, or who have not taken the exams are not expected to take the exam. However, they are required to submit an official high school transcript, if a high school graduate, and an official transcript for all college work. Applicants should also submit any other records, data, or letters required to support eligibility for admission, including competency test scores. SAT scores will be converted to ACT equivalencies according to a conversion table approved by the Board of Regents. Note: An official transcript is one that bears the original seal and signature of the official in charge of records at that institution.

#### **D. Preadmission Immunization Requirements**

In accordance with state law, every student (graduate and undergraduate) who has been admitted to a post-secondary institution - either public or private – in the state of South Dakota *who meets established criteria is obliged to demonstrate immunity to measles, mumps, and rubella*. Relevant criteria (the key factors which drive the need for compliance) are delineated below:

1. Age: students born on or after January 1, 1957 must comply; those born prior to this date are excused.
2. Course schedule: students who register for two or more credit-bearing classes – and at least one course involves face-to-face contact on a weekly basis for multiple weeks – are obliged to comply. This includes participation at all campuses, centers (including University Center, Capital University Center, and West River Higher Learning Center), and off-campus meeting locations.
3. Academic background: students who have completed prior collegiate coursework *in the state of South Dakota* (initiated prior to July 1, 2008) are excused from compliance. Note:

credits earned through distance learning, dual credit agreements, and exam/validation do not qualify.

4. Acceptable evidence of immunity *to each disease* includes:

Immunization record which specifies administration of two doses of vaccine; Medical laboratory report that verifies presence of disease-specific antibodies in the blood (i.e., positive blood titer); and /or, documentation of disease state as diagnosed by a qualified physician.

The law recognizes that special circumstances may preclude ability to demonstrate compliance as detailed above. Those students for whom vaccination presents a threat to health/well-being and those who adhere to a religious doctrine that opposes immunizations may petition for a permanent exemption or temporary waiver as appropriate. Forms are available at: <http://sdmines.sdsmt.edu/studentlife/forms>. Please note: the statute does *not* allow for philosophical objections.

### **Freshman Checklist**

- Submit application for admission.
- Enclose non-refundable application fee with application for admission (\$20.00).
- ACT or SAT I scores must be on file in the Admissions Office.
- Applicants must arrange to have an official copy of their high school transcript forwarded to the Office of Admissions (501 E. Saint Joseph Street, Rapid City, SD 57701) after their junior year is complete and grades have been recorded. A final transcript will also be necessary in order to verify final class rank, graduation, and satisfaction of the minimum course requirements for admission to South Dakota Public Higher Education Institutions.
- Prospective freshmen desiring scholarship consideration must be accepted for admission prior to the first working day in February.

### **Transfer Checklist**

- Application for admission.
- Non-refundable application fee of \$20.00.
- An official transcript from each postsecondary institution attended. (Sent by the institution attended directly to the Office of Admissions (501 E. Saint Joseph Street, Rapid City, SD 57701)
- All applicants must submit a high school transcript, or other proof of graduation from high school; or, if not a high school graduate, they must submit copies of their high school equivalency/GED scores and an official transcript of high school work completed.
- Applicants younger than twenty-one (21) who have completed less than 24 semester credits of college work must submit official copies of SAT I or ACT scores in addition to the above documents.
- Applicants who will be less than 21 years of age at the beginning of the semester for which they are applying for admission, and who have completed less than 24 credit hours of college coursework must meet the minimum course requirements for admission to SD Public Higher Education Institutions. (See “South Dakota Board of Regents minimum Undergraduate Admission Requirements.”)

Transfer applicants will be notified of their admission status at School of Mines shortly after all of the above documents have been submitted. No transfer credit evaluation will be made until “final” college/university transcripts are on file. Transfer credit evaluation is made by the Office of the Registrar and Academic Services in consultation with the head of the academic department in which the applicant intends to major.

## **Undergraduate International Student Admissions**

To be considered for admission, international students must meet the following requirements:

1. Rank in the upper half of secondary school graduation class.
2. Have a 2.75 (B) grade average if transferring from a college or university in the United States.
3. Be proficient in English or attend and complete an approved intensive English as a Second Language (ESL) program.
4. SAT or ACT scores OR submit recommendation letters from two teachers or professors familiar with the students' academic work.
5. Be financially self-sustaining. (Admission to School of Mines is not dependent on the ability to show adequate financing for education, but the I-20 will not be issued without this information.)

The following items are necessary to be considered for admission to the School of Mines. If you are admitted, the form I-20 or DS-2019 is necessary for admission to the United States for college attendance. The U.S. Embassy or Consulate website in your country will supply detailed information on the application process for the required student visas. This information may also be available from an EducationUSA office, which may be located near the Embassy or Consulate <http://www.educationusa.state.gov/>. The State Department offers general information on visa applications at: <http://travel.state.gov/>.

1. A completed application submitted prior to June 15 (fall) or November 1 (spring) and the State of South Dakota application fee of \$20.00. (The application will not be processed until the \$20.00 US fee is paid.) The deadline for the application is at least 10 weeks prior to the beginning of the term for which admission is desired if the student is outside the U.S.
2. Academic credentials (translated into English). All documents submitted to School of Mines to substantiate a request for admission must

be certified by an official school or governmental seal as originals or certified copies. An academic department may require submission of academic credentials to an independent credential evaluation service, the charge for which will be paid by the student. School of Mines only accepts credential evaluations from specified organizations. Please contact the Admissions Office or the Ivanhoe Center at [Ivanhoe@sdsmt.edu](mailto:Ivanhoe@sdsmt.edu).

3. English proficiency for students from countries in which English is not the native language must be verified by the TOEFL (Test of English as a Foreign Language) examination that is available through the Educational Testing Service (ETS). The results must be sent to: International Admissions South Dakota School of Mines and Technology 501 E. Saint Joseph Street Rapid City, SD 57701-3995

A TOEFL score of 530 (paper-based), 197 (computer-based), or 71 (Internet based) or better is required for undergraduate applicants. Students who are admitted may be required to take an English proficiency or placement test upon arrival. Information on worldwide test centers for the TOEFL, as well as registration information, can be obtained by contacting any U.S. Embassy or Consulate or by writing to Test of English as a Foreign Language, ETS, Princeton, NJ 08540, or by visiting their website at: [www.toefl.org](http://www.toefl.org).

Other English proficiency examinations, such as the IELTS, will be considered on an individual basis.

4. SAT or ACT score, OR the applicant may submit recommendation letters from two (2) professors or instructors familiar with the academic performance of the applicant.
5. Proof of Financial Responsibility. Admission to School of Mines is not dependent on the ability to show adequate financing for education, but the I-20 will not be issued without this information. The United States Citizenship and Immigration Service (USCIS) requires that a U.S. college or university must verify that the student is able to

pay all educational and incidental expenses before issuing the form I-20 or DS-2019.

The international applicant must provide a statement of finances (in English). This includes a financial (bank) statement from the student or sponsor, which must be verified by a bank official. The bank statement must show the actual amount—or more—that is available to the student. A statement that says “ample funds” is not acceptable. If the student has a financial sponsor, a letter or affidavit of support must accompany the financial statement. If the sponsor is a government agency, a letter of award and instructions for invoice procedures should be sent. International students are not eligible for School of Mines or federal loan programs and should not apply for such financial assistance.

6. International students must attend the school specified on their visa or they may be refused admittance to the United States. A student entering the United States for study must maintain his/her status. More information is available at the Ivanhoe International Center. Prospective students should not enter the United States on a B-1 or B-2 visitor’s visa, as the USCIS will not approve a change to the F-1 student visa. International students must not, under any circumstances, enter the United States with a WT if they are planning to become a full-time student. The WT status cannot be changed or extended, under any circumstances, once the student is in the United States. U.S. government reporting requirements have been added for international students (F and J status) have increased in recent years. As a result of the regulations that became effective on January 1, 2003, the Family Educational Rights and Privacy Act (FERPA) is waived for F and J students in respect to these specific reporting requirements. The regulations will be strictly enforced by the appropriate bureau(s) within the US Department of Homeland Security (DHS) and information will be reported electronically to DHS via Student and Exchange Visitor Information System (SEVIS). The consequences to students for non-compliance with these regulations are severe. For more information, e-mail the Ivanhoe Center at

[Ivanhoe@sdsmt.edu](mailto:Ivanhoe@sdsmt.edu) or go to <http://international.sdsmt.edu>.

Each international student (and any dependents accompanying him/her to the United States) is REQUIRED to enroll in the Major Medical Hospitalization/Surgical Insurance Plan provided through South Dakota School of Mines and Technology. No outside policies will be accepted as substitutes. The only exception to this rule is if the student is covered by his/her home country (documentation of this policy is required). Life insurance is also recommended.

### **Electronic University Consortium**

In fall 2000, the Electronic University Consortium (EUC) came online at: [www.WorldClassEducation.org](http://www.WorldClassEducation.org). The EUC provides a single connection point for distance education offerings from South Dakota School of Mines and Technology, as well as our sister institutions South Dakota State University, University of South Dakota, Dakota State University, Northern State University, and Black Hills State University. Students from throughout the world are able to register for and participate in classes offered via the Internet from any of these institutions. Courses offered by two-way interactive video and by correspondence are also listed on the EUC.

### **Current Reduced Tuition Programs for Non-Residents**

The current non-resident tuition rate is 150 percent of the resident rate: \$149.70 per credit hour compared to \$99.80. For more information, contact the Cashier’s Office at (605) 394-2372 or e-mail [cashier@sdsmt.edu](mailto:cashier@sdsmt.edu).

Reduced tuition is available for non-resident first-time freshmen, children of alumni, new transfers, and international students. Those undergraduate students will qualify for a rate of 150 percent of what residents pay. Students already enrolled in the public university system prior to summer 2006 will not be eligible for the new non-resident rate. Tuition assistance is also available to National Guard members, ROTC

cadets, South Dakota State Employees, certain elementary and secondary school teachers and vocational instructors, and persons 65 years of age or older. Graduate students who hold a state contract for an assistantship or fellowship may also be entitled to special reduced tuition and should contact the Graduate Education Office at (605) 394-1206. For current tuition information see the website: [www.sdsmt.edu](http://www.sdsmt.edu).

### **Minnesota Reciprocity**

Students from Minnesota can currently come to the South Dakota School of Mines and Technology at a comparable rate to Minnesota resident tuition under the Minnesota Reciprocity agreement. To apply, or for more information: [www.sdbor.edu/policy/5\\_FinanceBusiness/documents/5-5-1.pdf](http://www.sdbor.edu/policy/5_FinanceBusiness/documents/5-5-1.pdf).

### **Resident and Nonresident Classification of Students**

#### **Purposes of Classification**

Each person who applies for admission to a university shall be classified as a resident or a nonresident for admissions and tuition and fees purposes (See Policy 2:3 Admissions and Policy 5:5 Tuition and Fees).

#### **Information, Burden of Establishing Residency, Reclassification**

- A. The decision shall be based upon information provided by the student and all other relevant information.
- B. The institution is authorized to require such written documents, affidavits, verifications, or other evidence as are deemed necessary to establish the residence of the student, including proof of emancipation, adoption, or appointment of a guardian.
- C. Students have the burden of establishing residency by clear and convincing evidence.
- D. Students may appeal the original classification decision by written petition to a reviewing body appointed by the chief executive officer

of the institution within thirty (30) days after registration for that semester. The recommendation of the reviewing body shall be submitted to the chief executive officer for a decision. The decision of the chief executive officer shall be final, but students who have been classified as nonresidents retain full rights to petition the executive director of the South Dakota Board of Regents for reclassification after they have remained in South Dakota continuously for 12 months.

- E. After twelve (12) months continuous presence in South Dakota, students who were initially classified as nonresidents may petition for reclassification.
- F. Petitions for reclassification shall be filed with the Executive Director, who shall act upon them. The Executive Director shall report his disposition of such petitions to the Board at its regularly scheduled meetings. These reports shall be summarized in a manner consistent with the Family Educational Rights and Privacy Act.
- G. If a petition for reclassification is granted, the reduced tuition rate shall become effective with the first semester or session following the date on which the petition is granted. Students who fail to request resident status prior to a particular semester or session or to pursue a timely appeal shall be deemed to have waived any claim for reduced tuition for that semester or session.
- H. A student or prospective student who knowingly provides false information or refuses to provide or conceals information for the purpose of improperly achieving resident student status is subject to the full range of penalties, including expulsion, provided for by the Board of Regents.

#### **Establishing Bona Fide Residency**

For tuition purposes, residence means the place where a person has a permanent home, at which the person remains when not called elsewhere for labor, studies or other special or

temporary purposes, and to which the person returns at times of repose. It is the place a person has voluntarily fixed as the person's permanent habitation with intent to remain in such place for an indefinite period. A person, at any one time, has but one residence and a residence is not lost until another is gained.

- A. The residence of an un-emancipated person younger than twenty-one (21) years of age follows that of the parents or of a legal guardian who has actual custody of the person or administers the property of the person. In the case of divorce or separation, if either parent meets the residence requirements, the person shall be considered a resident.

Students who enter the state for the predominant purpose of attending a Board institution and who are under the custody of a guardian in fact, that is, a person who has been designated in writing by the students' parents or legal guardian to serve as their attorney in fact for purposes related to the individual unemancipated student's affairs, may file a residency petition with the Board at the time of admission.

- B. A person shall be classified as a resident student if the person has continuously resided in South Dakota for at least 12 consecutive months immediately preceding the first scheduled day of classes of the semester or other session in which the individual registers in the Regental system; except that unemancipated students whose parents established their residence in South Dakota for reasons not predominantly related to qualifying their children for reduced tuition, may be classified as residents, notwithstanding the fact that they have not resided in South Dakota for the requisite 12 months prior to the first scheduled day of classes.

If it appears that the parents of a person properly classified as a resident student under the provisions of this section have removed their residence from South Dakota, the person shall be reclassified to the status of nonresident unless the parents have been

residents for the 12 months immediately preceding such removal. However, no such reclassification is effective until the beginning of a semester next following the removal.

- C. Physical presence in South Dakota for the predominant purpose of attending an institution of higher education controlled by the Board does not count in determining the 12-month period of residence. Absence from South Dakota to pursue postsecondary education does not deprive a person of resident student status.
- D. A person once properly classified as a resident student shall be deemed to remain a resident student so long as remaining continuously enrolled in the Regental system until the person's degree shall have been earned, subject to the provisions of (B) above.
- E. International students whose visas permit them to establish domiciles in the United States or its territories or protectorates may qualify for resident tuition in the same manner as United States citizens.

### **Factors to Be Considered When Determining Whether Students Have Entered South Dakota for the Predominant Purpose of Attending a Public University**

- A. The following factors shall be considered relevant in evaluating a requested change in a student's nonresident status and in evaluating whether the person's physical presence in South Dakota is for the predominant purpose of attending an institution of higher education controlled by the Board:
- The residence of an un-emancipated student's parents or guardians;
  - The site of the source of the student's income;
  - To whom a student pays taxes, including property taxes;
  - The state in which a student's automobile is registered;
  - The state issuing the student's driver's license;

- Where the student is registered to vote;
- The marriage of the student to a resident of South Dakota;
- Ownership of property in South Dakota and outside of South Dakota;
- The residence claimed by the student on loan application, federal income tax returns, and other documents;
- Admission to a licensed profession in South Dakota;
- Membership in civic, community, and other organizations in South Dakota or elsewhere; and
- The facts and documents pertaining to the person's past and existing status as a student.



B. The existence of one or more of these factors does not require a finding of resident student status, nor does the nonexistence of one or more require a finding of nonresident student status. All factors shall be considered in combination, and resident student status may not result from the doing of acts which are required or routinely done by sojourners in testate or which are merely auxiliary to the fulfillment of educational purposes.

C. The fact that a person pays taxes and votes in the state does not in itself establish residence.

D. Students who do not meet the requirements of this policy may still be classified as residents if their situation presents unusual circumstances and their classification is within the general scope of this policy.

### **Retention of Residence While in Military Service**

In determining the residence status for tuition purposes, it is presumed that persons in military service who list South Dakota as their “home of record” and who, immediately upon release, return to South Dakota to enter college shall be classified as residents.

## Tuition and Fees

### Tuition, Living, and Other Expenses

The following rates are effective May 9, 2011 and are subject to change by Board of Regents action. For current information see the website: [www.sdsmt.edu](http://www.sdsmt.edu).

<b>Tuition and Fees</b>	<b>Resident</b>	<b>Non-Resident</b>
Undergraduate on-campus per semester credit	\$114.30	\$171.45*
Graduate on-campus per semester credit	\$173.25	\$366.70
University Support Fee - per credit	\$ 90.30	\$ 90.30
General Activity Fee - per credit	\$ 33.20	\$ 33.20

\*New students and transfers for Academic Year 2007 or after

\* Does not include Minnesota rates. For more information, please refer to Minnesota Reciprocity information.

See accompanying text for the description of fees  
for engineering and science courses as well as labs.

<b>Resident Hall Rent - per semester</b>	<b>Resident</b>	<b>Non-Resident</b>
Single Occupancy	\$1,692.35	\$1,692.35
Double Occupancy	\$1,512.15	\$1,512.15
Quad	\$1,720.15	\$1,720.15
Deluxe Quad	\$1,858.40	\$1,858.40

\* For residency information, contact the Admissions Office or refer to Board of Regents Policy at:

[www.sdbor.edu/policy/5\\_FinanceBusiness/](http://www.sdbor.edu/policy/5_FinanceBusiness/).

Reduced tuition is available for non-resident first-time freshmen, children of alumni, new transfers, and international students. Those undergraduate students will qualify for a rate of 150 percent of what residents pay. Students already enrolled in the public university system prior to summer 2006 will not be eligible for the new non-resident rate. Reduced tuition is also elementary and secondary school teachers and vocational instructors, and persons 65 years of age or older. Graduate students who hold a state contract for an assistantship or fellowship may also be entitled to special reduced tuition and should contact the Graduate Education Office at (605) 394-1206.

\*Students from Minnesota can currently come to the South Dakota School of Mines and  
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Technology at a comparable rate to Minnesota resident tuition under the Minnesota Reciprocity agreement. To apply, or for more information: [www.sdbor.edu/policy/5\\_FinanceBusiness/documents/5-5-1.pdf](http://www.sdbor.edu/policy/5_FinanceBusiness/documents/5-5-1.pdf).

### Typical Education Expenses for Full Time Undergraduate For One Semester

#### Payment Process

All tuition and fees are required to be paid in full or other financial arrangement made with the Cashier's Office no later than the third day of fall and spring semester classes and first day of summer semester classes. For the student's convenience, electronic bill and payment services are provided. If no financial arrangement is made by these dates, a late charge will be assessed on the next day. Examples of other financial arrangements may include payment plans,

Tuition and Fees

deferments for financial aid, or third party payments. (For a deferment for financial aid, contact the Financial Aid Office.) Students who owe a balance after the end of the add/drop period due to changes in class schedules are required to pay in full or to make other financial arrangements by the 19<sup>th</sup> class day for fall and spring semester. Since summer semester add/drop periods vary, check with the Cashier's Office for final financial arrangement dates for add/drop courses. If no financial arrangement is made, enrollments shall be cancelled.

### **Debit Card System**

The South Dakota School of Mines Grubby Gold Card is a money management system activated through each student's ID card. This account is similar to a checking account or a debit card. When you present your card to make a purchase at participating locations, on and off-campus, the amount will be immediately deducted from your account. Currently, Grubby Gold is accepted at select beverage and snack machines in Surbeck Center and in the dorms, at the bookstore, Hardrocker Café, Java City, washers and dryers in the dorms, and copy machines at Surbeck Center.

To add money to your Grubby Gold account or check account balances and account history, just create a Grubby gold account online. Look for the link at <http://grubbygold.sdsmt.edu>. Self-register by using your student ID number and your name as it is printed on your student ID. If your parents, family or friends know your student ID number, they can also add money to your Grubby Gold account by using the guest deposit feature online.

### **Fees**

#### **Application Fee**

Non-refundable charge upon initial application for admission. \$20 undergraduate and \$35 graduate.

#### **General Activity Fee**

A fee is assessed for each state-funded course for activities such as student organizations, cultural events, homecoming, student government, student newspapers, wellness center, intramurals student health services, and the Surbeck Student Center operational and debt expenses. The allocation of general activity fees is recommended to the president by students on the General Activity Fee Committee, and the president is the approving authority on how these fees are spent.

#### **University Support Fee**

A fee assessed for each state-funded course is used to purchase equipment, materials, and services in support of instructional programs. It is also used to provide necessary services such as financial aid, counseling, catalogs and bulletins, student testing, administration, operating and maintenance costs, and student information system software.

#### **Late Payment Charge**

If tuition and fees are not paid before established due dates, late payment charges will be assessed. If financial obligations are not met when due, student may be administratively withdrawn for the university.

#### **Engineering and Science Fee**

The Engineering and Science Fee is used for maintaining accredited professional programs in engineering and technology. This fee is used for such needs as maintaining state-of-the-art classrooms and laboratories, operating the required senior capstone group design projects, and maintaining the embedded learning outcomes assessment programs now required for accreditation.

#### **Lab Fee**

\$53.75 is charged for each laboratory course. The fee helps support the added costs associated with maintaining the laboratories.

#### **Credit by Examination**

This \$90.75 fee is charged for each course in which a student seeks credit by examination.

## **International Student Enrollment**

This one-time \$120.95 fee is assessed at the time of the international student's first semester enrollment in addition to the regular application fee.

## **Vehicle Registration**

All motor vehicles parked on campus must be registered with the Campus Safety Office. Contact this office at (605) 394-2251 for options, amounts, and appropriate display of parking permit or [www.sdsmt.edu/services/facilities](http://www.sdsmt.edu/services/facilities).

## **Transcript Fee**

A transcript of credits is an authentic copy of the student's academic record. One complete transcript of credits is provided without charge to each student upon graduation. After that the charge is \$5.00 each, and \$2.50 each copy thereafter per request.

## **Indebtedness**

A student who is indebted to the university and does not satisfy financial obligations when due may be withdrawn after notice from the university and will not be permitted to register or receive a transcript of grades until the indebtedness is paid. This applies to indebtedness for university tuition, room, board, fees, financial aid, and fines, but not to student organizations. If a student's account is placed with a collection agency, the student will be responsible for all collection costs, attorney's fees, and any other costs necessary for the collections of any unpaid balance.

## **Refunds**

### **Withdrawal Refunds Information**

Students who withdraw, drop out, or are expelled from School of Mines within the add/drop period (first 10 percent of term, commonly referred to as the census date) receive a 100 percent refund of tuition and course-related fees. Students who withdraw, drop out, or are expelled from the university after the add/drop period for the enrollment period for which they are assessed charges may be entitled to a refund of

tuition, fees, and other institutional charges calculated through 60 percent of the enrollment period. The refund shall be determined by computing the percentage of an enrollment period remaining after the date of withdrawal times the tuition, fees, and other institutional charges originally assessed the student.

A student's withdrawal date is 1) When the student began the withdrawal process or officially notified School of Mines of intent to withdraw by contacting School of Mines Academic and the Office of Enrollment Service, or 2) The midpoint of the period for a student who leaves without notifying School of Mines; or 3) at School of Mines option, the student's last documented date of academically related activity.

Federal Financial Aid Recipients: The U.S. Department of Education requires institutions to use the Return of Title IV Funds policy for students withdrawing from school and who are receiving Federal Title IV student financial aid. Title IV funds refers to the federal financial aid programs authorized under the Higher Education Act of 1965 (as amended) and includes the following Federal Student Aid programs: Subsidized and Unsubsidized Stafford Loan, Parent PLUS Loan, Grad PLUS Loan, Perkins Loans, Pell Grant, Academic Competitiveness Grant (ACG), National Science and Mathematics to Retain Talent Grant (SMART), Supplemental Educational Opportunity Grant (SEOG) and any other Federal Aid program enacted by Congress. Students are advised to review the information located at:

<http://sdmines.sdsmt.edu/finaid/withdrawal>.

## Financial Aid

The following information is intended to be a brief overview of the financial aid process and programs at the School of Mines. More up to date and detailed information is available on our website at: <http://sdmines.sdsmt.edu/finaid>.

With over 80 percent of our students receiving in excess of \$13.8 million in various forms of financial assistance from both within and outside the university, it is clear that many college students find it necessary to supplement their personal and family financial resources in order to attend college. The South Dakota School of Mines and Technology administers a comprehensive financial aid program to enable capable, qualified, and needy students to finance their college education with both need-based aid (grants, subsidized loans, and work-study) and non-need based aid (scholarships, outside agency assistance, unsubsidized loans, private alternative loans, etc.). However, the student should still be prepared to pay for a portion of college costs through savings from employment, and parents of dependent students are expected to assist with the student's cost of education to the extent to which they are able.

The School of Mines gives priority on a first come, first served basis in the awarding of the Federal Perkins Loan, Federal Supplemental Educational Opportunity Grant (SEOG) and Federal Work-Study (FWS) to students who's Free Application for Federal Student Aid (FAFSA) has been received by the FAFSA processor on January 1 and thereafter until funds are exhausted. Students who are eligible for the Federal Pell Grant, Federal Direct Loan, Federal Direct Grad PLUS Loan or the Federal Direct Parent PLUS Loan are awarded without regard to when the FAFSA is received for the school year the FAFSA is filed. The Financial Aid Office generally begins the Federal Student Aid awarding process for new incoming freshman by mid to late April and to current, returning and transfer students by late May and early June.

### I. General eligibility requirements for awarding Federal Student Aid

- A.** Must have applied for admission in a School of Mines degree program
- B.** Complete a new FAFSA each year to determine eligibility for Federal Student Aid Programs.
- C.** Be a U.S. citizen or eligible non-citizen.
- D.** Not be in default on a federal student loan or owe a federal student grant repayment.
- E.** Male students born after December 31, 1959, must register with Selective Service.
- F.** Follow the steps for reviewing your award letter at: <http://sdmines.sdsmt.edu/finaid/award.letter> and return the award letter and all required forms to the Financial Aid Office.
- G.** Complete the School of Mines Authorization to Apply Federal Student Aid form and return with the award letter to the Financial Aid Office.
- H.** Report to the Financial Aid Office any aid assistance received that is not listed on the award letter, which includes, but is not limited to scholarships, Voc-Rehab, BIA/Tribal Assistance, etc.
- I.** Be enrolled as a full-time student to receive full amount of aid awarded (indicate on the award letter if the planned enrollment will be less than full time and notify the Financial Aid Office if the planned and/or actual enrollment changes at any time).
- J.** Must maintain Satisfactory Academic Progress toward the completion of a School of Mines degree. Students who meet or exceed the standards as stated at: <http://sdmines.sdsmt.edu/finaid/SAP> can be assured of continued eligibility until the

completion of their degree.

**K.** Complete the Attendance Confirmation via WebAdvisor at least two weeks prior to every semester of attendance at Mines.

## **II. Financial aid programs**

The School of Mines is a full participant in the Federal Student Aid Programs. Specific information about each program is available at: <http://sdmines.sdsmt.edu/finaid>. The student's School of Mines award letter identifies the aid he or she is being awarded and provides information for finalizing the processing of the award.

**A. Grants** are gift aid based on financial need.

**1. The Federal Pell Grant** is awarded to students who have not yet completed their first bachelor's degree and is based on a federal formula used to analyze the information provided on the FAFSA.

**2. Federal Supplemental Educational Opportunity Grant (SEOG)** is awarded to Pell Grant eligible students based on the availability of funds.

**B. Student loans** provide an opportunity for students to borrow money for educationally related expenses. However, like any loan, they must be repaid according to the provisions of the promissory note. First time loan recipients are required to complete Entrance Loan Counseling as shown at:

<http://sdmines.sdsmt.edu/finaid/EntranceCounseling>.

**1. The Federal Direct Subsidized and Unsubsidized Loan** programs are obtained from the Federal Government as the lender. For the Subsidized Direct Loan, the Federal Government pays accrued interest on behalf of the student during periods of at least half-time enrollment or other eligible deferment periods. However, with the Unsubsidized Direct Loan, the Federal Government does not pay the accrued interest on behalf of the student while enrolled in school or during available deferment periods, with interest

accrual beginning at disbursement. For both the Sub and Unsub Direct Loans, payment on the principal balance is required to begin six months after the student graduates or is no longer enrolled at least half-time. Current interest information is available on our website.

**2. The Federal Perkins Loan** is a Federal Loan program administered by the School of Mines. The interest rate is fixed at 5 percent and repayment begins nine months after graduation or at least half-time enrollment ends.

**3. The Federal Direct Grad PLUS Loan** is available to graduate students (masters and Ph.D.) who have exhausted their eligibility for the Subsidized and Unsubsidized Stafford and Direct Loan programs. Monthly payments begin 60 days after the final disbursement for any academic year with a current fixed rate of 7.9 percent.

**4. The Federal Direct Parent PLUS** is borrowed on behalf of the parent's dependent student. Monthly payments begin 60 days after the final disbursement for any academic year with a current fixed interest rate of 7.9 percent.

**C. Work opportunities for part-time employment.**

**1. Federal Work-Study awards** are based on financial need as determined by the results of the FAFSA and the awarding policy of the School of Mines. Employment opportunities are available both on and off campus with off-campus positions focused on community service.

**2. Other employment opportunities** submitted by local employers or the South Dakota Job Service are regularly posted in the Surbeck Student Center.

**D. Scholarships from the School of Mines**

In order to be considered for incoming freshman scholarships at the School of Mines, prospective students must have been accepted for admission no later than the first business day in February prior to the year they plan to attend. The

online admission application available at: [www.GoToMines.com/admissions/apply](http://www.GoToMines.com/admissions/apply) is all that is needed for scholarship consideration. An additional option is available to students who are considering attending multiple South Dakota public universities is to file the common South Dakota Public Higher Education Undergraduate Application for Admission, available at <https://apply.sdbor.edu/>. Regardless of which application you submit, all incoming freshman accepted for admission will be competitively evaluated for incoming freshman scholarships. At the School of Mines, students apply for and are awarded a “scholarship” without regard for specific donor funding. The Foundation Office then assigns the scholarship recipients to the various donors based on the donor’s criteria.

### **1. Four-Year Support Scholarships**

The most prestigious scholarship assistance on campus provides assistance for incoming freshmen with renewable support for three years provided the recipient maintains full time enrollment (must enroll in a minimum of 12 School of Mines credit hours each semester), complete 24 credit hours per academic year, maintain a 3.0 or higher cumulative grade point average (CGPA), and is continuing progress toward completion of their degree.

### **2. National Merit Finalists**

The School of Mines offers a \$3,000 scholarship renewable for three years to National Merit Finalists who notify the National Merit Corporation via the PSAT/NMSQT that the School of Mines is their first-choice college. Full time enrollment (must enroll in a minimum of 12 School of Mines credit hours each semester), complete a minimum of 24 credit hours per academic year, maintain a 3.00 or higher CGPA and continuing progress toward completion of their degree are requirements for renewal.

### **3. Two-Year Support Scholarships**

The Tech Challenge scholarship is renewable for one year provided the recipient maintains full time enrollment (must enroll in a minimum of 12 School of Mines credit hours each semester),

complete a minimum of 24 credit hours per academic year, maintain a 3.0 or higher CGPA and continuing progress toward completion of their degree.

### **4. Annual Scholarship Support**

Although students are generally not required to complete an application for departmental scholarships, current students are required to complete an application for annual, non-renewable scholarships awarded by the University Scholarship Committee that are based on academic performance at the School of Mines and scholarship criteria. Information on availability of the online scholarship application is provided to students late in the fall semester for scholarships to be awarded for the following academic year. Scholarship recipients must maintain full time enrollment (must enroll in a minimum of 12 School of Mines credit hours) for each semester of the award and maintain the CGPA as required by the scholarship. If the scholarship is major specific, the recipient must maintain enrollment in the appropriate coursework needed for that major.

### **E. Graduate Student Support**

Graduate students should contact the Graduate Education Office at the School of Mines regarding available fellowships.

### **III. Carefully review your billing statement**

The Student Accounts Office will send an e-mail notification to the student’s Mines e-mail account informing him or her of availability to access their billing statement before each semester and whenever there is a change to the student’s account. Please pay attention to the amount owed and the payment guidelines set by the Business Office. Be advised that aid that requires the student’s endorsement on a check and Work-Study awards will not appear on the billing statement.

### **IV. Disbursement of aid**

With the exception of Federal Work-Study, which is paid monthly, and some scholarships, which are paid according to the wishes of the donor, financial aid is either credited to the

student's account or disbursed by check at the beginning of each semester, or after aid eligibility is determined, whichever is later. If the aid applied to the student's account exceeds institutional costs, he or she will either receive a cash disbursement (refund check) in the mail or the funds can be deposited directly to the student's bank account via Direct Deposit. Students can contact the Student Accounts Office for further information on Direct Deposit option. In the event that there are delays in disbursing of aid, students should always have available enough money to meet immediate expenses they might incur at the beginning of each semester, such as the purchase of books and supplies.

### **V. Multi-Institution Students**

At times it may be necessary to take classes at one of the other South Dakota Board of Regents universities in order to complete the student's degree requirements. Other than to sign up for classes through their School of Mines log on to WebAdvisor, no special arrangements need to be made in order to include those classes in their enrollment status for financial aid purposes at School of Mines. However, if the student plans to take classes at a non-Board of Regents school, they must contact the Financial Aid Office to determine if classes taken there can be used to fulfill degree requirements at the School of Mines and to determine their overall semester enrollment status.

School of Mines scholarship and fellowship recipients must receive prior approval from the Financial Aid Director in order to use non-School of Mines credit hours to meet the full time School of Mines credit hour requirement for scholarship and fellowship disbursement.

### **VI. Correspondence Studies**

The School of Mines does not offer courses via correspondence. However, students are advised to discuss possible options with the Financial Aid Director for receiving assistance to help pay for this type of coursework taken at another eligible institution.

### **VII. Summer financial aid and effect on eligibility for the coming school year**

Students who are interested in receiving aid for the summer must have completed the FAFSA for the coming school year. Their aid award will be based on a summer, fall, and spring academic year. As a result, receiving aid for the summer will directly impact the amount of aid available for the fall and spring semesters. Generally, students must carry at least a half-time course load of 6 credits for undergraduate and 4.5 for graduate students] to be eligible for summer financial aid. A School of Mines Summer Aid Application, which is available after March 31, must be completed before the student will be considered for summer aid.

### **VIII. Withdrawal and refunds**

Due to circumstances that may or may not be beyond the student's control, it may become necessary to withdraw from all classes prior to the end of a particular semester. Depending on the withdrawal date, the student may be entitled to a full or partial refund of tuition and fees, tablet PC rental, and if contracting with the university, for room and board.

A withdrawal is considered to be official when the student comes to the Office of the Registrar and Academic Services, Room 216 of the O'Harra Building to initiate the process. If that is not possible, he or she may call (800) 544-8162, Ext. 2400 or local at (605) 394-2400. In the event that the student leaves school without notifying the Office of the Registrar and Academic Services, or simply never attends classes and receives a 0.00 GPA for the semester, the university has the option of considering the withdrawal date to be 1) the midpoint of the period of enrollment; 2) the last documented date of academically related activity; or 3) if he or she did not notify the Office of the Registrar and Academic Services due to circumstances beyond his or her control, the date relative to that circumstance, whichever is later. It is important that a student clearly state that he or she is withdrawing from all classes. Dropping a class and withdrawing from all classes have a different impact on a student's status with the university. If enrolled at more than one campus

within the South Dakota Board of Regents university system, he or she must inform The Office of the Registrar and Academic Services staff whether the intent is to withdraw from all campuses, or just from the School of Mines.

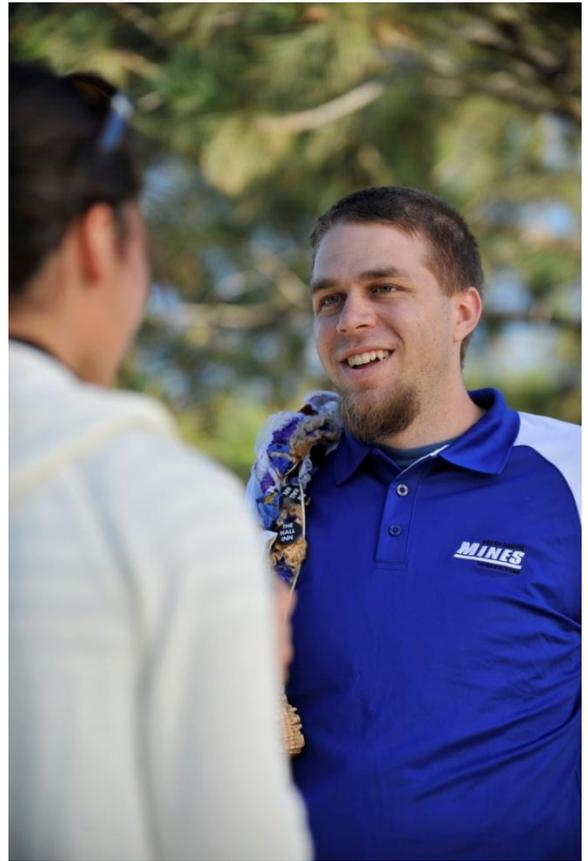
Students who have requested a Financial Aid Consortium Agreement between the School of Mines and a non-Board of Regent institution and are using those credit hours to determine their enrollment status for financial aid, must be withdrawing from both institutions in order for their withdrawal from the School of Mines to result in a refund calculation. Please review the withdrawal procedures outlined elsewhere in the college catalog. Information is also available on our website at:

<http://sdmines.sdsmt.edu/finaid/withdrawal>.

Examples are provided regarding what refund a student could expect to receive based on when he or she withdraws.

#### **IX. Additional Information**

Requests for additional information should be directed to the Financial Aid Office, South Dakota School of Mines and Technology, 501 E Saint Joseph St., Rapid City, SD 57701-3995, or call locally (605) 394-2274, or toll free (877) 877-6044 or via e-mail at [FinancialAid@sdsmt.edu](mailto:FinancialAid@sdsmt.edu).



*Mines Matters:* School of Mines students receive more than \$13.8 million annually in financial aid and scholarships. Eighty percent of School of Mines students receive some form of financial aid, with an average award of \$9,200.

## Academic Information

### Academic Organization

Academic organization of the South Dakota School of Mines and Technology centers around 16 departments.

Faculty and staff members of all departments work closely together to support and develop:

- quality undergraduate educational opportunities;
- focused quality graduate education;
- research and other scholarly activities in support of educational opportunities at the undergraduate and graduate levels;
- service programs for the people of the state of South Dakota, the region, and the nation.

Academic departments at South Dakota School of Mines and Technology are organized as follows:

Atmospheric Sciences  
Chemical and Biological Engineering  
Chemistry  
Civil and Environmental Engineering  
Electrical and Computer Engineering  
Geology and Geological Engineering  
Humanities  
Industrial Engineering and Engineering Management  
Math and Computer Science  
Mechanical Engineering  
Metallurgical Engineering  
Military Science  
Mining Engineering and Management  
Physical Education  
Physics  
Social Sciences

- Minors are available in:

Atmospheric Science  
Computer Science  
Geology  
Geospatial Technology  
Mathematics

Materials Science-Metals  
Occupational Safety  
Physics  
Robotics

See the department sections of this catalog for further details.

- No undergraduate degree program requires a minor.
- Regental undergraduate minors consist of 18-24 semester credit hours.
- No fewer than nine (9) semester credit hours in a minor must be taken at School of Mines.
- A cumulative grade point average of 2.00 or better must be attained in the coursework defining the minor.
- The specific courses required for a minor in each department and program offering a minor can be found in the section of this catalog where that program is described.
- Notification of intent to seek a minor is to be in effect no later than the time of registration for the first semester of the senior year (96 or more credit hours completed) on a form available in the Office of Academic and Enrollment Services . This form must be approved and signed by the head of the department from which the degree will be awarded, and the head of the department from which the minor will be awarded.

### **Certificates**

Certificates are available in:

Construction Management  
Engineering Management and Leadership  
Six Sigma Greenbelt  
Technology Innovation

See department sections of this catalog for further details.

### Credit Hours Definition

The amount of academic work scheduled or “carried” by a student is measured in terms of credit hours. A credit hour is three hours of in-class time and preparation combined per week for

one (1) semester. A recitation or lecture is scheduled as one fifty-minute period plus two (2) hours of preparation for an average student per week per credit hour. Each credit hour of laboratory work is scheduled as one-hundred-ten to one-hundred-seventy (110 to 170) minutes per week. Laboratories scheduled for two (2) hours per credit hour are expected to require one (1) hour of work outside of the scheduled time per week per credit hour.

### **Classification of Undergraduate Students**

All undergraduate students will be assigned one of the following admissions categories:

1. Regular: An admitted, enrolled student, who is pursuing a degree at the School of Mines.
2. Special: An enrolled student who has not been admitted, and is not pursuing a degree, will be permitted to accumulate more than thirty (30) hours only on an exceptional basis. Special students do not qualify for federal student aid or institutional scholarships.

An Admissions Office review is required in order for a student to move from one admissions category to another.

Freshman, sophomore, junior, or senior classification of undergraduate students is based on accumulated credits for courses passed:

- 0 to 31.99 credits - Freshman
- 32 to 63.99 credits - Sophomore
- 64 to 95.99 credits - Junior
- 96 or more credits - Senior

A full-time undergraduate student is defined as a student who is enrolled in at least twelve (12) credit hours during an academic term. An academic term is defined as fall, spring, and summer. A student on a cooperative education assignment who is registered for CP (Co-Op) credit shall be considered to have full-time status.

See the graduate student general information section of this catalog for the definition of a full-time and half-time graduate student.

### **Course Numbering System**

Tuition for courses numbered 000 through 499 will be assessed at the undergraduate rate for all students.

#### **Pre-College Courses**

001-099 Pre-college, remedial skills, special improvement (non-degree credit)

#### **Undergraduate Courses**

- 100-199 Freshman level
- 200-299 Sophomore level
- 300-399 Junior level
- 400-499 Senior level (may be dual listed with 500 level graduate course)

Tuition for courses numbered 500 through 899 will be assessed at the graduate rate for all students.

#### **Graduate Courses**

500-599: Entry level graduate (may be dual listed with a 400 level undergraduate course and may include limited enrollments by undergraduates)

600-699: Graduate level (undergraduate enrollment only by exception)

700-799: Graduate level (Graduate students only)

800-899: Doctoral and post-doctoral level (Doctoral and post-doctoral students only)

#### **Experimental Courses**

Experimental courses can be offered for a maximum of two (2) times before formal approval is received, but they must be reported through the system curriculum approval process.

### **Enrollment in Courses**

#### **A. Undergraduate Courses (001-499)**

1. All undergraduate and graduate students enrolling at Regental universities in courses numbered 001-499 shall be admitted as undergraduate students (either-degree seeking or non-degree seeking) and registered at the

undergraduate level. For all undergraduate and graduate students enrolling at Regental universities in courses numbered 001-499, the courses shall be recorded on the transcript at the undergraduate academic level and included in the calculation of all undergraduate grade point averages.

2. When an undergraduate course is used on a converted credit basis (transferred for one level to another) to meet graduate plan of study requirements at Regental universities, the course shall be recorded on the transcript at the undergraduate academic level with the credit hours approved for the course and then duplicated at the graduate level through an internal transfer policy (Refer to BOR policy 2:5.16). At the undergraduate level, the credit is included in the calculation of the undergraduate institutional grade point average and the undergraduate cumulative grade point average at the full credit rate. At the graduate level, the credit is included in the calculation of the graduate institutional grade point average and the graduate cumulative grade point average at the converted credit rate (transferred for one level to another).

3. Undergraduate courses required as prerequisites in preparation for registration in graduate courses shall be recorded on the transcript at the undergraduate level and will not be duplicated at the graduate level because the courses are not a part of the Regental graduate plan of study.

### **B. Graduate Courses (500-899)**

1. All undergraduate and graduate students enrolling at Regental universities in courses numbered 500-899 shall be admitted as graduate students (either degree seeking or non-degree seeking) and registered at the graduate level. For all undergraduate and graduate students enrolling at Regental universities in courses numbered 500-899, the courses shall be recorded on the transcript at the graduate academic level and included in the calculation of all graduate grade

point averages.

2. When a graduate course is used on a converted (transferred for one level to another) or actual credit basis to meet undergraduate degree requirements for a Regental accelerated program, the course shall be recorded on the transcript at the graduate academic level with the credit hours approved for the course and then duplicated at the undergraduate level through an internal transfer policy (Refer to BOR policy 2:5.16). At the graduate level, the credit is included in the calculation of the graduate institutional grade point average and the graduate cumulative grade point average at the full credit rate. At the undergraduate level, the credit is included in the calculation of the undergraduate institutional grade point average and the undergraduate cumulative grade point average at the converted (transferred for one level to another) or actual credit rate.

### **C. Undergraduate Students Taking Graduate Courses**

Undergraduate students who have completed a minimum of 96 credit hours may enroll in a limited number of 500 level courses. The Vice President for Academic Affairs may grant an exception for enrollment in a 600 level course. The student shall pay graduate tuition and the courses shall be recorded on a graduate transcript. These graduate courses may apply to an undergraduate degree.

### **Graduate Credit**

Graduate credit for School of Mines seniors, per faculty adopted regulations: "An undergraduate student who has senior standing at School of Mines and is ranked in the upper one-half of the class, may petition the Dean of Graduate Education on a form provided by the Office of the Registrar and Academic Services for the purpose that a course be recorded on his/her graduate record."

The following conditions or limitations apply:

1. The student must attest that he/she is planning to continue work toward an advanced degree at

the South Dakota School of Mines and Technology, but must understand that the university is under no obligation to credit courses so attempted toward any advanced degree until a graduate program of study has been approved.

2. The course(s) must be numbered 500-699.
3. The course(s) must not be required for his or her undergraduate degree; the hours may not count toward the 128 or 136 semester credit hours required for the Bachelor of Science degree.
4. The extra courses should not create an overload upon the student.
5. Not more than twelve (12) hours of graduate credit taken as a School of Mines undergraduate may be applied toward an advanced degree at the South Dakota School of Mines and Technology. Upon written justification by the head of the student's major department, the Dean of Graduate Education may approve a minor variance from this limit.
6. Petitions from undergraduate students other than those defined above will not be accepted. (See graduate student general information section of this catalog for graduate policy.)

### **Undergraduate Grading System**

Undergraduate grades will be assigned to the undergraduate academic level and to all courses and sections with course numbers ranging from 001 to 499. Plus and minus grades are not used.

#### **A Exceptional**

4.00 grade points per semester hour

#### **B Above Average**

3.00 grade points per semester hour

#### **C Average**

2.00 grade points per semester hour

#### **D Lowest Passing Grade**

1.00 grade points per semester hour

#### **F Failure**

0.00 grade points per semester hour

#### **S Satisfactory**

Does not calculate into any GPA

#### **U Unsatisfactory**

Does not calculate into any GPA

#### **RI Incomplete (Remedial)**

Does not calculate into any GPA

#### **RS Satisfactory (Remedial)**

Does not calculate into any GPA

#### **RU Unsatisfactory (Remedial)**

Does not calculate into any GPA

#### **W Withdrawal**

Does not calculate into any GPA, no credit granted

#### **AU Audit**

Does not calculate into any GPA

#### **I Incomplete**

Does not calculate into any GPA

#### **IP In Progress**

Does not calculate into any GPA

#### **EX Credit by Exam**

Does not calculate into any GPA

#### **CR Credit**

Does not calculate into any GPA

#### **LR Lab grade linked to recitation Grade**

O credit course

#### **NR Grade not Reported by Instructor**

Does not calculate into any GPA

## **NG No grade**

O credit tracking course

## **TR Note for NSE/MEDT**

Does not calculate into the GPA

## **Academic Amnesty\***

Does not calculate in any GPA, no credit given

\*Letter grade followed by an asterisk indicates Academic Amnesty granted.

## **Incomplete Grade**

An incomplete (I) grade may be granted only when all of the following conditions apply:

- a. A student has encountered extenuating circumstances that do not permit him/her to complete the course.
- b. The student must be earning a passing grade at the time the incomplete is necessitated. Anticipated course failure is not a justification for an incomplete.
- c. The student does not have to repeat the course to meet the requirements.
- d. The instructor must agree to grant an incomplete grade.
- e. The instructor and student must agree on a plan to complete the coursework.
- f. The coursework must be completed within one semester; extensions may be granted by the Vice President for Academic Affairs/Provost.
- g. If the student completes the course within the specified time, the grades that may be assigned are A, B, C, D, F, S, RS, RU, or U.
- h. If the student does not complete the course within the specified time, the grade assigned will be F (Failure) or U (Unsatisfactory) or RU (Remedial Unsatisfactory).

An in progress (IP) grade may be granted only when all of the following conditions apply:

- a. The requirements for the course (for every student enrolled in the course) extend beyond the current term.
- b. The extension beyond the current term must be defined before the class begins.

c. The instructor must request permission to award IP grades for a course from their department head, and then approval must be obtained from the Vice President for Academic Affairs.

d. A definite date for completion of the course must be established in the course syllabus.

An audit (AU) grade may be granted only when the student has elected the AU option on or prior to the census date of the term.

A credit (CR) grade may be granted only for non course credit that is not related to an examination or to equating transfer grades to the BOR grading system. This grade is not used for any Regental university courses.

An examination for credit (EX) grade may be granted only for non course credit validation obtained through a validation process. This grade is not used for any Regental university course.

A grade of NG will be used only with those course sections that are designated as Tracking/Program Sustaining (Q).

Remedial grades (RI, RS, RU) may be granted only for courses numbered 001 to 099.

S Satisfactory/Unsatisfactory (S/U) grade may be granted only when the entire course requires the S/U grade or the student has elected the S/U option on or prior to census date of the term.

## **Definition of Grade Point Averages**

The following grade point averages are calculated each academic term (fall, spring, summer):

Institutional GPA-based on credits earned at a specific Regental university. Utilized to determine if degree requirements have been met and to determine honors designation at graduation.

System Term GPA-based on credits earned at any of the six Regental universities within a given academic term (fall, spring, summer). Utilized to determine minimum progression status.

Transfer GPA-based on credits earned and officially transferred from an accredited college or university outside the Regental system. When a letter grade that normally calculates into the grade point average exists for a non-academic course

(e.g., credit earned via examination), it will be included in the transfer GPA.

Cumulative GPA-based on all credits earned by the student (transfer credit plus system credit). Utilized to determine minimum progression status, to determine if degree requirements have been met and to determine honors designation at graduation.

### **Calculation of grade point averages when undergraduate courses are repeated**

When a course has been repeated for credit, all attempts will be entered on the transcript but the last grade earned will be used in the calculation of the cumulative grade point average (See also 2:5.11).

<b>Class</b>	<b>Credit Hour Range</b>	<b>GPA Standard</b>
Freshman	0-31.99	2.0
Sophomore	32-63.99	2.0
Junior	64-95.99	2.0
Senior	96+	2.0

### **Minimum Progression Standards**

Minimum progression standards and related actions are based on the student's cumulative grade point average and system term grade point average.

1. A student with a cumulative grade point average of 2.0 or better is considered to be in good academic standing.
2. If a student's cumulative grade point average falls below 2.0 in any academic term (i.e. fall, spring, summer), the student is placed on academic probation the following term.
3. While on academic probation, the student must earn a system term grade point average of 2.0 or better.
4. When a student on academic probation achieves a cumulative grade point average of 2.0 or better, the student is returned to good academic standing.
5. A student on academic probation who fails to maintain a system term grade point average of 2.0 or better is placed on academic suspension for a minimum period of two academic terms.
6. Students on academic suspension will not be allowed to register for any coursework at any

Regental university except when an appeal has been approved by the Regental university from which the student is pursuing a degree. An approved appeal granted by one Regental university will be honored by all Regental universities. Also refer to policy 2:3.G Probation/Suspension of Students.

7. Only Academic Suspension will be entered on the student's transcript. Academic probation will be noted in the internal academic record only.

Progression and graduation are contingent on satisfactory performance on the Proficiency Examination. Refer to policy 2:28.

### **Minimum Graduation Standards**

To be awarded a baccalaureate degree, an associate degree or certificate a student must at a minimum have a cumulative GPA of 2.0 or higher.

### **Academic Amnesty**

The goal of academic amnesty is to respond to the academic needs of matured individuals as they develop newly identified potential. Through the application of academic amnesty, the student's prior academic record can be excluded from current work under certain conditions.

### **Eligibility**

The student must:

1. be an undergraduate, full-time or part-time, degree-seeking student at one of the universities in the South Dakota Regental system.
2. not have been enrolled in any Regental university for a minimum of three calendar years (nine (9) consecutive terms including fall, spring, and summer) prior to the most recent admission to the home institution. Exceptions may be granted in rare cases only by the Board of Regents Senior Administrator upon recommendation by the Vice President for Academic Affairs.
3. have completed a minimum of twenty-four (24) graded credit hours taken at any Regental university with a minimum grade point

average of 2.0 for the twenty-four (24) credit hours after the most recent admission to the home institution.

4. not have earned a baccalaureate degree from any university.
5. not have been granted any prior academic amnesty at any Regental university.
6. submit a formal Academic Amnesty Petition to his or her home university following the procedures established by that university.

**Conditions:**

1. Academic amnesty does not apply to individual courses. Academic amnesty may be requested for either (a) all previous post-secondary education courses, or (b) all previous post-secondary education courses at a specific institution, or (c) a specified time period not to exceed one academic year (fall/spring).
2. Academic amnesty, if granted, shall not be rescinded.
3. Courses for which academic amnesty is granted will:
  - a. remain on the student's permanent record.
  - b. be recorded on the student's undergraduate transcript with the original grade followed by an asterisk (\*)
  - c. not be included in the calculation of the student's grade point average because no credit is given.
  - d. not be used to satisfy any of the graduation requirements of the current degree program.
4. Academic amnesty decisions will be made by the student's home institution and will be honored by all other institutions within the South Dakota Regental system.
5. Universities outside of the South Dakota Regental system are not bound by the academic amnesty decisions made by the South Dakota Regental system.
6. Regental graduate programs and graduate professional schools may consider all previous undergraduate coursework when making admissions decisions.

**Dean's List Designation**

Undergraduate, full-time and part-time students may be designated for the Dean's List at the end of the fall and spring terms. The Dean's List designation is determined by the home university and is based on a student's total course registrations for academic credit for the term from any Regental university. The Dean's List designation does not appear on the transcript.

According to the South Dakota Board of Regents policy, undergraduate full-time students must meet the following guidelines to be awarded Dean's List designation:

- Students must have earned a minimum of 12 credit hours in courses numbered 100-699 during the term.
- Students must achieve a System Term GPA of at least 3.50.
- Students with F, I, U, RI, or RU grades are not eligible regardless of System Term GPA attained.

**Academic Recognition for Undergraduate, Part-Time Students**

Undergraduate, part-time students taking fewer than 12 credits per term may be designated for academic recognition for part-time students at the end of the fall and spring terms. The academic recognition for part-time students designation is determined by the home university. The academic recognition for part-time students designation does not appear on the transcript.

To be awarded the academic recognition for part-time students designation, students must meet the following guidelines:

- Students must have completed at least 12 credits hours prior to the current semester at one or more Regental institution.
- The student must have earned at least 3 and up to 11 credit hours of 100-699 level courses during the term.
- Students must achieve a System Term GPA of at least 3.50.
- Students with F, I, U, RI or RU grades are not

eligible regardless of System Term GPA attained.

### **Date for a Grade of W**

Undergraduate and graduate students who drop a course, or withdraw from the System, shall receive a grade of “W” if that action occurs anytime between the day after the census day for that course and the day that corresponds with the completion of 70 percent of the class days for that course. Likewise, a student who withdraws from the system during that time period also shall receive grades of “W” for all the courses in which he/she is registered.

For standard classes, the last day to receive a grade of “W” is determined by calculating 70 percent of the class meeting days in the term, counting from the first day of classes in the term and rounding up if the calculation produces a fractional value greater than or equal to 0.5.

For any non-standard course, the last day to receive a grade of “W” is based on the number of class meeting days for the course, using the method described above.

A notation of the date of withdrawal will be included on the student’s transcript if he/she withdraws from the system.

If a student withdraws from a course after the time period specified above, a grade of “F” will automatically be assigned by the Office of the Registrar and Academic Services.

### **Withdrawal from the University**

The effective date used for students withdrawing from the university is the date that the withdrawal process is initiated in the Office of the Registrar and Academic Services. This notice must be given by the student using the appropriate forms. Dates for withdrawing from the university will be proportionally adjusted for summer terms of instruction.

Complete withdrawal from the university from the day after registration day through 70 percent of the class meeting days in the term results in the assignment of “W” grades unless the professor-in-charge has previously assigned a final grade. A withdrawal from the university must be initiated in the Office of the Registrar and Academic

Services and processed through the Director of Retention and Testing. A withdrawal from the university will be processed only when all courses at all Regental universities are being dropped by a student.

If a student withdraws from the university after completion of 70 percent of class days, grades of “F” automatically are assigned by the Office of the Registrar and Academic Services in all courses for which the student was enrolled unless a final grade has previously been issued by the course instructor. In the event that a final grade has not been assigned, consideration may be given to extenuating circumstances that may warrant the assignment of a grade of “W.” Should such extenuating circumstances exist, students wishing to appeal must complete the Application for Academic Appeal form that is available at the Office of the Vice President for Academic Affairs or can be downloaded from <http://sdmines.sdsmt.edu/studentlife/forms>. Such appeal must be filed within one term after the term in which the withdrawal occurred.

### **Re-admission Following Withdrawal**

A student who has withdrawn from the university may be readmitted in that same semester by permission of the Vice President for Academic Affairs if the student has paid the appropriate tuition and fees.

### **Transcript of Credits**

A transcript of credits is an authentic copy of the student’s academic record from each Regental university attended. The fee is \$5.00 for one copy, and \$2.50 for each additional copy per request. A transcript must include all courses attempted. Transcripts are released only on written request with the signature of the individual concerned. This order must be placed in person, by mail, or by FAX to the Office of the Registrar and Academic Services. Upon graduation each student is entitled to one complete transcript of the credits earned without charge.

### **Attendance**

Every student is expected to attend each lecture or laboratory session for which he or she is

scheduled. The faculty has allowed no system of authorized “cuts.” A student who fails to attend classes regularly must satisfy such requirements as the instructor in a course may prescribe.

### **Excused Absences for School Sponsored Events.**

The faculty recognizes extracurricular activities to be a valued component of student development and education. When an activity results in a classroom absence, the faculty members have agreed to accommodate students involved in these activities in accordance with this policy.

#### **Procedures:**

1. Students who participate in recognized activities will notify their instructors prior to the absence.
2. Students will be given the opportunity to make-up any exams missed in the course of the absence.
3. Students will consult with their instructors regarding the make-up/submission of other graded activities that will be missed as a consequence of the absence.
4. Recognized activities are those determined by the advisor of the sponsoring School of Mines organization or the coach of the involved athletic team. If there are any questions, the advisor or coach should consult with the Vice President for Student Affairs or Athletic Director.
5. All other arrangements (if allowable) for absences not covered under this policy must be decided through consultation between the faculty member and the student, and/or under the guidelines of the class syllabus of the instructor.
6. Unresolved issues may be taken up following the established School of Mines Grievance Procedure for Students Policy III-A-31.

Recognized activities under this policy are determined by the School of Mines advisor/coach. Upon request or as a standard process the advisor/coach may send an e-mail notice verifying the event.

### **Campus Clearing Policy.**

All graduating students are responsible for return of all college property, library books, keys, etc., and payment of all financial obligations to the college before their diplomas will be released.

### **Conduct.**

South Dakota School of Mines and Technology subscribes to the widely recognized traditions and lawful missions of tax-supported higher education in the United States. These traditions and missions work to: (1) develop students to well-rounded maturity, physically, socially, emotionally, intellectually, and vocationally; (2) develop, refine, and teach ethical and cultural values; (3) teach the practice of excellence in thought, behavior, and performance; (4) teach principles of patriotism, civil obligation, and respect for the law; and (5) transfer the wealth of knowledge and tradition from one generation to the other. The regulations established by the Regents, faculty, or administration, have been developed to enhance the opportunities for fulfilling the above purposes. Students are expected to adhere to and support such policies.

In general, students are expected to conduct themselves as responsible citizens at all times and to uphold all federal, state and local laws. Conduct that is held detrimental to the college community (composed of students, faculty, staff and administration) may result in disciplinary action.

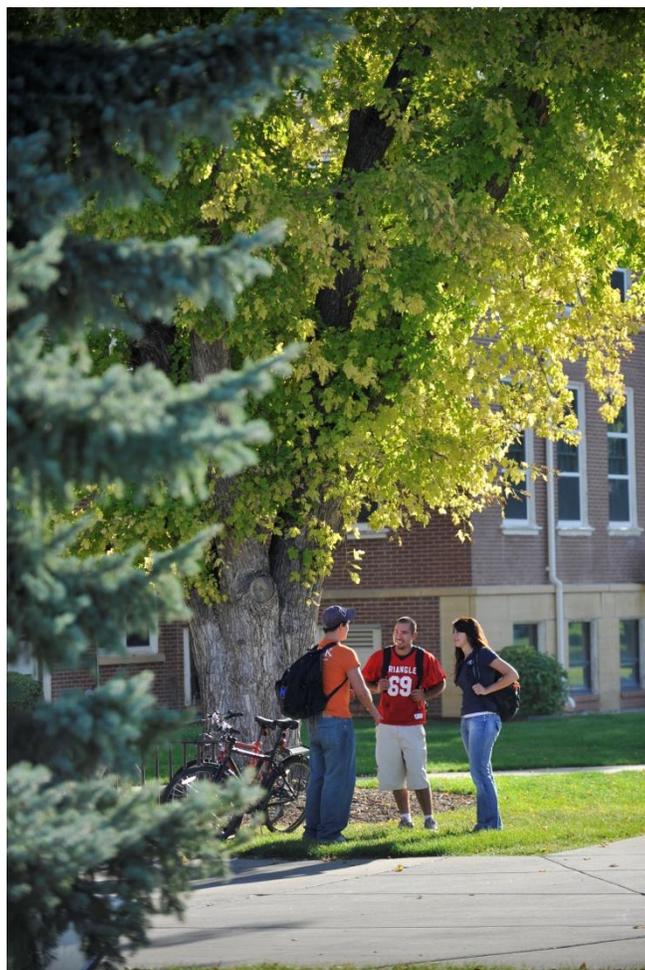
The Regents for the state supported institutions of higher learning in South Dakota have formulated the following policy statement relating to student conduct and behavior:

*The attendance of a student at one of the higher education institutions under the jurisdiction of the Board of Regents is a voluntary entrance into the academic community. By such act the student assumes obligations of conduct and performance imposed by the institution. The constitutional rights of students will not be abridged by action of the academic community. The institutions may discipline or expel the student from the academic community for any intentional act, which disrupts or prevents the accomplishment of any lawful*

*mission, process, or function of the institution or in order to secure compliance with the obligations of conduct and performance imposed. (Regents Policy Manual, Sec. 10.1.2. June 1990)*

Complete details of current policy regarding student conduct, responsibilities, and disciplinary sanctions will be found in the student code of conduct brochure. A Code of Student Rights and Responsibilities and the Board of Regents Policy on Student Conduct was adopted in January of 1995. Adopted policy serves as a basic set of guidelines for students, faculty members, and administration. School of Mines judicial process provides all members of the student body with the facilities for appeal and adjudication.

Admission and enrollment in the university obligates the student to be familiar with and to abide by the standards and the rules and regulations of the university as well as the laws of the various levels of government. Students should be aware of and familiar with such laws, rules, and regulations with respect to their status on the campus, as defined in the student code of conduct. The student code of conduct is printed annually and is available to students at registration or upon request and online. Changes in some of these rules may be desirable from time to time, and student cooperation and participation in bringing about changes through appropriate channels is encouraged. However, violations of existing regulations will not be condoned and disciplinary sanctions may be imposed for such violations.



## **Registration**

### **Academic Terms Defined**

The School of Mines operates a fall, spring, and summer term. Fall and spring shall operate on a semester basis. Summer term begins the day after spring semester ends and continues until the day before fall semester begins.

A semester shall consist of a minimum of 15 weeks. The number of class days in a given semester shall be inclusive of those days set aside for registration, assessment/performance testing and final examinations but exclusive of holidays and days set aside for new student orientation. New student orientation may be concurrent with or prior to registration.

Academic guidelines require that all courses offered for credit must involve a minimum of 15 contact hours over 3 instructional days for each credit hour awarded.

Courses offered by distance education should have equivalent standards, rigor, student outcomes, substance and assignments as courses offered by face-to-face means. Distance education courses may be scheduled on a semester basis and require that students complete learning experiences on a particular timeline (i.e. each week). The required length for a distance education course is determined by course expectations and scheduling. The student will conclude the course upon completion of course requirements. Typically, a one credit hour course lasting for a semester equates to 45 hours of effort by the student.

### **Academic Calendar**

Institutions of higher education, under control of the South Dakota Board of Regents, shall operate on a common academic calendar with common periods during the summer term and the fall and spring semesters at each institution when classes are not in session. Academic calendars shall be designed a minimum of two years in advance with annual extensions recommended to the Executive Director by the Council of Presidents and Superintendents no later than the

May meeting.

### **Holidays**

The schedule of holidays for the institutions of higher education is listed below. Classes shall not be scheduled to meet on holidays.

#### **New Years Day**

January 1\*.

#### **Martin Luther King Jr. Day**

Third Monday in January.

#### **Presidents Day**

Third Monday in February.

#### **Memorial Day**

Last Monday in May.

#### **Independence Day**

July 4\*.

#### **Labor Day**

First Monday in September

#### **Native American Day**

Second Monday in October.

#### **Veterans Day**

November 11\*.

#### **Thanksgiving Day**

Fourth Thursday in November.

#### **Christmas Day**

December 25\*

\* If January 1, July 4, November 11, or December 25 fall on a Sunday, the Monday following shall be observed as the holiday; if they fall on a Saturday, the previous Friday shall be observed as the holiday.

### **Drop and Add Period**

The drop/add period is the time period during which students may adjust their academic schedule for the term without financial or academic consequences. The last day of the

drop/add period for a course is designated as the census date for that course and is the official date for enrollment reporting. The end of the drop and add period for standard and non-standard courses offered in a semester shall be the date the first 10 percent of the term ends or the day following the first class meeting, whichever is later. When calculating 10 percent of the term, breaks of five or more days are not included when counting the total number of days but Saturdays, Sundays, and holidays are. Student registrations can only be added to courses after the end of the drop and add period by approval of the chief academic officer of the university.

### **Registration Changes**

All students will be assigned an academic advisor upon admission; thereafter, all course registrations and changes, other than withdrawal from the university, should be approved by the assigned advisor. Students may request advisor or major changes from the Office of the Registrar and Academic Services.

### **Credit by Validation**

#### **Advanced Placement Program (AP)**

Entering freshman students who have completed an honors course in high school and who have taken and successfully passed appropriate College Entrance Examination Board Advanced Placement test with a score of 3, 4, or 5 may receive course credit. South Dakota Board of Regents policy on specific courses for which credit is given and other requirements are found at: [http://www.sdbor.edu/policy/2-Accademic\\_Affairs/documents/2-5.pdf](http://www.sdbor.edu/policy/2-Accademic_Affairs/documents/2-5.pdf).

#### **College Level Examination Program (CLEP)**

The South Dakota Board of Regents and its universities encourage high school student to pursue rigorous academic programs and to take advantage of opportunities available to them to earn college credit. The College Board's College Level Examination Program (CLEP) provides an opportunity to earn college credit. Colleges and universities award college credit for satisfactory

performance on the CLEP examinations. Satisfactory performance on CLEP examinations can reduce the cost of college education by reducing the number of credits a student must take to complete the degree. CLEP tests may be retaken only following a lapse of six months. South Dakota Board of Regents policy on specific courses for which credit is given and other requirements are found at:

[http://www.sdbor.edu/policy/2-Accademic\\_Affairs/documents/2-5.pdf](http://www.sdbor.edu/policy/2-Accademic_Affairs/documents/2-5.pdf).

#### **International Baccalaureate (IB)**

School of Mines recognizes the rigor of IB courses and the IB Diploma Program and encourages students to complete higher level courses and exams when ready. Students who complete higher level courses and exams and obtain a score of five (5) or above will be considered for advanced placement credit in the corresponding courses. South Dakota Board of Regents policy on specific courses for which credit is given and other requirements are found at: [http://www.sdbor.edu/policy/2-Accademic\\_Affairs/documents/2-5.pdf](http://www.sdbor.edu/policy/2-Accademic_Affairs/documents/2-5.pdf).

#### **Credit by University Examination**

The School of Mines faculty has adopted a policy to permit college credit by university examination. Any student enrolled in the college who has studied a subject independently or who has completed equivalent college level course elsewhere for which he or she is unable to get a transcript acceptable to this institution may request a special examination to establish credit under the conditions specified below:

1. The student must consult his or her advisor and the head of the department in which the course is offered, who will conduct a preliminary survey of the work in which the student claims to be prepared and will determine whether an examination is warranted, what topics it should cover, and what credit may be expected.
2. After determining eligibility to take an examination the candidate pays a per-subject fee at the Office of Student Accounts/Cashier's Office and then secures

the appropriate form from the Office of the Registrar and Academic Services.

3. If the student successfully completes the examination, the permanent record will show "Credit by Examination" with a grade of "EX". No entry will be made on a permanent record if the examination is failed.
4. Credit by examination is not permitted if the student has previously completed the course for collegiate credit.

### **Credit by Verification**

Credits earned through validation methods other than nationally recognized examinations (that is, university administered tests and verification like military credit or prior learning) are not allowed:

1. To exceed 32 credits for baccalaureate degrees
2. To exceed 16 credits for associate degrees
3. If the student previously visited or is currently registered for the class
4. For any graduate level courses (exceptions for some programs)

### **Dual Use of Credit**

Many high school students complete college-level courses while enrolled in high school. School of Mines encourages talented high school students to extend their educational background in this manner. South Dakota law provides that students in grades 10, 11 and 12 may enroll in higher education as a special student in a course or courses offered with the school district's approval, and these courses may be applied to high school graduation requirements. See Admissions procedures for further information.

### **Undergraduate Pass-Fail Option**

1. Any undergraduate student with a minimum cumulative GPA of 2.00 at South Dakota School of Mines and Technology is eligible to elect one free elective course per semester on a pass or fail basis. Courses taken under the Pass/Fail option cannot be used to satisfy the sixteen (16) credit hours of humanities/social science requirement for the bachelor of science degree.

2. The student shall notify the Office of the Registrar and Academic Services in writing of his or her request that the course be graded on a pass or fail basis. Only the Office of the Registrar and Academic Services and the student's advisor are to be notified of the intention of the student to be graded on a pass or fail basis. A student will have the option during the drop and add period of each semester to change from pass or fail to traditional grading, or vice versa.
3. The instructor will report the student's grade based on the college's regular grading system. If a grade of "D" or better is recorded, the student will receive a "Satisfactory," a grade of "U" will be recorded as a "Fail," and the "U" grade will count in calculating credits attempted.
4. Credits earned under this option may be used toward a student's graduation requirements, if appropriate and applicable, but only if a grade of "S" is recorded. A passing grade will be recorded as "S" and will not be used in the calculation of the student's GPA. A course taken on a pass or fail basis will not be converted, after a grade has been recorded, to a traditional grade for the purpose of improving a GPA.
5. The pass or fail option shall apply only to the student's first registration in a course.

### **Registration Retake Policy**

The registration retake policy defines how many times a student may register for (take) a course.

The retake policies approved by the BOR are as follows:

1. A student will be allowed a total of three takes for undergraduate courses (course numbers of 001 to 499) for which credit is only counted toward graduation once. The student must petition in writing to the Vice President for Academic Affairs to be permitted to take an undergraduate course more than three times.

Students wishing to appeal must complete the Application for Academic Appeal form that is available at the Office of the Vice President for Academic Affairs or can be

downloaded from:

<http://sdmines.sdsmt.edu/studentlife/forms>. At the undergraduate level only the LAST attempt (take) of the course will count toward graduation and into the grade point average calculations.

2. A student will be allowed a total of two takes for graduate courses (course numbers of 500 or above) for which credit is only counted toward graduation once. The student must petition the graduate dean for permission to take a graduate course more than two times.
3. A student will be allowed unlimited takes for an undergraduate or graduate course for which credit toward graduation may be received more than once (e.g., Independent Study, Thesis). All takes will count into grade point average calculations. Individual departments/majors may limit the number of credits allowed toward graduation in certain courses. Students should check with their advisor.
4. The Audit (AU) grade is the only grade that will not be counted as a take of a course. All other grades, including Withdraw "W" grade, will count as a take of a course.
5. Transfer courses and non-courses (CLEP, credit by exam) will also count as a take of a course.
6. The count for retakes will begin with courses in which students are enrolled fall 2003. Takes of a course prior to fall 2003 will not be counted.

### **Audited Courses and Registrations for No Credit**

The outside preparation of auditors is entirely voluntary. Their participation in classroom discussions and examinations, and the minimum attendance requirements are subject to arrangements with the instructor of the course being audited. Failure to meet these arrangements will be cause for changing the grade in the course from "AU" to "W." An auditor is allowed neither credit nor a grade for the course even if the auditor satisfactorily passes the final examination of the course. An audited course cannot count toward the definition of a full-time load for

purposes of securing financial aid nor for establishing eligibility to compete in intercollegiate contests. An audited course may not be used to qualify for a reduced tuition rate, but will be counted toward any upper limits on the number of credit hours a student may carry, and will be counted in determining requirements for paying campus fees.

A course taken for no credit but with a grade will be treated the same as an audited course except that the student will be expected to prepare and participate in the course to the same extent as all other students. The grade awarded will not be counted in the student's grade point average.

The request to audit a course or to enroll with no credit must be made at the time of the drop and add period by written petition to the Office of the Registrar and Academic Services. The petition has no effect on the tuition charges for a course.

### **Overloads**

A normal student load is 18 credit hours or fewer. An overload is a course load in excess of 18 credit hours.

To register for an overload, students must consult with their academic advisors. Student requests for overload enrollments should be submitted in writing to their college dean (or equivalent) at their "HOME" institution to grant the approval for registration in credits beyond the overload status. This approval will normally be granted based on a student's exceptional past academic experience.

### **Deadlines for Adding Courses**

1. Students may add daytime or night courses to their schedules through the first 10 percent of the term. When calculating 10 percent of the term, breaks of five or more days are not included but Saturdays, Sundays, and holidays are. This date is listed in the Academic Calendar, which is on the inside front cover of this catalog.
2. In exceptional circumstances, students may add daytime or night courses with the permission of the instructor and the department head responsible for the student's

proposed additional course, through the 15th day of classes.

3. Students wishing to add daytime or night courses beyond the period specified above must file a written appeal with the Vice President for Academic Affairs/Provost (or their designee); the appeal must be signed by the student and approved by the instructor of the course involved and the student's advisor.
4. Students may add summer term courses through the first 10 percent of the term. When calculating 10 percent of the term, breaks of five (5) or more days are not included but Saturdays, Sundays, and holidays are.
5. In extreme circumstances, students may add summer school courses after this period with permission of the instructor and the Vice President for Academic Affairs (or their designee).
6. No student will be permitted to attend any class unless he/she is registered and listed on the class attendance roll.
7. Following fee assessment, the students are required to pay for all additional tuition and fees at the Student Accounts/Cashier's Office. Failure to pay may result in students being dropped from the sections that they added. It is the responsibility of the instructor in each class to check the class roll carefully during the first few weeks of each semester to be certain that all students attending a given class are listed on the class roll. Any student whose name does not appear on the class roll should not be permitted to attend that class and should be referred to the Office of the Registrar and Academic Services promptly for clarification of his or her status.
8. Students can add and drop courses by using WebAdvisor, a web interface to the Colleague Student Information System.

### **Deadlines for Dropping a Course**

Please see "Date for a Grade of W" on page 34 for information about dropping a course.

### **Mandatory Placement Procedure**

A mandatory placement procedure for mathematics and English is used at all Regental

universities in the state. The instruments and criteria used for other mandatory placement are at the discretion of each institution.

The ACT is the required initial test used to place students who attend a South Dakota regental university into their mathematics and English courses. A student can be placed in classes via the ACT sub-scores for math and English, or, for more accurate placement, using the ACT COMPASS test, which is administered at South Dakota universities such as the School of Mines. The COMPASS test is administered on a computer and takes approximately 30 to 40 minutes for each section (math, writing, and reading). Students who need to take the COMPASS test should sign up for and attend a COMPASS Day (dates are listed below) by going to the New Student Checklist from the Mines homepage or contact the Registrar and Academic Services Office at (605) 394-2400.

Students will need to take all or part of the COMPASS test if:

1. They have not taken the ACT within five years from date of enrollment and have not taken and passed any college level English or math courses.
2. They scored above 24 on their ACT math.
3. They scored a 24 or less on their ACT math and want to challenge their course placement. Students have the option of taking the higher of the two scores, but are warned that a deficiency warrants serious contemplation and students should consider the class that best reflects the requirements of math success. At School of Mines, advanced math, especially calculus, is a mainstay in the curriculum, regardless of major.
4. They scored 17 or less on their ACT writing.

COMPASS results are designed to assist the institution in placing students into appropriate math and English courses or, if necessary, into developmental or preparatory courses. We caution students that successful completion of a high school course (e.g., trigonometry) does not

guarantee that this course has been mastered at the college level. Placement is confirmed by passing the appropriate COMPASS test area.

### **Cooperative Education Program**

A partnership with business, industry, and government agencies, the Cooperative Education Program provides students with opportunities to apply their classroom learning to “real world” work experiences in industry. Co-op students are hired by employers to work in positions related to their major. Minimum GPA and other co-op eligibility requirements vary among employers. Interested students should contact the Career Center or their department’s Cooperative Education Coordinator. Students are responsible for securing their own co-op positions and are encouraged to register with the Career Center for assistance with identifying and applying for co-op opportunities. After accepting a co-op offer, students are to inform the Career Center of their co-op employer, salary, and dates of employment.

During their co-op work experience, students are expected to apply knowledge learned in the classroom and to grow professionally through development of their interpersonal, communication, teamwork, and workplace etiquette skills.

#### **1. Academic Credit:** 1 to 3 credits.

Prerequisite: Permission of instructor. Credit is available for each semester or summer work experience upon approval by the departmental Cooperative Education Coordinator. Students must satisfy departmental requirements in order to earn credit for their co-op. Requirements include a written report of the work experience and an employer’s evaluation of work performance. Because the work performed by a student working full-time while on co-op is equivalent to the workload of a full-time student, a student on co-op who is registered for CP credit shall be considered to have full-time status.

**2. Administration:** The Cooperative Education Steering Committee is comprised of the departmental Cooperative Education Coordinators, the Provost and Vice President for

Academic Affairs, and the director of Career Center. The committee is responsible for developing cooperative education industrial or business experiences; assisting students with identifying co-op opportunities; maintaining contact with cooperative education employers; and conducting an on-going evaluation of the program. For additional information, contact the director of Career Center (605) 394-2667 or visit: <http://careers.sdsmt.edu/>.



## **Bachelor of Science Graduation Requirements**

An Application for Graduation and Commencement must be completed by the date indicated on the academic calendar which is located in the academic calendar section of the catalog. If you are completing degree requirements during the summer term you must complete the form for the preceding May graduation. A student is allowed to walk only once in a commencement ceremony. Students must be actively enrolled in the semester that they graduate and meet the requirements of the degree, or they must meet the requirements that are in place at the time they request the degree be granted. This form is online.

### **Minimum Graduation Standards**

To be awarded a baccalaureate degree, an associate degree or a certificate a student must at a minimum have a cumulative GPA of 2.0 or higher.

### **Baccalaureate Degree**

The institution granting the degree determines the honors designation for its graduates. To earn an honors designation at graduation, the student must meet both the following cumulative and institutional grade point averages:

#### **Summa Cum Laude:**

equal to or greater than 3.90

#### **Magna Cum Laude:**

equal to or greater than 3.70 and less than 3.90

#### **Cum Laude:**

equal to or greater than 3.50 and less than 3.70

The student must have completed a minimum of 64 credit hours at the institution granting the degree. Courses that are part of a formal collaborative agreement among Regental universities are considered to be earned from the institution granting the degree.

### **Associate Degree**

The institution granting the degree determines the honors designation for its associate-level graduates. To earn an honor designation at graduation, an associate-level graduate must meet both the following cumulative and institutional grade point averages:

#### **With highest honor:**

equal to or greater than 3.90

#### **With high honor:**

equal to or greater than 3.70 and less than 3.90

#### **With honor:**

equal to or greater than 3.50 and less than 3.7

An associate-level graduate must have completed a minimum of 32 credit hours at the institution granting the degree. Courses that are part of a formal collaborative agreement among Regental universities are considered to be earned from the institution granting the degree.

### **Two Bachelor of Science Degrees From South Dakota School of Mines and Technology**

An undergraduate student who wishes to qualify for a second bachelor of science degree conferred by School of Mines must complete a minimum of thirty (32) semester hours of credit in residence beyond the credit hours used for the first B.S. degree.

Students should report their intent to pursue two (2) bachelor of science degrees to the Office of the Registrar and Academic Services. This action will initiate the assignment of an advisor in each discipline.

### **General Requirements**

The following rules on graduation requirements apply for the bachelor of science degree in any curriculum offered by the university. Requirements that apply to many or all programs are described below. Please refer to the

curriculum for an individual degree program for specific course requirements. Each candidate for a degree is personally responsible for meeting all requirements for graduation. No university official can relieve a candidate of this responsibility.

The South Dakota School of Mines and Technology reserves the right to change any course of study or any part of a curriculum in keeping with accreditation, educational, and scientific developments.

### **General Education Core Requirements**

General education core requirements must be completed within the first sixty-four (64) credits. Requests for exceptions to these general education requirements must be approved by the student's advisor and by the Vice President for Academic Affairs/Provost. The required core is listed below.

#### **Goal #1**

Students will write effectively and responsibly and understand and interpret the written expression of others.

Student Learning Outcomes: As a result of taking courses meeting this goal, a student will

1. Write using standard American English, including correct punctuation, grammar, and sentence structure;
2. Write logically;
3. Write persuasively, with a variety of rhetorical strategies (e.g., expository, argumentative, descriptive);
4. Incorporate formal research and documentation in their writing, including research obtained through modern, technology-based research tools.

Each course meeting this goal includes the following student outcomes:

Required: #1, #2, #3, and #4

**Credit Hours:** 6 hours

#### **Courses:**

ENGL 101    Composition I  
ENGL 201    Composition II  
ENGL 279/289    Technical Communications I

and II<sup>1</sup>

<sup>1</sup> Engineering and sciences students at School of Mines take this six credit sequence in the sophomore and junior years. Both courses develop written and speech communications in an integrated fashion in the context of the major. Students must finish the entire sequence, as well as ENGL 101, to satisfy the requirements of Goal #1 and Goal #2.

#### **Goal #2**

Students will communicate effectively and responsibly through speaking and listening.

**Student Learning Outcomes:** Courses satisfying this goal will require students to

1. Prepare and deliver speeches for a variety of audiences and settings;
2. Demonstrate speaking competencies including choice and use of topic, supporting materials, organizational pattern, language usage, presentational aids, and delivery;
3. Demonstrate listening competencies by summarizing, analyzing, and paraphrasing ideas, perspectives and emotional content.

**Credit Hours:** 3 hours

Courses:

ENGL 279/289    Technical Communications I and II<sup>1</sup>  
SPCM 101        Fundamentals of Speech

<sup>1</sup>Technical Communications I and II develop written and speech communications in an integrated fashion in the context of the major. Students must finish the entire sequence, as well as ENGL 101, to satisfy the requirements of Goal #1 and Goal #2.

#### **Goal #3**

Students will understand the organization, potential, and diversity of the human community through study of the social sciences.

Student Learning Outcomes: As a result of taking courses meeting this goal, students will

1. Identify and explain basic concepts, terminology and theories of the selected social science disciplines from different spatial, temporal, cultural, and/or institutional contents.
2. Apply selected social science concepts and theories to contemporary issues;
3. Identify and explain the social or aesthetic values of different cultures. In addition, as a result of taking course meeting this goal, students will be able to demonstrate a basic understanding of at least one of the following:
  - The origin and evolution of human institutions;
  - The allocation of human or natural resources within societies;
  - The impact of diverse philosophical, ethical or religious views.

Each course meeting this goal includes the following student learning outcomes:

Required: #1, #2, and #3

At least one of the following: #4, #5, or #6

**Credit Hours:** 6 hours in two disciplines

**Courses:**

ANTH 210	Cultural Anthropology
GEOG 101	Introduction to Geography
GEOG 210	World Regional Geography
GEOG 212	Geography of North America
HIST 151/152	United States History I/II
POLS 100	American Government
POLS 210	State and Local Government
POLS 250	World Politics
PSYC 101	General Psychology
SOC 100	Introduction to Sociology
SOC 150	Social Problems
SOC 250	Courtship and Marriage

**Goal #4**

Students will understand the diversity and complexity of the human experience through study of the arts and humanities.

Student Learning Outcomes: As a result of taking courses meeting this goal, students will

1. Demonstrate knowledge of the diversity of values, beliefs, and ideas embodied in the human experience;
2. Identify and explain basic concepts of the selected disciplines within the arts and humanities. In addition, as a result of taking courses meeting this goal, students will be able to do at least one of the following:
  - Identify and explain the contributions of other cultures from the perspective of the selected disciplines within the arts and humanities;
  - Demonstrate creative and aesthetic understanding;
  - Explain and interpret formal and stylistic elements of the literary or fine arts;
  - Demonstrate foundational competency in reading, writing, and speaking a non-English language.

Each course meeting this goal includes the following student learning outcomes:

Required: #1, #2

At least one of the following: #3, #4, #5, or #6

**Credit Hours:** 6 hours in two disciplines or in a sequence of foreign language courses)

**Courses:**

ART 111/112	Drawing I and II
ARTH 211	History of World Art I
CHIN 101/102	Introductory Chinese I and II
ENGL 210	Introduction to Literature
ENGL 212	World Literature II
ENGL 221/222	British Literature I and II
ENGL 241/242	American Lit I and II
ENGL 250	Science Fiction
GER 101/102	Introductory German I and II
HIST 121/122	Western Civilization I and II
HUM 100	Introduction to Humanities
HUM 200	Connections: Humanities and Technology
MUS 100	Music Appreciation
PHIL 100	Introduction to Philosophy
PHIL 200	Introduction to Logic
PHIL 220	Introduction to Ethics
PHIL 233	Philosophy and Literature

SPAN 101/102 Introductory Spanish I and II

**Goal #5**

Students will understand and apply fundamental mathematical processes and reasoning.

Student Learning Outcomes: As a result of taking courses meeting this goal, students will

1. Use mathematical symbols and mathematical structure to model and solve real world problems;
2. Demonstrate appropriate communication skills related to mathematical terms and concepts;
3. Demonstrate the correct use of quantifiable measurements of real world situations.

Each course meeting this goal includes the following student learning outcomes: Required: #1, #2, and #3

**Credit Hours:** 3 hours

Courses:

MATH 102	College Algebra
MATH 115	Precalculus
MATH 120	Trigonometry
MATH 123	Calculus I
MATH 125	Calculus II
MATH 225	Calculus III
MATH 281	Statistics

**Goal #6**

Students will understand the fundamental principles of the natural sciences and apply scientific methods of inquiry to investigate the natural world.

Student Learning Outcomes: As a result of taking courses meeting this goal, students will

1. Demonstrate the scientific method in a laboratory experience;
2. Gather and critically evaluate data using the scientific method;
3. Identify and explain the basic concepts, terminology and theories of the selected natural sciences;
4. Apply selected natural science concepts and theories to contemporary issues.

Each course meeting this goal includes the following student learning outcomes: Required: #1, #2, #3, and #4.

**Credit Hours:** 6 hours

Courses:

BIOL 151/151L	General Biology I and Laboratory
BIOL 153/153L	General Biology II and Laboratory
CHEM 106/106L	Chemistry Survey/Laboratory
CHEM 108/108L	Organic Chemistry/Laboratory
CHEM 112/112L	General Chemistry I and Laboratory
CHEM 114/114L	General Chemistry II and Laboratory
GEOL 201/201L	Physical Geology/Laboratory
PHYS 111/111L	Introduction to Physics I and Laboratory
PHYS 113/113L	Introduction to Physics II and Laboratory
PHYS 211	University Physics I
PHYS 213/213L	University Physics II and Laboratory

**Goal #7**

Students will recognize when information is needed and have the ability to locate, organize, critically evaluate, and effectively use information from a variety of sources with intellectual integrity.

Student Learning Outcomes: As a result of taking courses meeting this goal, students will

1. Determine the extent of information needed;
2. Access the needed information effectively and efficiently;
3. Evaluate information and its sources critically;
4. Use information effectively to accomplish a specific purpose;
5. Use information in an ethical and legal manner.

Each course meeting this goal includes the following student learning outcomes: Required: #1, #2, #3, #4, and #5

**Credit Hours:** 9 hours

Courses:

ENGL 101	Composition I
SPCM 101	Fundamentals of Speech
ENGL 201	Composition II
ENGL 279/289	Technical Communications I and II <sup>1</sup>

### **General Education Globalization/Global Issues and Writing Intensive Requirements**

In addition to the seven system-wide general education requirements described above, all students will achieve learning outcomes focused on advancing their writing skills and their knowledge of global issues. Each academic program has designated one or more classes (the equivalent of one credit hour of study) as meeting each of these requirements. The syllabi of the courses designated state the requirement(s) met and explain how student achievement of the outcomes are assessed and factored into the course grade.

#### **Globalization/Global Issues Goal Statement**

Students will understand the implications of global issues for the human community and for the practice of their disciplines.

**Student Learning Outcomes:** As a result of taking courses meeting this goal, students will

1. Identify and analyze global issues, including how multiple perspectives impact such issues; and
2. Demonstrate a basic understanding of the impact of global issues on the practice of their discipline.

#### **Writing Intensive Goal Statement**

Students will write effectively and responsibly in accordance with the needs of their own disciplines.

**Student Learning Outcomes:** As a result of taking courses meeting this goal, students will

1. Produce documents written for technical, professional, and general audiences within the context of their disciplines;
2. Identify, evaluate, and use potential sources of information from within their

- disciplines for writing assignments that require research and study; and,
3. Use instructor feedback throughout the semester to improve the quality of their writing.

### **Pre General Education Courses in English and Mathematics**

Pre-general education courses include ENGL 031, ENGL 032, ENGL 033, MATH 021, and MATH 101.

### **Completion of Pre General Education Courses**

1. Students placed in pre general education courses must enroll in and complete the courses within the first 30 credits hours attempted.
2. If a student does not complete the pre general education course(s) within the first 30 credit hours attempted, a registration hold is placed on the student's record. During the next 12 credit hours attempted, the student must enroll in and complete the pre general education course(s).
3. If the pre general education course(s) is not completed within the first 42 credit hours attempted, the only course(s) in which a student may enroll is the pre general education course(s); and the student's status is changed from degree seeking to non degree seeking.
4. Students transferring from non-Regental institutions must enroll in pre-general education courses during the first 30 attempted Regental credit hours. These students may enroll in other courses concurrently with the pre-general education courses. If the student does not complete the pre-general education courses during the first 30 Regental credit hours attempted during the next 12 credit hours attempted, the student must enroll in and complete the pre-general education course(s). If the student does not successfully complete the pre-general education course(s) within 42 attempted Regental credit hours, the only course(s) in which a student may enroll in the pre-general education course(s); and the student's status is

changed from degree seeking to non-degree seeking. The Vice President for Academic Affairs/Provost may grant an exception. Credit hours for the pre general education courses are included in the total number of credit hours attempted.

The grades assigned for courses numbered less than 100 will be RI, RS and RU.

### **Other Curricular Requirements**

- A. Humanities and social sciences requirements: minimum of 15 or sixteen 16 credit hours - This subject area must include six credits in humanities and 6 credits in social sciences. The number required for each major is listed in the department section of the catalog. Students majoring in engineering must complete at least three of these credits at an advanced level.

#### **Humanities**

Art: ART 111, 112, ARTH 211, 321, 491, 492  
English: ENGL 210, 212, 221, 222, 241, 242, 250, 300, 330, 343, 350, 360, 374, 383, 391, 392  
Foreign Language: CHIN 101, 102, GER 101, 102, SPAN 101, 102  
History: HIST 121, 122  
Humanities: HUM 100, 200, 291, 292, 350, 375, 491, 492  
Music: MUAP 200, 201, MUS 100, 110, 217, 317  
Philosophy: PHIL 100, 200, 220, 233

#### **Social Sciences**

Anthropology: ANTH 210  
Geography: GEOG 101, 210, 212, 400, 492  
History: HIST 151, 152, 492  
Political Science: POLS 100, 250, 350, 407, 492  
Psychology: PSYC 101, 319, 323, 331, 391, 392, 451, 461  
Sociology: SOC 100, 150, 250, 351, 391, 392, 411, 420

All courses numbered 300 and above are upper level courses.

- B. All degree candidates must complete ENGL 101, ENGL 279, and ENGL 289, which cannot be used to meet the humanities and social sciences requirements.
- C. Physical Education: minimum of 2 credit hours. MUEN 101, 121, 122, and MSL 101L and MSL 102L can be counted for the physical education requirement.
- D. Electives: Free Electives vary with the individual department. Any course may be selected which is at freshman level or higher (i.e. 100 level or higher). ROTC credits may be accepted, depending on the number of degree electives available in each department.
- E. Science Electives: Courses may be selected — from biology, chemistry, geology, physics, or atmospheric science.

For information regarding the Associate of Arts degree requirements, see page 94.

#### **Semester Credit and Grade-Point Average**

Additional requirements are listed with each departmental curriculum found in a later section of this catalog. All curricula require passing grades in the prescribed courses and a minimum cumulative grade point average of 2.00. Each engineering curriculum requires 136 hours of credit for graduation and each science curriculum requires one 128 hours of credit.

#### **Military Science Credits**

Military Science credits may apply to all degrees as free electives. This option varies with the number of free electives available in an individual curriculum. A veteran may petition the Registrar and Director of Academic Services to receive credit for basic military science and physical education.

#### **Transfer Credit**

Articulation of credit may be allowed for previous college education if the courses are equivalent to required or elective courses at this university and if each course presented is of

passing quality.

The acceptability of transfer credit is determined by the student's major department.

### **Credit Definitions**

#### **Credits in Residence**

Credit in residence within the Board of Regents system is a course offered by any of the degree-granting Regental institutions at any approved sites using any approved method of delivery.

#### **Institutional Credits**

An institutional credit is a credit offered by the degree granting institution and includes credits that are part of a formal collaborative agreement between that institution and another Regental institution.

#### **Validated Credits**

Credit earned for college level courses by validation methods such as Credit by Exam, CLEP, AP, portfolio, and others within the Regental system will not be considered "credits in residence."

### **Institutional Credit Requirements for Degree-Seeking Students**

1. Minimum number of credit hours that must be earned from the institution granting the degree:

Baccalaureate	32 hours
Associate	16 hours

2. Number of the last credit hours earned preceding completion of the degree that must be earned from the institution granting the degree:

Baccalaureate	16 of the last 32 hours
Associate	8 of the last 16 hours

3. Minimum number of credit hours specified in the major or minor requirements that must be completed at the degree granting institution: 50 percent. However, this requirement may be

waived for students enrolled in the set of majors offered by the system's Centers which include in the established programs of study common courses offered by one of the other Regental universities. In addition, the Vice President for Academic Affairs/Provost may make exceptions to this requirement for individuals based on the student's prior learning experiences.

#### **Required Check-out Procedure**

All graduating seniors and students terminating enrollment at School of Mines are responsible for ensuring that they have returned all keys, library books, laboratory equipment, and other university property to the appropriate departments prior to graduation or their last day of enrollment. All financial obligations to the university or any of its departments must also be paid prior to graduation or termination of enrollment at School of Mines.

Perkins Student Loan recipients must complete an exit interview with a Business Office representative prior to graduation or termination of enrollment at School of Mines. The university reserves the right to withhold a student's diploma and/or transcript of grades for failure to meet any of the above specified requirements.

### **Collegiate Assessment of Academic Proficiency**

#### **CAAP Exams Required for Graduation**

The South Dakota Board of Regents has mandated that all students attending a state university in South Dakota and seeking their first undergraduate degree take and pass the Board of Regents Proficiency Examination. Baccalaureate degree-seeking students will sit for the exam on completion of 48 passed credit hours at or above the 100 level and associate degree-seeking students will sit for the exam on completion of 32 passed credit hours at or above the 100 level. Enrolled students who have already earned a baccalaureate degree are exempt from the requirement.

Testing will be offered during a two-week period during the fall and spring semesters. Students who fail to sit for the exam, when required to do so, will not be allowed to register

for courses at any of the state universities for two academic terms unless the student seeks and is granted a deferment for a valid cause (i.e. co-op, internship, etc).

Students failing to achieve the minimum proficiency level on one or more components of the exam will be allowed to retest. Retesting must occur within one year of after initial testing. During that year, students may continue to enroll in courses. As preparation for retesting, students are required to complete a development plan for remediation, within one month of notice of failure and in collaboration with the director of Retention and Testing. Students will be able to retest twice during that year and a fee of \$12.00 will be charged to cover the cost of testing.

Students will be informed by the testing office when they are eligible to test. Approximately four to six weeks after a student has tested, he or she will receive the results and an explanation of how to interpret his or her achievement. Students who failed to achieve an acceptable score within one year from initial testing will not be permitted to continue their enrollment. An appeal process for certification of proficiency using alternate methods is available to those students.



## Policies and Procedures

The policies and procedures listed in this section were established by the South Dakota Board of Regents and/or South Dakota School of Mines and Technology. For further information regarding policies in this section, please contact one of the Vice President's Offices at the university or visit:

<http://sdmines.sdsmt.edu/sdsmt/policies>.

### **Computer and Network Usage Guidelines and Policy**

Students, faculty, staff and others affiliated with School of Mines are provided access to computing and networking services for use in academic pursuits and other activities that advance the goals of the institution.

All computer users must be properly registered and authorized through Information Technology Services (ITS). In accepting authorization to use computing or networking services, a user agrees to comply with all applicable federal, state and local laws and all regulations and policies of both the university and the Regents of the state of South Dakota.

Individuals should guard their electronic identity. Choose secure passwords, and never reveal them to anyone. Individuals can be held liable for activity carried out by others using their accounts. Keep all passwords and access mechanisms secure and private. Facilities and network services are provided for use only by account holders, not their family members or friends.

Theft, misuse, or other abuse of computing or networking services will not be tolerated and may result in loss of computer and/or network privileges, disciplinary action, criminal or civil prosecution.

To connect to the wireless network, we require a wireless equipped laptop and Windows XP/Vista operating system. Instructions on how to connect are located on the ITS website:

<http://its.sdsmt.edu>.

All guidelines and terms of use apply to ALL

computer usage, wireless as well as wired desktop and laptop.

Unacceptable activities include, but are not limited to:

- Unauthorized file access or file transfer;
- Use of another individual's identification, password, or account;
- Use of computing or networking facilities that interferes with the work of another student, faculty member, or university official, or with the normal operation of computers, terminals, peripherals, or networks at the university or elsewhere;
- Making, acquiring, or using unauthorized copies of computer software or violating terms of applicable software licensing agreements;
- Use of computer or network systems that result in violation of copyright law;
- Running, installing, or distributing any program intended to damage or to place excessive load on a computer system or network;
- Attempting to circumvent data protection schemes through any mechanism, including unauthorized access or tampering with security;
- Electronically posting or distributing materials resulting in any violation of existing laws, regulations, or university or Regental policies;
- Attempting to monitor or tamper with another person's electronic communications, or reading, copying, changing, or deleting another person's files or software without the explicit agreement of that person; and
- Providing access to computer accounts, Internet connectivity, electronic mail, or other significant services to persons not authorized for use of School of Mines facilities, resources, or network services. For example, students with computers hosted on the residence hall network may not permit family or friends to use these services. Although these guidelines cover most aspects of the policy, a full copy of the current university policy on acceptable use of

computing and network resources may be found at: <http://its.sdsmt.edu/student/8408/>.

### **Family Educational Rights and Privacy Act (FERPA) of 1974 or Buckley Amendment**

The purpose of FERPA is to protect the privacy rights of students from the indiscriminate collection, maintenance, disclosure, and release of personally identifiable student information, including information regarding student status or performance.

Under FERPA each current and former student at School of Mines has the following fundamental rights:

- The right to review and inspect the student's education records.
- The right to request the amendment of the student's education records that the student believes are inaccurate or misleading, and the right to a hearing if the request for amendment is not granted.
- The right to consent to disclosures of personally identifiable information contained in the student's education records, except to the extent that FERPA authorizes disclosure without consent.
- The right to file a complaint with the U.S. Department of Education concerning alleged failures by School of Mines to comply with the requirements of FERPA.

Students should be aware that these rights and privileges are available to them. Formal notification regarding FERPA is provided annually. An announcement covering information designated as Public or Directory Information is included on posters, in the Family Matters, First Year Information and Commuter Connection newsletters and on the Academic and Enrollment Family Educational Rights and Privacy Act web page at: <http://sdmines.sdsmt.edu/ferpa>. Directory information includes the student's name, local and permanent address, telephone listing, electronic mail address, photograph (e.g., year book photos), date and place of birth, major field of study, dates of attendance (including graduation date), grade level, enrollment status (e.g., undergraduate or

graduate, full or part time), participation in officially recognized activities and sports, weight and height of members of athletic teams, degree, honors and awards received, and the most recent education agency or institution attended (previous to School of Mines). This information is critical to some obligations and services performed by the university. Students have the right to request that such information concerning them be withheld. For a full description of FERPA, information regarding the location of students' educational records, and procedures at School of Mines for compliance with the law, please contact the Office of the Registrar and Academic Services. US government reporting requirements have been added for international students (F and J status). As a result of the regulations that became effective on January 1, 2003, the Family Educational Rights and Privacy Act (FERPA) is waived for F and J students in respect to these specific reporting requirements. The regulations will be strictly enforced by the appropriate bureau(s) within the US Department of Homeland Security (DHS) and information will be reported electronically to DHS via Student and Exchange Visitor Information System (SEVIS). The consequences to students for non-compliance with the new regulations are severe. Contact the director of the Ivanhoe International Center at [Ivanhoe@sdsmt.edu](mailto:Ivanhoe@sdsmt.edu) for more information.

### **Final Examination Policy**

The South Dakota School of Mines and Technology provides a policy for the administration of final examinations.

The faculty, recognizing that courses and programs of instruction differ substantially and that methodologies of instruction and evaluation remain the province of each instructor, does not seek to impose any mandatory final examination policy upon the constituent faculty of this institution. However, each faculty member is hereby encouraged to give the last examination (comprehensive or non-comprehensive) during the final examination week.

A five-day final examination period shall be scheduled by the registration officer. No special

individual or departmental requests will be honored in constructing the final examination schedule.

The instructor or instructors for each course shall indicate to their department head whether or not they intend to give a final examination, the number of hours for the exam, and whether additional rooms are needed for alternate seating; requests for additional rooms can be honored only if rooms are available. No additions will be permitted once the schedule has been published. All final exam requests will be due from departments at the time course registry requests are due. The final version of the exam schedule will be published in the Course Listings bulletin.

Final exams in all laboratory courses and courses of one credit or less will be given during the last regularly scheduled class period of the semester. Final examinations for evening classes meeting after 4:30 p.m. will be held at the last meeting of the class during final exam week. Final examinations for all other courses are scheduled by the registration officer according to the regular class meeting time during the semester and must be given at the scheduled time; they may not be rescheduled or given prior to the start of the final examination period. Examinations will be held in the regularly scheduled classrooms unless instructors make special advance arrangements through the registration officer.

Instructors in multi-section courses may request a “common final examination” period if requests are made in advance. Rooms must be reserved with the registration officer for such exams in order to avoid conflicts.

Final exam periods will be one hour and 50 minutes each, although instructors may request a longer final exam period (two hours and 50 minutes) if needed.

If a student is scheduled for three or more examinations on any one day, the middle examination(s) of the day shall be rescheduled for this student by the instructor(s) upon the request of the student. The student will be required to make this request between the 10<sup>th</sup> and 15<sup>th</sup> day of classes.

Other than those events approved by the faculty of the South Dakota School of Mines and

Technology, final examinations will be the only events scheduled during the week of final examinations. Students having conflicts arising from participation in such scheduled events must see their professors at least one week prior to the examinations week to determine an equitable alternative to taking the examination at the scheduled time.

Instructors will submit all grades not later than three working days after the last day of final examinations for the term.

### **Requests for Waivers**

In extenuating circumstances students may request that a requirement stated in the academic policies of the institution or of the South Dakota Board of Regents be waived. Examples of such requirements include, but are not limited to, the limit on the number of times a course may be attempted, the time limits on completion of pre-general education and general education courses, the academic suspension policy, the proficiency exam policy, and the change of grade from an F to a W. Students wishing to appeal must complete the Application for Academic Appeal form that is available at the Office of the Vice President for Academic Affairs or can be downloaded from: <http://sdmines.sdsmt.edu/studentlife/forms>.

### **Student Academic Freedom Rights**

The School of Mines and the South Dakota Board of Regents have a longstanding commitment to protecting those freedoms of inquiry and learning that are essential to the expansion of knowledge and the correction of error. This includes protections for student freedom in learning. In its relevant parts, Board of Regents policy, which applies to the School of Mines and to all other public universities, provides the following:

A. To secure student freedom in learning, faculty members in the classroom and in seminar should encourage free and orderly discussion, inquiry and expression of the course subject matter. Student performance may be evaluated solely on an academic basis, not on opinions or conduct in

matters unrelated to academic standards.

B. Students should be free to take reasoned exception to the data or views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled.

C. Each institution shall establish an academic appeals procedure to permit review of student allegations that an academic evaluation was tainted by prejudiced or capricious consideration of student opinions or conduct unrelated to academic standards. These procedures shall prohibit retaliation against persons who initiate appeals or who participate in the review of appeals.

D. Students are responsible for maintaining standards of academic performance established for each course in which they are enrolled. [www.sdbor.edu/policy/1-Governance/documents/1-11.pdf](http://www.sdbor.edu/policy/1-Governance/documents/1-11.pdf).

The School of Mines policy implementation of item C above reads as follows:

### **Student Appeals Policy**

A procedure is provided for situations where a student feels that an institutional or Board of Regents policy affecting terms or conditions of enrollment or academic standing has been improperly applied. Students who believe that an academic evaluation has been unfairly applied should follow this procedure. The South Dakota Board of Regents Student Appeals for Academic Affairs policy 2:9 can be reviewed in its entirety at: [http://www.sdbor.edu/policy/2-Accademic\\_Affairs/documents/2-9.pdf](http://www.sdbor.edu/policy/2-Accademic_Affairs/documents/2-9.pdf). Students who wish to discuss their situation and how this process applies should consult with the Vice President for Student Affairs and Dean of Students.

### **Anti-Harassment Policy**

It is the policy of South Dakota School of Mines and Technology that harassment not be tolerated. It distracts the harasser, the victim, and others from the tasks of the workplace and academic environment; it undermines morale and the psychological well-being of the victim; and it leads to expensive litigation and to possible liability. The university has no tolerance for harassment, whether it occurs on or off campus, during or after normal business hours, at work-related social functions, or during business-related travel. Any employee or student violating this policy will be subject to disciplinary action up to and including termination or dismissal. The South Dakota School of Mines and Technology Anti-Harassment policy IV-A-20, the South Dakota Board of Regents Sexual Harassment policy 1:17, and the South Dakota Board of Regents Human Rights Complaint Procedure 1:18 can be reviewed in their entirety at:

<http://sdmines.sdsmt.edu/hr/rules>, or contact the Affirmative Action Officer/Title IX-EEO Coordinator in the Human Resources Office.

### **Alcohol and Drug Policy**

#### **POLICY**

The South Dakota School of Mines and Technology and the South Dakota Board of Regents (4:27 Drug Free Environment and 3:4 Student Conduct Code) are committed to providing a drug free environment.

Furthermore, the School of Mines prohibits the possession of empty alcoholic beverage containers of any kind. Likewise, being in the presence of alcohol or other illicit substances, whether on campus or in the School of Mines managed residences, is also prohibited.

BOR alcohol and other drug policy violations are cumulative throughout a student's enrollment at South Dakota Board of Regents institutions (they stay on the student's discipline record and are transferable). The alcohol and other drug policy violations are not cumulative between academic years.

This policy does not replace nor restrict the Student Conduct Code (3:4) or the Drug Free Environment policy (4:27) as established by the South Dakota Board of Regents.

## **PROCEDURE**

Any employee violating this prohibition shall be subject to appropriate disciplinary action, which may include termination of employment.

Students found in violation of the School of Mines policy for alcohol and other drugs may or may not also be in violation of BOR policy concerning alcohol and other drugs (BOR Policy 3.4.2.B.16). Interpretation is at the discretion of the student conduct administrator on a case by case basis. In the event a student is found responsible for a second violation of the School of Mines Policy IV-A-03 within the same academic year, it will be considered a violation of BOR Policy (3.4.2.B.16.) automatically.

Recognized student organizations are expected to report underage drinking at their sponsored events or on their property to the student conduct administrator for remedial action with individual students. Failure to report via the campus student conduct process may result in action being taken against the student organization.

At a minimum, students who violate the School of Mines alcohol or other drug policy will be sanctioned as follows:

1. 1<sup>st</sup> violation—a \$50 fine, completion of the *Choices* interactive journal; if under 21, parental notification will include a copy of the letter of sanction being sent to the student's parent/legal guardian.
2. 2<sup>nd</sup> violation—a \$100 fine, completion of a brief alcohol assessment and any recommended consequences from the assessment, one-year disciplinary probation; if under 21, parental notification.
3. 3<sup>rd</sup> violation—probable suspension for at least a semester; in extenuating circumstances, student may stay enrolled but must complete an approved

treatment program; if under 21 parental notification.

## **Policy Governing Academic Integrity**

High standards of academic honesty and intellectual integrity are essential to the success of our students and the institution. The campus community will not tolerate acts of dishonesty in any academic activities at School of Mines. Such acts jeopardize not only the individual student, but also the integrity and dignity of the institution and its members.

The South Dakota Board of Regents has clearly defined those acts that constitute violations of academic integrity (BOR Policy 3.4.2.B.1). These acts include, but are not limited to, cheating, fraud, plagiarism, or knowingly furnishing false information within the academic arena. These acts of dishonesty violate the ethical values the university works to instill in all members of the campus community.

Faculty and administrators should consistently communicate the importance of academic integrity and ethical principles to our students. In addition, all members of the campus community should take reasonable steps to anticipate, deter, and confront acts of dishonesty in all areas of academics — research, assignments, and exams. The instructor of record for each course is responsible for clarifying the academic integrity standards for that course within the course syllabus.

The consequences for any act of academic dishonesty shall be at the discretion of the instructor of record, subject to due process as outlined in BOR policy 3.4.3A. Sanctions may range from requiring the student to repeat the work in question to failure in the course. To ensure fairness to all involved and to conform to South Dakota Board of Regents policies, sanctions may be imposed only in accordance with the following procedure. In the following, the term “student conduct officer” refers to the person appointed by the senior student affairs officer to consider cases of academic dishonesty, as described in BOR Policy 3:4. Among other responsibilities, the Student Conduct Office is

expected to maintain university-wide records on all actions related to student academic dishonesty.

An instructor who intends to hold a student accountable for an act of academic dishonesty must provide written notification to the student and the Student Conduct Office within ten working days of the time the alleged violation becomes known to the instructor. The written notification must include a description of the alleged violation, the sanction(s) the instructor intends to impose, a statement notifying the student that he or she may request an informal meeting with the instructor, and a statement describing the student's due process rights. This notice may be in the form of an email or the instructor of record may use the Academic Integrity Reporting Form available on the School of Mines website.

Resolution of the allegation may be achieved in one of three ways:

1. The student admits responsibility and accepts the consequence(s) in writing. There shall be no subsequent proceedings.
2. The student requests a meeting with the instructor of record within 10 working days of receiving the notification or within the first 10 working days of the following semester, whichever is appropriate. At the request of either the student or the instructor of record, a student conduct officer may be present. The purpose of the meeting would be to dispose of the matter through mutual consent by the parties involved. If mutual agreement can be reached, there shall be no subsequent proceedings. If mutual agreement cannot be reached, the matter is referred for formal disposition.
3. The matter is resolved through formal disposition and therefore referred to the Student Conduct Office. Please refer to BOR Policy 3:4 for specific procedures that will be followed for formal disposition.

## **Intellectual Property Statement**

The South Dakota Board of Regents has developed a policy on intellectual property that sets forth the principles and procedures through which the Board will balance those interests.

South Dakota Board of Regents employees who carry out or administer such instructional, research and service activities routinely produce works or make discoveries that may be subject to legal protection as intellectual properties.

The Board recognizes and affirms the public policy principle, woven into the very fabric of the United States Constitution by its framers, that creators of intellectual properties should obtain a fair return from the fruits of their inventiveness. It also recognizes and affirms the principle that the public should have a fair return on its investment in support of such creative efforts.

For further information on intellectual property, see Board of Regents Policy 4:34. [www.sdbor.edu/policy/4-Personnel/documents/4-34.pdf](http://www.sdbor.edu/policy/4-Personnel/documents/4-34.pdf).

## **Software Copyright Statement**

The South Dakota School of Mines and Technology has obtained licenses from a variety of vendors to use their software on computers that are owned and controlled by the school. South Dakota School of Mines and Technology does not own this software or its related documentation and, in general, School of Mines does not have the right to reproduce such software or to permit its reproduction by others. Microsoft MSDN is the only exception. Please contact the ITS Help Desk for information regarding MSDN, [helpdesk@sdsmt.edu](mailto:helpdesk@sdsmt.edu).

School of Mines students, faculty, and staff shall use all software only in accordance with applicable license agreements. Centrally managed licensing agreements are on file in the Information Technology Service Office or the Business Office. Making, acquiring, or using unauthorized copies of computer software or other copyrighted materials may result in disciplinary or legal action as the circumstances warrant.

The following statement regarding intellectual property and the legal and ethical use of software was developed by EDUCOM, a nonprofit consortium of higher education institutions, which promotes the use of computing, networking and information resources in teaching, learning, scholarship, and research. School of Mines subscribes to the spirit of this statement, and strives to promote understanding and observation of it.

### **Software and Intellectual Rights**

Respect for intellectual labor and creativity is vital to academic discourse and enterprise. This

principle applies to works of all authors and publishers in all media. It encompasses respect for the right to acknowledgment, right to privacy, and right to determine the form, manner, and terms of publication and distribution.

Because electronic information is volatile and easily reproduced, respect for the work and personal expression of others is especially critical in computer environments. Violations of authorial integrity, including plagiarism, invasion of privacy, unauthorized access, and trade secret and copyright violations, may be grounds for sanctions against members of the academic community.



*Mines Matters:* Information Technology Services (ITS) serves academic and administrative technology needs campus-wide. Network connections for individuals in the residence halls are also managed through ITS.

## Music and Intercollegiate Athletics

### Music Program

The Music Program, a division of the Department of Humanities, is housed in the King Center. Included are an ensemble rehearsal area of 1,600 square feet with adjoining music offices, music library, and storage, and two smaller rehearsal areas of 1,000 square feet; one designated as an applied music teaching studio and small ensemble rehearsal area and the other which provides space for an electronic music laboratory and individual practice. Cultural and educational enrichment opportunities provided by Music Activities include the following:

- Academic offerings — see courses listed under MUS, MUEN, or MUAP in this catalog, on Web Advisor, or on the Music Activities website <http://music.sdsmt.edu>.
- Ensembles — Symphonic Band, Concert Choir, Jazz Band, Master Chorale, Brass Choir, String

Ensemble, and other instrumental and vocal ensembles.

#### • Performance Opportunities

Concerts are presented by the major ensembles every semester at venues around Rapid City and the Black Hills.

Recitals are presented by faculty and students throughout the academic year in the Rapid City area.

Appearances are made throughout South Dakota and neighboring states at various venues such as the music association conventions, alumni gatherings, festivals, and competitions.

Appearances are made at national and international events resulting in critical acclaim and recognition through first-place awards such as the New Years Eve Mass in Vienna's Karlskirche (1990), Lindenhofhausen Harmonie-Festival (1993), Florence's Palazzo Vecchio (1996), Circolo Musica in Venice (2001), the Konstanz (Germany) Münster (2003), and the Association of Irish Musical Societies Choral Festival (2006).

For current concert listings and more information, visit <http://music.sdsmt.edu>.



## **Intercollegiate Athletics**

The athletic program has always been considered a major extracurricular activity on the campus of School of Mines. It is believed that a student's participation in athletics fosters well-rounded development. The intercollegiate sports scheduled throughout the year include men's football, cross country, basketball, golf and track, and the women's sports include volleyball, cross country, basketball, track and golf

The university is in its second year of candidacy for membership within the NCAA D-II with an expected full membership to be achieved beginning fall semester 2013. The various Hardrockers teams play a full regional schedule that encompasses teams from a variety of states including South Dakota, North Dakota, Minnesota, Wisconsin, Nebraska, Colorado, Montana, Iowa and Missouri. The individual athletic sport season schedules are developed each year with an attempt to balance the number of home and away contests evenly thereby providing the loyal fans of the Hardrockers an opportunity to support the teams in Rapid City on a regular basis.

The athletic facilities for South Dakota School of Mines and Technology include

- 1) the 4000 seat and 260 car drive-up O'Hara Stadium that has a 400 meter championship Mondo track and a state-of-the-art synthetic turf football field, and
- 2) the King Center which has the 2,200 seat Goodell gymnasium, two weight rooms, a 25 yard 6-lane swimming pool and the spectacular Christiansen Hall of Fame.

### **Eligibility for Intercollegiate Athletics**

To be eligible for intercollegiate competition at the South Dakota School of Mines and Technology

- 1) Entering freshmen must enroll with the NCAA Eligibility Center and complete the NCAA mandated process to become eligible for their freshman season.
- 2) All student-athletes wishing to participate in intercollegiate athletics must be

continually enrolled as a full-time student in a minimum of 12 semester credit hours at the time of participation. Students become immediately ineligible upon dropping below 12 credit hours of enrollment during a term of participation.

- 3) All student-athletes must be making normal progress toward a recognized degree and maintain the GPA required to remain in good standing as set forth by this catalog.
- 4) All student-athletes must pass a minimum of 24 credit hours (or equivalent) in the two terms of attendance immediately preceding their next term of participation. A second-term freshman must pass 6 credit hours (or equivalent) in the first term to be eligible for term two.
- 5) Transfer students from a four-year institution must have eligibility remaining at the institution they are transferring from and be academically eligible at their previous institution to be able to further intercollegiate competition at SDSM&T.



## Atmospheric Sciences Minor



### Contact Information

#### **Dr. Donna V. Kliche**

Department of Atmospheric Sciences  
Mineral Industries 201A  
(605) 394-2291  
E-mail: [Donna.Kliche@sdsmt.edu](mailto:Donna.Kliche@sdsmt.edu)

### Faculty

Professor Detwiler; Emeritus Professors Helsdon, Hjelmfelt and Smith; Associate Professors Capehart, Kliche, Sundareshwar and French; Instructors Clabo and Farley; Adjunct Professors Stamm and Bothwell; Adjunct Research Scientist Bunkers.

The purpose of the atmospheric sciences curriculum is to educate students to the level of scientists and engineers who are capable of developing and applying knowledge concerning physical, dynamical, and chemical processes in

the atmosphere.

### Undergraduate minor in Atmospheric Sciences

A minor in atmospheric sciences is offered to any student enrolled in any undergraduate degree program that allows minors at the School of Mines. For some majors this would require an additional semester or more of study beyond the normal four years. A minimum of 18 credits in atmospheric science coursework must be earned. Two courses, Introduction to Atmospheric Sciences (ATM 301) and Global Environmental Change (ATM 403) are required for the minor.

### **Specialization in Atmospheric Sciences within the Bachelor of Science in Interdisciplinary Sciences degree program**

Students in the Bachelor of Science in Interdisciplinary Sciences (IS) degree program may choose a specialization in atmospheric sciences. The successful student is expected to be capable of independent and critical thinking in the areas of physical, synoptic, and dynamic meteorology; remote sensing; and global atmospheric change. As such, the student should be qualified for employment where expertise in atmospheric sciences is a primary requirement, though need not necessarily qualify as a meteorologist by the federal government's criteria. The curriculum also is suitable for preparation toward graduate study at the M.S. and Ph.D. level.

The IS Bachelor of Science degree program offers a specialization in atmospheric sciences. General requirements for a B.S. in Interdisciplinary Sciences are described on page 111. Required coursework for the atmospheric sciences specialization includes

1) All courses and other curriculum requirements for the general IS degree requirement.

2) The atmospheric sciences undergraduate series: ATM 301, ATM 401, ATM 404, ATM 403, ATM 430, ATM 450, ATM 450L, ATM 455, ATM 455L, ATM 460

3) The following mathematics and science courses (which may require additional prerequisites): BIOL 311, CHEM 114, CHEM 114L, CSC 150, PHYS 213, PHYS 213L, MATH 225, MATH 321

4) Sufficient professional development electives for a total of 128 academic credit hours.

### **Federal Certifications as a Meteorologist**

Students in the undergraduate minor or IS programs desiring to be qualified for federal employment as meteorologists (with the National Weather Service or other federal government agencies employing meteorologists) should contact a Department of Atmospheric Sciences advisor to ensure that their plan of study meets the strictly enforced civil service requirements. The IS ATM academic program from catalog year 2010 and onward satisfies these requirements. The basic requirements for federal civil service qualification as a meteorologist (as dictated by the United States Office of Personnel Management):

### **Degree: meteorology, atmospheric science, or other natural science major that includes**

A. At least 24 semester hours (36 quarters) of credit in atmospheric science/meteorology including a minimum:

1. Six semester hours of atmospheric dynamics and thermodynamics
2. Six semester hours of analysis and prediction of weather systems (synoptic/mesoscale)
3. Three semester hours of physical meteorology and
4. Two semester hours of remote sensing of atmosphere and/or instrumentation

B. Six semester hours of physics, with at least one course that includes laboratory sessions

C. Three semester hours of ordinary differential equations

D. At least 9 semester hours of coursework appropriate for a physical science major in any combination of three or more of the following: physical hydrology, statistics, chemistry, physical oceanography, physical climatology, radiative transfer, aeronomy, advanced thermodynamics, advanced electricity and magnetism, light and optics, and computer science.

**OR:** Combination of education and experience-coursework as shown in A above, plus appropriate experience or additional education.

**Note:** There is a prerequisite or corequisite of calculus, physics, and differential equations for coursework in atmospheric dynamics and thermodynamics. Calculus courses must be appropriate for a physical science major.

### **Atmospheric sciences undergraduate curriculum scheduling**

It is the student's responsibility to check with his or her advisor in the atmospheric sciences department for any course offering or other program modifications that may occur after the publication of this catalog. Most atmospheric science courses are offered only every other year. Attention must be paid to this two-year cycle in planning a program of study.

### **Master of Science Graduate Degree Program**

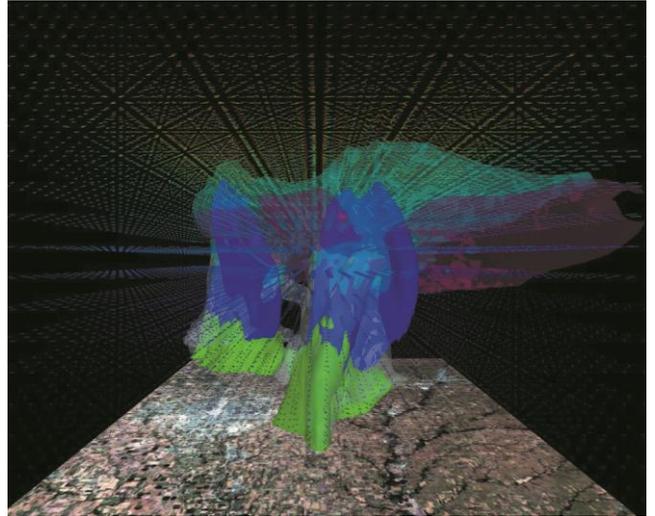
A master of science graduate program in the atmospheric sciences is offered to students with undergraduate degrees in atmospheric sciences or meteorology, physics, mathematical sciences, biology, chemistry, or engineering. A resident undergraduate student in any of these fields may take upper-division courses in meteorology as electives, either as part of their undergraduate degree program or otherwise, and proceed directly to graduate work in meteorology upon receipt of the bachelor's degree. In addition to meeting the goals listed above for undergraduate minor and IS atmospheric science graduates, the master of science graduate will be able to review the literature; devise strategies for attacking a problem in atmospheric sciences; acquire, organize, and interpret data; and prepare results for both oral and written presentation. He or she is

expected to be able to carry out such original investigations both individually and as a member of a team.

A master of science degree requires 24 credit hours of coursework, with an additional 6 semester hours of research credit for completing a thesis. There are two specializations in the program, meteorology and earth systems. See page 166 for more details. A properly-prepared undergraduate science or engineering graduate with minimal meteorological background may use the M.S. program to complete sufficient coursework to satisfy the federal civil service requirements for employment as a meteorologist. The M.S. program can be a stepping-stone to Ph.D. work in the atmospheric and environmental sciences, as well as a terminal degree leading to employment in private industry or government.

### **Atmospheric and Environmental Sciences Interdisciplinary Ph.D. Graduate Program**

In addition to the M.S. program in atmospheric sciences, the atmospheric sciences department participates in the Atmospheric and Environmental Sciences (AES) Ph.D. program. Faculty in several departments are involved in delivering the program, including civil and environmental engineering, geology and geological engineering, and atmospheric sciences. Degree candidates are expected to complete courses in a broad range of topics selected from these disciplines. For complete information on the AES program, please refer to the AES section of this catalog beginning on page 162.



## Biology

### Contact Information

#### **Dr. Sookie S. Bang**

Department of Chemical and Biological  
Engineering

McLaury 102

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<http://cbe.sdsmt.edu>

### Faculty

Professor Bang; Assistant Professor Sani;

Instructors Coble and Machura.

### Biology

The biological sciences play an increasing role in everyday life and are relevant to numerous career fields including several engineering and technological disciplines. A variety of courses are offered to expose students to major theories and

disciplines of biology while completing their primary field of study at SDSM&T. Whether anticipating a career in the health sciences, chemical and environmental engineering, or biological research, students need a working knowledge of biology as part of their background. The biology courses are offered for students in science, engineering, and general studies. Students are advised to take laboratory courses whenever possible.

Minimum enrollments, as established by administration policy, are necessary to teach a course. Although a major or minor in biology is not available, it is recommended that students considering medical, dental, veterinary, or graduate school in a biology field take one of the approved biology sequences. Record of completion of an approved sequence can be made as part of a student's permanent record. A minimum of 18 credits is recommended with 8 of those credits being BIOL 151/151L; BIOL 153/153L; or equivalent. At least 6 credits should be at the 300 level or above.



## Recommended Options:

### A. General Biology Sequence

Eight (8) core credits:

BIOL 151, 151L, 153, 153L

Ten (10) additional credits from:

BIOL 231	General Microbiology	3
BIOL 231L	General Microbiology Lab	1
BIOL 341	Microbial Processes in Engr and Natural Sciences	3
BIOL 371	Genetics	3
BIOL 431	Industrial Microbiology	3
BIOL 431L	Industrial Microbiology Lab	1
BIOL 491	Independent Study	1-4

### B. Health Science Sequence

Eight (8) core credits:

BIOL 151, 151L, 153, 153L

Ten (10) additional credits from:

BIOL 121	Basic Anatomy	3
BIOL 121L	Basic Anatomy Lab	1
BIOL 123	Basic Physiology	3
BIOL 123L	Basic Physiology Lab	1
BIOL 231	General Microbiology	3
BIOL 231L	General Microbiology Lab	1
BIOL 371	Genetics	3
BIOL 423	Pathogenesis	3
BIOL 423L	Pathogenesis Lab	1
BIOL 492	Topics	1-5

### C. Environmental Science Sequence

Eight (8) core credits:

BIOL 151, 151L, 153, 153L

Ten (10) additional credits from:

BIOL 311	Principles of Ecology	3
BIOL 341	Microbial Processes in Engr and Natural Sciences	3
BIOL 371	Genetics	3
BIOL 431	Industrial Microbiology	3
BIOL 431L	Industrial Microbiology Lab	1
BIOL 406	Global Environment Change	3
BIOL 492	Topics	1-5

## Biological Laboratories

The biological laboratory, located on the second floor of the Chemical and Biological Engineering and Chemistry Building (CBC) is a brand new laboratory equipped with state-of-the-art equipment and tools for laboratory teaching. All of the laboratory courses are taught by a single, professional instructor to preserve continuity among sections and courses in the biology sequence.

The biology laboratory courses augment lecture courses by providing students with a hands-on learning experience. Depending on the course, students will learn and use techniques in microbiology and microscopy, perform detailed animal dissections, or collect environmental data on field trips to local sites.

## Chemical Engineering B.S.



### Contact Information

#### **Dr. Robb Winter**

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Web: <http://cbe.sdsmt.edu/>

### Faculty

Professors Bang, Dixon, Puszynski and Winter;  
Associate Professors Gilcrease and Menkhaus;  
Assistant Professors Benjamin, Hower, Sani and Shende;  
Instructors Coble and Machura.

### Emeritus and Other Faculty

Professor and Composites and Polymer Engineering Laboratory Director Salem;  
Associate Professor and 2010 Center for Bioprocessing Research and Development Director Christopher; and Emeritus Professors Bauer and Munro.

### Staff

Chemical and Biological Engineering Secretary, Linda Embrock. Chemical and Instrumentation Specialist, Ivan Filipov.

### Chemical and Biological Engineering (CBE)

The Department of Chemical and Biological Engineering (CBE) offers a B.S. degree in Chemical Engineering which is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>. CBE also offers a M.S. degree in Chemical Engineering and a Ph.D. in Chemical and Biological Engineering. Our department name, Chemical and Biological Engineering, reflects the forward-looking integration of chemical engineering, chemical sciences and biological sciences.

### **What is Chemical Engineering?**

Chemical Engineering (ChE) is an optimal combination of the molecular sciences (chemistry and biology), the physical sciences (physical chemistry and physics), the analytical sciences (math and computer programming) and engineering. Chemical Engineering focuses on the description and design of processes that combine engineering principles of heat and fluid flow with chemical reactions and molecular separations to produce high-value products useful to humankind from multiple raw material sources. Chemical Engineers do this while always insuring that the processes they design, build and manage are safe, environmentally benign and economical. Examples of such processes include:

Artificial organs and biomedicine  
Bioenergy production

Biological fermentation  
Biopharmaceuticals  
Ceramic manufacturing  
Energetic materials production  
Food processing  
Microprocessor manufacturing  
Mineral and ore refining  
Oil and natural gas refining  
Paper manufacturing  
Pharmaceutical design and manufacturing  
Polymer production  
Polymer composites production  
Nanomaterials manufacturing

Designing and modeling such processes requires a strong fundamental understanding of the chemical and biological phenomena at work. ChE students develop a wide range of problem solving skills grounded in mathematics and computer analysis techniques. ChE graduates are recruited for their technical engineering knowledge as well as their problem solving, systems analysis, and communication skills.

### **What do chemical engineers do?**

ChE graduates work in a wide variety of manufacturing, process design, and research fields. The unique combination of molecular sciences and engineering analysis make ChE professionals highly qualified for many career options in chemical, petroleum, mineral processing, pharmaceutical, food processing, biotechnology, semiconductor, defense, and alternative fuel industries, state and federal government and academia. Recent graduates from SDSM&T have gone to work in ChE positions at companies like ADM, Dakota Gasification, Dow Chemical, Dow Corning, Cargill, Caterpillar, Freeport-McMoRan Copper and Gold, Halliburton, Lafarge, Lyondell-Basel, Michelin, POET, Quadra Mining, SD DENR, Solvay Chemicals and many others. CBE alumni also regularly pursue graduate education at many of the country's top research institutions such as Stanford and the University of Wisconsin.

To delve deeper into the board range of exciting careers available to you in chemical engineering

go to the American Institute of Chemical Engineers website ([www.aiche.org](http://www.aiche.org)) and pull down Career Resources/Career Facts then click on "Chemical Engineers in Action: Innovation at Work" (<http://www.chemicalengineering.org/>). You will find that if you wish to be engaged in discovering answers to the World's pressing engineering challenges, Chemical Engineering is the field for you (<http://www.engineeringchallenges.org/cms/challenges.aspx>).

Another attribute that sets Chemical Engineering apart from many other engineering career paths is that chemical engineering opens doors to other professions. The problem solving skills and process analysis tools developed in the Chemical Engineering curriculum make ChE grads uniquely suited to pursue careers as doctors, patent lawyers, business managers, financial analysts, marketing directors, environmental stewards, policy makers, and philanthropy directors.

### **What will I learn as a ChE student?**

ChE students take multiple courses in chemistry and biology to develop a fundamental understanding of the molecular sciences. The program includes physics, math, and computer courses to provide the analytical tools required to design processes. Finally the core Chemical Engineering curriculum includes engineering courses in thermodynamics, heat and mass transport, fluid dynamics, chemical reaction kinetics and reactor design, molecular separations and unit operations, and process design and control. Elective courses are also available to provide specialization in emphasis such as advanced materials (e.g. composites, nanomaterials and polymers), bioprocessing/biochemical engineering, energy technology, environmental engineering, and petroleum engineering.

### **Chemical Engineering at the School of Mines**

The vision of the CBE Department is: **To provide nationally and internationally recognized**

## **chemical and biological engineering education and research.**

Through the baccalaureate degree, students are prepared to become practicing chemical engineers, ready to enter the workforce and make immediate contributions. As a graduate of the chemical engineering program you will be able to perform at a level that meets or exceeds industry, government lab, and graduate school expectations. Within a few years of your graduation, you will have the characteristics described by the following *Chemical Engineering Program Educational Objectives*:

1. Graduates apply fundamental and practical knowledge of unit operations, thermodynamics, reaction engineering, process control and design of chemical/biological processes.
2. Graduates are successfully employed and advancing in governmental and industrial positions requiring chemical engineering expertise.
3. Graduates are prepared to succeed in graduate and professional programs.

At the time of your graduation, you will have the characteristics described by the following *Chemical Engineering Program Outcomes*.

1. Graduates possess fundamental and practical knowledge of unit operations, thermodynamics, reaction engineering, process control and design of safe and economical chemical engineering processes.
  - 1.a. Students will demonstrate their ability to solve technical problems through the application of engineering principles.
  - 1.b. Students will be able to experimentally verify mathematical model predictions and theory in the areas of process measurements and feedback control loops; momentum, heat, and mass transfer; and reaction kinetics.

2. Graduates are able to apply critical thinking skills to the solution of chemical engineering problems
  - 2.a. Students will be able to articulate the concept of critical thinking and practice it at a beginner's level.
  - 2.b. Students will become proficient at applying critical thinking to technical and non-technical problems.
3. Graduates possess effective oral and written communication skills for work in a technical environment.
  - 3.a. Students will be able to write memoranda and reports that effectively communicate technical information to technical and non-technical audiences.
  - 3.b. Students will be able to present professionally to technical and non-technical audiences.
4. Graduates are able to interact effectively as team members and in leadership roles.
  - 4.a. Students will be able to work effectively with others.
  - 4.b. Students will be able to function effectively as team leaders.
5. Graduates are able to apply computer tools effectively in a variety of project situations.
  - 5.a. Students will be able to solve complex problems by formulating and solving numerical solutions.
  - 5.b. Students will be able to apply fundamental programming logic skills across a variety of software program platforms.
6. Graduates are motivated to be professional and continue learning throughout their lives.
  - 6.a. Students will have positive experiences of learning material on their own.
  - 6.b. Students will demonstrate awareness of engineering ethics, global issues and environmental impact.

## **Where do I find more information on Chemical Engineering at SDSM&T?**

Visit our webpage <http://cbe.sdsmt.edu/> to learn more about chemical engineering at the

SDSM&T. You will learn more about industries in which you can be employed, the AIChE Safety and Chemical Education Certificate Program, profession development opportunities, scholarship opportunities, CBE laboratories, and co-op, intern, and research employment opportunities while you pursue your degree as well as new initiatives within CBE.

### Chemical Engineering Curriculum/Checklist

The courses listed in the curriculum have been chosen to develop a well-rounded education, beginning with the foundations of mathematics, physics, biology, and chemistry, and culminating with a capstone process design course at the senior level. Along the way, students develop competencies in fluid dynamics, heat transfer, mass transfer, thermodynamics, computer solutions to complex engineering problems, process control, kinetics, and reactor design, all while developing their critical thinking, general problem solving and communication skills.

Although a minor in chemical engineering is not available, you can obtain an emphasis in emerging areas such as biochemical engineering, environmental engineering, petroleum engineering, energy technology or advanced materials by tailoring their elective courses.

Students in the SDSM&T B.S. environmental engineering program may elect chemical engineering as their emphasis. With the increased national attention on the environment, the opportunity exists at SDSM&T for you to earn dual degrees in chemical engineering and environmental engineering, thus coupling a focus on the environment with complementary chemical processing and design skills.

The chemical engineering faculty at the SDSM&T keep the curriculum current and dynamic. As a part of this evolutionary process, the faculty continues to develop innovative approaches to teaching chemical engineering lectures and laboratories. An example of this is the integration of process design and simulation throughout the chemical engineering laboratory experiences. Sophisticated process design simulators (such as the commercial software, AspenPlus and COMSOL), are being co-

integrated with process design projects. Major funding for this development came from the National Science Foundation and from industrial sponsors. The chemical engineering faculty is also involved in the university's Tablet PC Program. Tablet PCs have been used to explore new ways to deliver courses and integrate sophisticated process software. In addition, the SDSM&T offers the opportunity for students and professors to interact in small groups and individual learning sessions.

*Students are responsible for checking with their advisors for any program modifications that may occur after the publication of this catalog.*

### Freshman Year

#### **First Semester**

MATH 123	Calculus I	4
CHEM 112	General Chemistry I	3
CHEM 112L	General Chemistry I Lab	1
CBE 111/L	Intro Chem Proc Mod	2
ENGL 101	Composition I	3
Humanities or Social Sciences Elective(s)		3
PE	Physical Education/MUEN	1
<b>TOTAL</b>		<b>17</b>

#### **Second Semester**

MATH 125	Calculus II	4
CHEM 114	General Chemistry II	3
CHEM 114L	General Chemistry II Lab	1
PHYS 211	University Physics I	3
CBE 117L	Programming for CBE	1
Humanities or Social Sciences Elective(s)		6
<b>TOTAL</b>		<b>18</b>

### Sophomore Year

#### **First Semester**

CBE 217	ChemE Material Balances	3
MATH 321	Differential Equations	3
Biology Elective		3
CHEM 326	Organic Chemistry I	3
CHEM 220L	Exp. Organic Chem. IA	1
PHYS 213	University Physics II	3
PE	Physical Education/MUEN	1
<b>TOTAL</b>		<b>17</b>

#### **Second Semester**

CBE 218	ChemE Fluid Mechanics	3
CBE 222	ChemE. Process Thermo	3

CBE 250	Computer App. in ChemE	2
CHEM 328	Organic Chemistry II	3
MATH 225	Calculus III	4
ENGL 279	Technical Comm. I	3
<b>TOTAL</b>		<b>18</b>

**TOTAL**

**16**

**136 credits required for graduation**

**Junior Year**

**First Semester**

CBE 317	ChemE Heat Transfer	3
CBE 321	ChemE Equil Thermo	3
CBE 333	Process Measure and Control	1
CBE 333L	ChemE Process Controls Lab	1
CBE 361L	ChemE Fluids Lab	1
CHEM 230	Analytical Chem. for Engr.	2
CHEM 332L	Analytical Chem. Lab	1
CHEM 341	Physical Chem. for Engr. I	2
ENGL 289	Technical Comm. II	3
<b>TOTAL</b>		<b>17</b>

**Second Semester**

CBE 318	ChemE Mass Transfer	3
CBE 343	Chem Kinetics/Reactor Dsgn	3
CBE 362L	ChemE Heat Transfer Lab	1
CBE 364	Chem Proc Dsgn Econ Safety	2
CHEM 343	Physical Chem. for Engr. II	2
CHEM 345L	Physical Chem. I and II Lab	1
Engineering Elective		3
Hum/SS Elective(s)		3
<b>TOTAL</b>		<b>18</b>

**Senior Year**

**First Semester**

CBE 417	ChemE Equilibrium Seps	2
CBE 463	Process Design for ChE	2
CBE 465	Adv Process & Equip Dsgn	2
Chemical Engineering Elective		3
Department Approved Elective		3
Hum/SS 300 Level or Higher Elective(s)		3
<b>TOTAL</b>		<b>15</b>

**Second Semester**

CBE 433	Process Control	3
CBE 461L	ChemE Mass Trans/Reac Eng Lab	1
CBE 466	Capstone Design for ChE	2
CBE 487	Global &Cont Issues in ChemE	1
Chemical Engineering Elective		3
Chemical Engineering Lab Elective		1
Department Approved Elective		5

## Curriculum Notes

### Board of Regents General Education

Requirements: Students working in conjunction with their advisor need to ensure General Education Requirements are completed in the required timeframe. Hum/SS electives require 6 credit (cr) hr each from Humanities and Social Sciences. Additionally, 3 cr hr of advanced (300 level or higher) of either Hum or SS is required.

Optional emphases in ChE: The academic advisor recommends and approves courses to take if students are interested in an emphasis in one of these areas: bioprocessing/biochemical engineering, energy technology, environmental engineering, petroleum engineering, or advanced materials (nano materials, polymers, ceramics, materials processing, corrosion, or solid state/semi-conductors).

BIOL Elective (3 cr hr): Select from BIOL 341, 231, 371 or other approved by advisor.

CHE Elective (6 cr hr): Select 6 credits from CBE 424, 434/434L, 444, 450, 455, 474, 474L, 476, 484, 484L, 488, 491, 492, 498 or others approved by advisor.

CHE Lab Elective (1 cr hr): Select 1 credit from CBE 434L, 474L, 484L, 498 or other approved by advisor.

Engineering Elective (3 cr hr): Select 3 credits from engineering courses other than CBE prefix; requires advisor approval. These courses are typically at a 200 level or higher.

Department Approved Elective (8 cr hr): Select from the following: CBE, Chem, or other approved courses to fulfill emphasis electives. These courses are typically at a 120 level or higher. May include up to three (3) credits of advanced military science and up to six (6) credits of cooperative education (CP 297, CP 397, or CP 497)

## Chemistry B.S.



### Contact Information

#### **Dr. Michael Gunn (Interim Head)**

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Chemistry/Chemical Engineering 220  
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### Faculty

Professor Boyles; Associate Professors Fong and Heglund; Assistant Professors Meyer, Smirnova and Zhu; Instructors Christofferson, Filipova and Marshall.

### Staff

Department of Chemistry Secretary, Tara Huber;  
Chemical and Instrumentation Specialist,  
Margaret Smallbrock.

### Chemistry

The Department of Chemistry offers undergraduate chemistry courses that meet the requirements for the bachelor of science degree and for other programs on campus. The chemistry program offers the American Chemical Society (ACS) certified degree, which meets the national requirements of the ACS. This degree requires 128 semester credits.

Upon graduation with a bachelor's degree in chemistry, students have knowledge of chemical and physical phenomena at the molecular level. They are expected to possess the skills of critical

thinking in chemical problem-solving, such as instrumental data interpretation for molecular structure characterization. Students are expected to have a command of the four major sub-disciplines of chemistry, namely, analytical, inorganic, organic, and physical chemistry, as well as to be familiar with the chemical literature.

Chemistry graduates of the department distinguish themselves in that the chemistry curriculum gives them ample opportunity to supplement their chemical knowledge with a breadth of other courses, which may be elected from diverse offerings on campus including mathematics, engineering, the humanities, social sciences, biological and physical sciences, and more. This distinctive latitude inherent within the chemistry curriculum allows students to develop as well-rounded individuals who are able to face and meet the challenges they may anticipate in their chosen careers.

Chemistry, by its very nature, is the central science in the world, and many graduates use their degrees as a solid foundation for advanced study in chemistry as well as for study in medicine, pharmacy, veterinary medicine, forensic science, materials science, environmental science, medical technology, physical therapy, patent or environmental law, and education. These fields are all possibilities for students with a chemistry education. Likewise, students who opt not to further their education beyond their B.S. degrees in chemistry are also prepared for a wide variety of employment opportunities. Among former chemistry graduates, these have included research and quality assurance positions in academic, industrial, governmental, and private sectors of the economy.

The department also participates in both the M.S. and Ph.D. programs in Materials and Engineering Science (MES), the Ph.D. program in Biomedical Engineering, and the Ph.D. program in Nanoscience and Nanoengineering. Students seeking these degrees may choose to emphasize any of the representative sub-disciplines of chemistry in addition to interdisciplinary research specialties as an integral part of their graduate program of study.

The department prides itself in having modern instrumentation available not only for research but

as an integral part of undergraduate education. The instrumentation within the department currently includes FT-IR spectrometers, a 300-MHz superconducting heteronuclear nuclear magnetic resonance spectrometer, a spectrofluorometer, a diode-array spectrophotometer, a voltammograph, an atomic absorption spectrometer, a gas chromatograph-mass spectrometer, and other instruments.

Advisors work closely with their assigned students in order to ensure that they will complete all degree requirements in a timely manner, will meet prerequisites for further education such as medical school, and will be knowledgeable about post-graduation options and employment opportunities.

### **Bachelor of Science in Chemistry, ACS Certified**

The ACS-certified curriculum provides an excellent foundation in science and mathematics for professional preparation in chemistry and meets the nationally-recognized high standards established by the American Chemical Society. This curriculum opens the way for a variety of careers in research and development in private industry or government and gives the student an excellent foundation for graduate study in chemistry.

Students desiring to meet the minimum requirements for certification by the American Chemical Society should follow the curriculum outlined below.

#### **Freshman Year**

##### **First Semester**

CHEM 112	General Chemistry I	3
CHEM 112L	General Chemistry I Lab	1
ENGL 101	Composition I	3
MATH 123	Calculus I	4
Gen. Ed. Goal 3 or 4	Elective	3
IS 110	Explorations	2
CHEM 290	Seminar	0.5
<b>TOTAL</b>		<b>16.5</b>

##### **Second Semester**

CHEM 114	General Chemistry II	3
CHEM 114L	General Chemistry II Lab	1

MATH 125	Calculus II	4
PHYS 211	University Physics I	3
Gen. Ed. Goal 3	Elective	3
Gen. Ed. Goal 4	Elective	3
CHEM 290	Seminar	0.5
<b>TOTAL</b>		<b>17.5</b>

#### **Sophomore Year**

##### **First Semester**

CHEM 332	Analytical Chemistry	3
CHEM 332L	Analytical Chemistry Lab	1
CHEM 326	Organic Chemistry I	3
CHEM 326L	Organic Chem I Lab	2
MATH 321	Differential Equations	3
CHEM 252	Systematic Inorganic Chemistry	3
PE	Physical Education	1
CHEM 290	Seminar	0.5
<b>TOTAL</b>		<b>16.5</b>

##### **Second Semester**

PHYS 213	University Physics II	3
PHYS 213L	University Physics II Lab	1
CHEM 328	Organic Chemistry II	3
CHEM 328L	Organic Chem II Lab	2
ENGL 279	Technical Comm I	3
Humanities or Social Sciences	Elective(s) <sup>1</sup>	4
CHEM 290	Seminar	0.5
<b>TOTAL</b>		<b>16.5</b>

#### **Junior Year**

##### **First Semester**

ENGL 289	Technical Comm II	3
CHEM 342	Physical Chemistry I	3
CHEM 342L	Physical Chem I Lab	1
Elective(s)		6
PE	Physical Education	1
CHEM 490	Seminar	0.5
<b>TOTAL</b>		<b>14.5</b>

##### **Second Semester**

CHEM 344L	Physical Chem II Lab	1
CHEM 344	Physical Chemistry II	3
CHEM 370	Chemical Literature	1
Advanced Chemistry Requirement <sup>2</sup>		6
CHEM 490	Seminar	0.5
Advanced Chemistry Elective(s) <sup>3</sup>		3
<b>TOTAL</b>		<b>14.5</b>

## Senior Year

### First Semester

Elective(s)	9
CHEM 490 Seminar	0.5
Advanced Chemistry Requirement <sup>2</sup>	3
Humanities or Social Science Electives <sup>1</sup>	3
<b>TOTAL</b>	<b>15.5</b>

### Second Semester

Electives	10
Adv Chemistry Requirement <sup>2</sup>	6
CHEM 490 Seminar	0.5
<b>TOTAL</b>	<b>16.5</b>

**128 credits required for graduation**

### Curriculum Notes

<sup>1</sup>A minimum of 16 credit hours of university-approved humanities and social sciences are required with a minimum of 6 hours in humanities and 6 hours in social sciences.

<sup>2</sup>Fifteen credits of advanced chemistry courses are required: Chem. 434, 434L, 452, 452L, 460, and 482.

<sup>3</sup>Three credits of advanced chemistry electives are required. Take any one of the following courses: 420, 421, 426.



## Civil Engineering B.S.



### Contact Information

#### **Dr. Molly M. Gribb**

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Engineering, Civil/Mechanical 122  
(605) 394-1697

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### Faculty

Professors Amos, Bang, Fontaine, Gribb, Hansen, Kenner and Mott; Associate Professors Stone and Surovek; Assistant Professors Arneson-Meyer, Benning, Fick, Nam and Robinson; Distinguished Professor Emeritus Ramakrishnan; Professors Emeritus Hovey, Iyer and Preber; Associate Professor Emeritus Klasi.

### Civil Engineering Program Objectives

The objectives of the undergraduate civil engineering program are to produce graduates with capabilities to engage in the professional practice of civil engineering working in the public or private sectors, actively participate in professional organizations that promote civil engineering and provide continuing self-development, and pursue advanced studies in civil engineering or a related professional discipline.

### Civil Engineering Education

An undergraduate education in civil engineering is founded upon a broad knowledge of engineering sciences and selected courses in mathematics, physical sciences, humanities, social sciences, technical communication, and computational methods. Required civil engineering courses address environmental, geotechnical, structural, and water resource engineering. Students may take electives to specialize in one of these areas or complete courses in several areas for a broad-based civil engineering background. Students may also engage in undergraduate research and apply up to six credits toward degree requirements. Graduate programs in civil engineering or construction management afford opportunities for motivated students to pursue advanced studies.

The bachelor of science program in civil engineering is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

### Design in the Civil Engineering Curriculum

The civil engineering curriculum begins with students gaining fundamental understanding of humanities, social sciences, mathematics, and basic sciences. Courses in the engineering sciences begin the transition from theory to creative application. During the junior year, students complete required courses in four major areas of the civil engineering program; environmental, geotechnical, structural, and water resources engineering. In each of these courses, students learn to apply mathematics, science, and engineering science to the solution of civil engineering problems while learning the fundamental elements of sustainable engineering design. During the senior year, students complete five elective courses. A two-semester capstone design course allows students to work in multi-disciplinary teams to develop alternative solutions, perform feasibility and economic analyses, and create detailed design. The capstone design experience culminates with a

formal final written report and a presentation to the faculty and the students' peers.

### **Experiential Learning in Civil Engineering**

Students participate in a number of courses aimed at providing hands-on, in depth understanding of the four areas of civil engineering. Students perform experiments in the department's materials, water resources, geotechnical and environmental laboratories in the junior year. Students may also participate in undergraduate research or scholarship, which may include design for the American Society of Civil Engineers (ASCE) steel bridge or concrete canoe competitions, or cooperative education. Students must apply for the cooperative education program prior to starting work. For more information about the cooperative education program, contact Dr. Scott Amos ([Scott.Amos@sdsmt.edu](mailto:Scott.Amos@sdsmt.edu)).

### **Professionalism**

For promotion of ethics and professional and teamwork skills, students in civil engineering are encouraged to participate in the student chapter of ASCE, American Concrete Institute or any other of the many student organizations on campus. During the senior year, students in the civil engineering program are strongly encouraged to take the Fundamentals of Engineering (FE) examination. Passing the FE examination is the first step toward registration as a Professional Engineering (PE). The second and final step in the registration process is the successful completion of the Professional Engineering examination, which is normally taken after working under the supervision of a PE for at least four years.

### **Department Approved Electives**

The Civil Engineering Curriculum includes 15 credit hours of Department Approved Electives that students may use to broaden their education in many Civil Engineering areas, gain knowledge and skills in a specialized area of Civil Engineering or create a knowledge base tailored to their individual career goals. Department Approved Electives may include the following:

- Any CEE or ENVE 300 or 400 level course not applied to another CEE graduation requirement.
- Up to 6 credit hours of CEE 498 (Undergraduate Research/Scholarship), CEE 491 (Independent Study) or CP 497 (Cooperative Education); not more than 3 credits may be CEE 491 or CP 497.
- Up to 6 credit hours of 300 or 400 level courses in engineering, science, math or computer science not applied to another CEE graduation requirement.

A minor is not available in civil engineering.

### **Civil Engineering Curriculum/Checklist**

Students are responsible for checking with their advisors for any program modifications that may occur after the publication of this catalog.

#### **Freshman Year**

##### **First Semester**

ENGL 101	Composition I	3
CHEM 112	General Chemistry I	3
MATH 123	Calculus I	4
CEE 130/L	Intro to Civil Engineering	2
PE	Physical Education	1
Humanities or Social Sciences Elective <sup>1</sup>		3
<b>TOTAL</b>		<b>16</b>

##### **Second Semester**

CHEM 112L	General Chem I Lab	1
CHEM 114	General Chem II	3
PHYS 211	University Physics I	3
MATH 125	Calculus II	4
CEE 117/L	Computer Aided Design and Interpretation in CEE	2
PE	Physical Education	1
Humanities or Social Sciences Elective(s) <sup>1</sup>		3
<b>TOTAL</b>		<b>17</b>

#### **Sophomore Year**

##### **First Semester**

MATH 225	Calculus III	4
EM 214 <sup>2</sup>	Statics	3
CEE 284	Applied Numerical Methods	3
CEE 206/L	CEE Practice &	

Engineering, Surveys I	4
Humanities or Social Sciences Elective(s) <sup>1</sup>	3
<b>TOTAL</b>	<b>17</b>

Humanities or Social Sciences Elective <sup>1</sup>	3
<b>TOTAL</b>	<b>16</b>

### **136 credits required for graduation**

#### **Second Semester**

ENGL 279	Technical Communications I	3
MATH 321	Differential Equations	3
ME 221	Dynamics of Mechanisms	3
EM 331	Fluid Mechanics	3
EM 321 <sup>1</sup>	Mechanics of Materials	3
Humanities or Social Sciences Elective <sup>1</sup>		3
<b>TOTAL</b>		<b>18</b>

#### **Junior Year<sup>1</sup>**

##### **First Semester**

ENGL 289	Technical Communications II	3
CEE 316/L	Engr and Const Materials	3
CEE 326	Intro Env Engr Design	3
CEE 336/L	Hydraulic Systems Design	3
CEE 346/L	Geotechnical Engineering I	3
CEE 353	Structural Theory	3
<b>TOTAL</b>		<b>18</b>

##### **Second Semester**

Science Electives <sup>3</sup>		6
One of the following two courses:		
CEE 368/L	Intro to Transportation Engr.	3
CEE 325	Intro to Sustainable Design	3
Three of the following four courses <sup>2</sup> :		
CEE 327	Env Engr Proc Analysis	3
CEE 337	Engineering Hydrology	3
CEE 347	Geotechnical Engr. II	3
CEE 357/L	Design of Metal Structures	3
<b>TOTAL</b>		<b>18</b>

#### **Senior Year**

##### **First Semester**

IENG 302	Engineering Economics	3
CEE 474	Engr Project Management	3
CEE	Dept Approved Electives	9
CEE 464	CE Capstone Design I	1
<b>TOTAL</b>		<b>16</b>

##### **Second Semester**

CEE 463	CEE Profession	2
ME 211	Intro to Thermodynamics	3
CEE 465	CE Capstone Design II	2
CEE	Dept Approved Electives	6

#### **Minor in Geospatial Technology**

Geospatial technology is a rapidly expanding field that covers the management and analysis of spatial data from many sources, such as satellites, airborne remote sensing, geographic information systems (GIS), global positioning systems (GPS), surveying, and more. Complete information on the requirements is given in the Geology B.S. section.

#### **Curriculum Notes**

<sup>1</sup>Consult the section of the catalog addressing graduation requirements for a description of the combinations of lower level (1xx/2xx) social sciences and humanities courses meeting the SDBOR General Education Goals #3 and #4. Students must complete at least 3 credits at an advanced level (300 or above).

<sup>2</sup>Students must earn a C or better in EM 214 to enroll in EM 321.

<sup>3</sup>Science electives may be chosen from physics, chemistry, biology, geology, or atmospheric science with at least 3 credit hours from any course in BIO, GEOL, or ATM, or GEOE 221.

## Computer Engineering B.S.



### Contact Information

#### **Dr. Kazem Sohraby**

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Electrical Engineering/Physics 311

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### Faculty

Professors Corwin, Logar, Sohraby and Weiss;  
Associate Professors McGough and Tolle;  
Assistant Professor Hoover; Instructor Linde;  
Adjunct Associate Professor Hemmelman;  
Professors Emeritus Batchelder, Cox, McNeil,  
Meiners, Opp and Simonson.

### Computer Engineering

The computer engineering curriculum prepares students for life-long careers by providing them with the engineering and technical education appropriate to meet modern technological challenges. The basic curriculum includes required coursework in mathematics, basic sciences, humanities, social sciences, and fundamental engineering topics in circuit analysis, electronics, electrical systems, digital systems, assembly language, data structures, operating systems, and software engineering. Computer engineering students are required to select three (3) senior elective courses from a wide variety of subject areas to fit their particular interests.

Elective subject areas include digital signal processing, microprocessor-based system design, computer networks, and computer architecture. The bachelor of science program in computer engineering is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 – telephone (410) 347-7700

### Mission

The mission of the computer engineering program, in support of the mission of School of Mines, is to provide computer engineering students with education that is broadly based in the fundamentals of the profession so that graduates will be able to maintain a high degree of adaptability throughout their professional careers. It is also intended that the students will develop a dedication to the profession and an ability to maintain professional competency through a program of life-long learning.

### Objectives

1. Graduates will be able to successfully practice computer engineering and related fields regionally, nationally, and globally.
2. Graduates will be well-educated in the fundamental concepts of computer engineering and be able to continue their professional development throughout their careers.
3. Graduates will be skilled in clear communications and teamwork and capable of functioning responsibly in diverse environments.

### Program Strengths

A two-semester capstone design experience requires computer engineering students to conduct their own design project in a simulated industrial environment. They are encouraged to work on team projects, which are often multidisciplinary. This foundation provides students with a broad base of understanding that allows them to apply their knowledge of scientific and engineering principles to the practical and innovative solutions

of existing and future problems.

Students are required to develop a high level of written and oral communication skills and to work well as a member of a team. They must develop a social and ethical awareness so they understand their responsibility to protect both the occupational and public health and safety and to implement these factors in their professional activities. Students are encouraged to participate in the activities of professional societies, such as the Institute of Electrical and Electronics Engineers and Eta Kappa Nu, to enhance their educational and social life while on campus and to gain professional contacts for their careers. Students have opportunities to participate in cooperative education and summer intern programs whereby they elect to seek employment to experience engineering work before they complete their degree requirements. Students gain insight into future opportunities and are often hired by their intern companies after graduation.

### **Integration of Design Concepts**

One of the key elements of the undergraduate computer engineering education experience is to integrate design throughout the curriculum. Students experience various design concepts in a variety of settings:

- Hands-on laboratory projects (including team projects);
- Effective integration of computer applications;
- Senior elective courses;
- Senior capstone experience; and
- Participation in competitive team projects such as the Robotics team, the Alternative Fuel Vehicle Team, the Unmanned Aerial Vehicle Team, Lunar Regolith Mining, and the Formula SAE Mini-Indy Team.

### **Graduate School Opportunities**

The undergraduate curriculum is broad based to give graduates flexibility in their career paths. Qualified students may study areas of interest in more depth and specialize further by pursuing a graduate program at the School of Mines.

### **Laboratories**

The Electrical and Computer Engineering Department houses well-equipped laboratories designed to give students easy access to experimental support for their theoretical studies. Junior and senior laboratory projects are conducted on an open laboratory basis that allows students to schedule experimental work at their own convenience. Laboratory facilities are open to students and are supervised until 10 p.m. on most weeknights.

Four general-purpose laboratories are fully equipped to provide facilities for experiments in such diverse areas as communication systems, control systems, electromechanics, energy conversion, digital circuits, and electronics. These laboratories can also be used to provide practical experience under the direct supervision of electrical and computer engineering faculty. In addition, there are special-purpose laboratories serving the fields of power systems, antennas, microwave engineering, analog and digital systems, mechatronics, real-time embedded systems, computer instrumentation, microprocessor development, reconfigurable logic, and parallel processing and cluster computing (in conjunction with the Mathematics and Computer Science Department).

Seniors and graduate students have access to facilities to work on senior design and graduate thesis projects. The work area allows students a convenient place in which to work for the duration of their project.

### **Notes on Computer Engineering Courses**

Classes that are typically offered every semester include CENG 244, CENG 464, and CENG 465.

### **Computer Engineering Curriculum/Checklist**

Students are responsible for checking with their advisors for any program modifications that may occur after the publication of this catalog.

### Freshman Year

#### **First Semester**

MATH 123	Calculus I	4
CHEM 112	General Chemistry I	3
CHEM 112L	General Chemistry I Lab	1
CENG 244/L	Intro to Digital Systems	4
PE	Physical Education <sup>1</sup>	1
Humanities or Social Sciences Elective(s)		3
<b>TOTAL</b>		<b>16</b>

#### **Second Semester**

ENGL 101	Composition I	3
MATH 125	Calculus II	4
PHYS 211	University Physics I	3
PE	Physical Education	1
Humanities or Social Sciences Elective(s)		3
CSC 150/L	Computer Science I	3
<b>TOTAL</b>		<b>17</b>

### Sophomore Year

#### **First Semester**

EE 220/L	Circuits I	4
MATH 321	Differential Equations	3
PHYS 213	University Physics II	3
PHYS 213L	University Physics II Lab	1
EE 264/L	Sophomore Design	2
CSC 250	Computer Science II	4
<b>TOTAL</b>		<b>17</b>

#### **Second Semester**

CSC 251	Finite Structures	4
ENGL 279	Tech Comm. I	3
EE 221/L	Circuits II	4
Humanities or Social Sciences Elective(s)		3
EE 351	Mechatronics and Measurement Systems	4
<b>TOTAL</b>		<b>18</b>

### Junior Year

#### **First Semester**

CENG 314/L	Assembly Language	3
ENGL 289	Tech Comm II	3
EE 320/L	Electronics I	4
CSC 300	Data Structures	4
MATH 225	Calculus III	4
<b>TOTAL</b>		<b>18</b>

### **Second Semester**

EE 312	Signals	3.5
CSC 470	Software Engineering	3
CENG 342/L	Digital Systems	4
Approved Math Elective <sup>2</sup>		3
EM 216	Statics and Dynamics	4
<b>TOTAL</b>		<b>17.5</b>

### Senior Year

#### **First Semester**

EE 311/L	Systems	3.5
CENG 464	Senior Design I	2
CENG Elective(s) <sup>3</sup>		4
IENG 301	Basic Engr. Economics	2
Free Elective		2
Humanities or Social Sciences Elective(s)		3
<b>TOTAL</b>		<b>16.5</b>

#### **Second Semester**

CENG 465	Senior Design II	2
CSC 456/L	Operating Systems	4
CENG Elective(s) <sup>3</sup>		3
CENG Elective(s) <sup>3</sup>		4
Upper Level Humanities or Social Sciences Elective		3
<b>TOTAL</b>		<b>16</b>

### **136 credits required for graduation**

#### **Curriculum Notes**

<sup>1</sup> Music ensemble courses, (MUEN 101, 121 or 122) may be substituted for physical education courses for qualified students. Any other substitution must be approved in advance by the physical education department head.

<sup>2</sup> MATH 381 and 441 are approved electives

<sup>3</sup> Eleven CENG elective credits are required.

#### **CENG Electives**

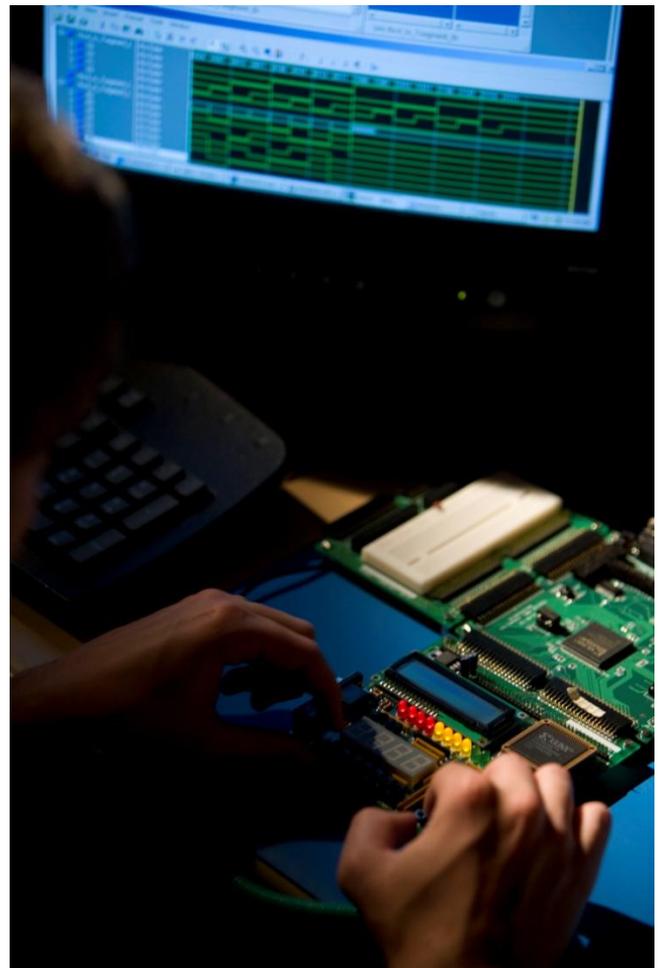
EE 322	Electronics II	4
EE 421	Communications Systems	4
EE 451	Control Systems	4
CENG 420	Design of Digital Signal Processing Systems	4
CENG 440	VLSI Design	4
CENG 442	Microprocessor Design	4
CENG 444	Computer Networks	4

(credit for only one of CENG 444 or CSC 463 may be used)

CENG 446	Advanced Computer Architectures	4
(credit for only one of CENG 446 or CSC 440 may be used)		
CENG 447	Embedded and Real-Time Computer Systems	4
CSC 410	Parallel Computing	3
CSC 415	Robotics	3
CSC 416	Introduction to Autonomous Systems	3
CSC 433	Computer Graphics	3
CSC 440	Adv Digital Systems	4
CSC 447	Artificial Intelligence	3
CSC 464	Intro to Digital Image Processing and Computer Vision	3
CSC 476	Theory of Compilers	3

A maximum of 4 co-op credits may be used toward the CENG electives requirement if a written request presented by the student is approved by the ECE faculty. The student request must justify that the CENG design requirement is met.

The Computer Engineering program utilizes the Fundamentals of Engineering, (FE), exam taken by students prior to graduation for program assessment.



## Computer Science B.S. and Minor



### Contact Information

#### **Dr. Kyle Riley**

Department of Mathematics  
and Computer Science

McLaury 308

(605) 394-2471

E-mail: [Kyle.Riley@sdsmt.edu](mailto:Kyle.Riley@sdsmt.edu)

### Faculty

Professors Corwin, Logar and Weiss; Associate Professor McGough; Assistant Professor Qiao; Instructor Schrader; Emeritus Professors Carda, Opp and Weger.

### General Information

The Department of Mathematics and Computer Science offers a bachelor of science degree in computer science and a master of science degree in Robotics and Intelligent Autonomous Systems (RIAS). The bachelor of science degree in computer science is accredited by the by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 – telephone (410) 347-7700. Details on the mission and learning outcomes of the Computer Science program can be found off the department website, [www.mcs.sdsmt.edu/](http://www.mcs.sdsmt.edu/).

Students who desire to major in this program should announce their intention to the Department of Mathematics and Computer Science as early as possible and should consult advisors in the department at each registration period.

Any student who is pursuing a double major and whose designated advisor is in another department should consult an advisor in the mathematics and computer science department at each registration.

### Laboratories

The School of Mines has a variety of computing platforms available. Resources include an extensive PC network, a Linux lab, a Tablet PC lab, and two robotics labs. The Linux lab is fully equipped with quad-core desktops Other computing resources may be accessed via the Internet. The institution encourages its students to use the computer facilities in the creative and efficient solution of scientific and engineering problems.

### Computer Science Major

The primary goal of the computer science program is to prepare graduates to enter a dynamic and rapidly changing field as competent computer scientists. Graduates are expected to be capable in all phases of software development including design, development, and testing. Graduates should also have a firm understanding of hardware technologies. These capabilities require the graduate to possess good

communication skills, both oral and written, and the ability to work effectively as a team member. Graduates must be able to read and comprehend the literature of the discipline and be sufficiently well-versed in general theory to allow growth within the discipline as it advances. Most of the graduates will pursue careers as software engineers within the computer industry. Some may choose careers as entrepreneurs and others will pursue advanced degrees and careers in research.

The sample Computer Science Checklist in this section lists all required courses for the bachelor's degree in their proper prerequisite sequence. Students should consult course listings for prerequisites and should consult their advisors at each registration.

A computer science major must complete a minimum of 16 credits in humanities and social science, with at least 6 credit hours in humanities and at least 6 credit hours in social science. Refer to the humanities and social sciences section of this catalog for a list of courses satisfying these requirements. It is also important to refer to the general education core requirements under bachelor of science graduation requirements for further information. Students must complete the general education core requirements within the first 64 credits.

Any computer science major desiring a minor in another field should consult his or her advisor in the Department of Mathematics and Computer Science as early in his or her program of study as possible. The Office of the Registrar and Academic Services has a form that must be signed by the student and the department heads of both departments involved.

### **Minor in Computer Science**

A minor in the Department of Mathematics and Computer Science must be approved by the student's major department. The Office of the Registrar and Academic Services has forms that should be completed and signed by the department heads from both departments involved in this minor. The minor in computer science requires the completion of 21 credit hours.

The core coursework includes CSC 150, CSC 250, CSC 251, CSC 300, and at least 6 credit hours from an approved list.

The approved list of courses for the minor: CSC 314, CSC 317, CSC 372, CSC 410, CSC 412, CSC 415, CSC 416, CSC 421, CSC 433, CSC 440, CSC 445, CSC 447, CSC 448, CSC 449, CSC 456, CSC 461, CSC 463, CSC 464, CSC 470, CSC 476, and CSC 484.

### **Minor in Robotics**

The South Dakota School of Mines and Technology offers a minor in robotics, which is a great way to enhance any program of study to prepare graduates for a workplace that has become highly automated. A minor in robotics must be approved by the student's major department along with the approval of the Department Head for Mathematics and Computer Science. The core coursework includes CSC 150, CSC/CENG 415, CSF/CENG 416, along with CSC 300 or CSC 405. The minor is then complete with an additional 6 credits from courses on an approved list. The approved list of courses for the minor: CSC 447, CSC 449, CSC 456, and CSC 464.

### **Computer Science and Mathematics Double Major**

Due to the large number of courses common to the computer science major and the mathematics major, many students find it attractive to pursue a double major in these two areas. Students seeking the double major should consult their advisors for details about this option.

### **Computer Science Curriculum**

For the bachelor of science in Computer Science, a student must:

1. Take all of the courses listed in the Computer Science curriculum checklist;
2. Successfully complete a minimum of 3 computer science elective courses numbered 400 or above must be taken. A 3-credit Co-op

may be substituted for one computer science elective. Special topics and independent study courses may not be used to satisfy the computer science elective requirement.; and

3. Have a departmental grade point average of at least 2.00 in all CSC courses 300 level or higher. (Courses taken more than once will have only the higher grade counted for computing the departmental grade point average.)

### Computer Science Curriculum/Checklist

Students are responsible for checking with their advisors for any program modifications that may occur after the publication of this catalog.

#### Freshman Year

##### **First Semester**

ENGL 101	Composition I	3
Science Elective <sup>1</sup>		3
Science Elective Lab <sup>1</sup>		1
MATH 123	Calculus I	4
CSC 150/L	Computer Science I	3
Humanities or Social Sciences Elective(s) <sup>1</sup>		3
<b>TOTAL</b>		<b>17</b>

##### **Second Semester**

MATH 125	Calculus II	4
Humanities or Social Sciences Elective(s) <sup>1</sup>		3
CSC 250	Computer Science II	4
CSC 251	Finite Structures	4
PE	Physical Education	1
<b>TOTAL</b>		<b>16</b>

#### Sophomore Year

##### **First Semester**

CSC 300	Data Structures	4
MATH 225	Calculus III	4
CENG 244/L	Intro to Digital Systems	4
PE	Physical Education	1
Humanities or Social Sciences Elective(s) <sup>1</sup>		3
<b>TOTAL</b>		<b>16</b>

##### **Second Semester**

ENGL 279	Technical Comm	3
CSC 314/L	Assembly Language	4
Humanities or Social Sciences Elective(s) <sup>1</sup>		3

Science Elective <sup>1</sup>	3
Science Elective Lab <sup>1</sup>	1
Free Elective	2
<b>TOTAL</b>	<b>16</b>

#### Junior Year

##### **First Semester**

ENGL 289	Technical Comm II	3
MATH 321	Differential Equations	3
PHYS 211	University Physics I	3
CSC 372	Analysis of Algorithms	3
Elective or CSC Elective <sup>1</sup>		4
<b>TOTAL</b>		<b>16</b>

##### **Second Semester**

CSC 317/L	Computer Organization and Architecture	4
MATH 315	Linear Algebra	3
CSC 461	Programming Languages	3
CSC 470	Software Engineering	3
CSC Elective <sup>1</sup>		3
<b>TOTAL</b>		<b>16</b>

#### Senior Year

##### **First Semester**

CSC 465	Senior Design I	2
CSC 484	Database Mgmt Systems	3
CSC 421	Graphical User Interfaces With Object Oriented Programming	3
Humanities or Social Sciences Elective(s) <sup>1</sup>		5
Free Elective		3
<b>TOTAL</b>		<b>16</b>

##### **Second Semester**

CSC 456/L	Operating Systems	4
CSC 467	Senior Design II	2
HUM 375	Computers in Society <sup>1</sup>	3
CSC Electives <sup>1</sup>		3
MATH 381	Intro to Probability and Statistics	3
<b>TOTAL</b>		<b>15</b>

**128 credits required for graduation**

## Curriculum Notes

- CSC 465/467 is a two-course sequence in senior design. It is expected that the course sequence will be taken in successive semesters.
- An exit exam, such as the Major Field Achievement Test in Computer Science, will be given as part of CSC 467. The overall results of this exam will be used to assess the computer science program.
- CSC 105 may not be counted toward any mathematics, computer science, or engineering degree. Other majors should consult their departments on policy regarding this course.
- MUEN 101, 121, 122 can be used to substitute for one or two of the required two physical education credits.

<sup>1</sup>Elective courses must be chosen to satisfy all of the following requirements.

- Sixteen semester hours in humanities or social science. At least 6 hours must be in humanities and at least 6 hours must be in social sciences.
- Six credit hours of humanities and 6 credit hours of social science must be completed within the first 64 hours. It is important to refer to the general education requirements under bachelor of science graduation requirements for further information.
- A minimum of 3 computer science elective courses numbered 400 or above must be taken. A 3-credit Co-op may be substituted for one computer science elective. Special topics and independent study courses may not be used to satisfy the computer science elective requirement.
- Eleven credits of science. The science requirement for this major consists of PHYS 211 and two more lecture courses from among BIOL 121, BIOL 123, BIOL 231, BIOL 151, BIOL 153, CHEM 112, CHEM 114, GEOL 201, or PHYS 213; plus two labs that accompany the science courses taken, i.e., either BIOL 121L,

BIOL 123L, BIOL 231L, BIOL 151L, BIOL 153L, CHEM 112L, CHEM 114L, GEOL 201L, or PHYS 213L. Students must complete science classes from at least two different disciplines.

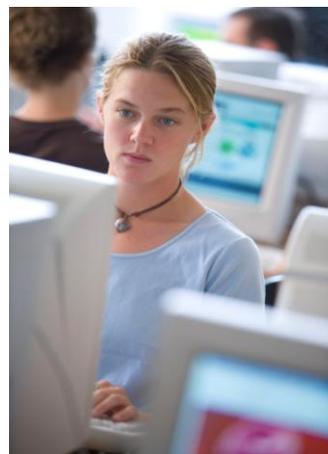
## Course Offering Schedule

In an attempt to help students plan their future semesters, the following information is presented. This reflects the best available knowledge at the time of the preparation of this document. This is not meant as a guarantee of when classes will be offered. Students concerned about when classes will be offered should contact the department head for any changes to the following. Courses not listed below have no defined rotation and will be offered contingent on demand and staff. Most computer science courses are not suitable to offering in an eight-week Summer session. Students should not expect computer science offerings in the summer.

Classes that are typically offered every semester include CSC 105, CSC 150, CSC 250, CSC 251, CSC 314, and CSC 300.

Classes that are typically offered every fall semester include CSC 372, CSC 415/515, CSC 421/521, CSC 465, and CSC 484.

Classes that are typically offered every spring semester include CSC 317, CSC 416/516, CSC 461, CSC 456, CSC 467 and CSC 470.



## **Electrical Engineering B.S.**



### **Contact Information**

#### **Dr. Kazem Sohraby**

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### **Faculty**

Steven P. Miller Endowed Chair and Professor Whites; Professor Sohraby; Associate Professors Montoya and Tolle; Assistant Professors Anagnostou and Hoover; Instructor Linde; Adjunct Associate Professor Hemmelman; Professors Emeritus Batchelder, Cox, McNeil, Meiners, Opp and Simonson.

### **Electrical Engineering**

The electrical engineering curriculum prepares students for life-long careers by providing them with the engineering and technical education appropriate to meet modern technological challenges. The basic curriculum includes required coursework in mathematics, basic sciences, humanities, social sciences, and fundamental engineering topics in circuit analysis, electronics, electrical systems, electromagnetics, energy systems, and properties of materials. Electrical engineering students are required to select 3 senior elective courses from a wide variety of subject areas to fit their particular

interests. Elective subject areas include communication systems, power systems, control systems, microwave engineering, antenna engineering, and computer systems.

The bachelor of science program in electrical engineering is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

### **Mission**

The mission of the electrical engineering program, in support of the mission of School of Mines, is to provide electrical engineering students with education that is broadly based in the fundamentals of the profession so that graduates will be able to maintain a high degree of adaptability throughout their professional careers. It is also intended that the students will develop a dedication to the profession and an ability to maintain professional competency through a program of lifelong learning.

### **Objectives**

1. Graduates will be able to successfully practice electrical engineering and related fields regionally, nationally, and globally.
2. Graduates will be well-educated in the fundamental concepts of electrical engineering and be able to continue their professional development throughout their careers.
3. Graduates will be skilled in clear communications and teamwork and capable of functioning responsibly in diverse environments.

### **Program Strengths**

A two-semester capstone design experience requires electrical engineering students to conduct their own design project in a simulated industrial environment. They are encouraged to work on team projects and often the team projects are multidisciplinary. This foundation provides students with a broad base of understanding that allows them to apply their knowledge of scientific

and engineering principles to the practical and innovative solutions of existing and future problems.

Students are required to develop a high level of written and oral communication skills and to work well as members of a team. They must develop a social and ethical awareness so they understand their responsibility to protect both occupational and public health and safety and to implement these factors in their professional activities. Students are encouraged to participate in the activities of professional societies, such as the Institute of Electrical and Electronics Engineers and Eta Kappa Nu, to enhance their educational and social life while on campus and to gain professional contacts for their careers. Students have opportunities to participate in cooperative education and summer intern programs whereby they elect to seek employment to experience engineering work before they complete their degree requirements. Students gain insight into future opportunities and are often hired by their intern companies after graduation.

### **Integration of Design Concepts**

One of the key elements of the undergraduate electrical engineering education experience is to integrate design throughout the curriculum. Students experience various design concepts in a variety of settings:

- Laboratory projects (including team projects);
- Effective integration of computer applications;
- Senior elective courses;
- Senior capstone experience; and
- Participation in competitive team projects such as the Robotics Team, the Alternative Fuel Vehicle Team, the Unmanned Aerial Vehicle Team, Lunar Regolith Mining, and the Formula SAE Mini-Indy Team.

### **Graduate School Opportunities**

The undergraduate curriculum is broadly based to give graduates flexibility in their career paths. Qualified students may study areas of interest in more depth and specialize further by pursuing a graduate program at the School of

Mines.

### **Laboratories**

The electrical and computer engineering department houses well-equipped laboratories designed to give students easy access to experimental support for their theoretical studies. Junior and senior laboratory projects are conducted on an open laboratory basis that allows students to schedule experimental work at their own convenience. Laboratory facilities are open to students and are supervised until 10 p.m. on most weeknights.

Four general-purpose laboratories are fully equipped to provide facilities for experiments in such diverse areas as communication systems, control systems, electromechanics, energy conversion, digital circuits, and electronics. These laboratories can also be used to provide practical experience under the direct supervision of electrical and computer engineering faculty. In addition, there are special-purpose laboratories serving the fields of power systems, antennas, microwave engineering, analog and digital systems, mechatronics, real-time embedded systems, computer instrumentation, microprocessor development, reconfigurable logic, and parallel processing and cluster computing (in conjunction with the Mathematics and Computer Science Department).

Seniors and graduate students have access to facilities to work on senior design and graduate thesis projects. The work area allows them a convenient place in which to work for the duration of their project.

### **Notes on Electrical Engineering Courses**

Classes that are typically offered every semester include EE 220, EE 221, EE 301, EE 351, EE 464, and EE 465.

### **Electrical Engineering Curriculum/Checklist**

Students are responsible for checking with their advisors for any program modifications that may occur after the publication of this catalog.

### Freshman Year

#### **First Semester**

MATH 123	Calculus I	4
CHEM 112	General Chemistry I	3
CHEM 112L	General Chemistry I Lab	1
CENG 244/L	Intro to Digital Systems	4
Humanities or Social Sciences Elective(s)		3
PE	Physical Education <sup>1</sup>	1
<b>TOTAL</b>		<b>16</b>

#### **Second Semester**

ENGL 101	Composition I	3
MATH 125	Calculus II	4
PHYS 211	University Physics I	3
PE	Physical Education	1
Humanities or Social Sciences Elective(s)		3
CSC 150/L	Computer Science I	3
<b>TOTAL</b>		<b>17</b>

### Sophomore Year

#### **First Semester**

EE 220/L	Circuits I	4
MATH 321	Differential Equations	3
ENGL 279	Technical Comm I	3
PHYS 213	University Physics II	3
PHYS 213L	University Physics II Lab	1
Humanities or Social Sciences Elective(s)		3
<b>TOTAL</b>		<b>17</b>

#### **Second Semester**

EM 216	Statics and Dynamics	4
EE 221/L	Circuits II	4
MATH 225	Calculus III	4
EE 351/L	Mechatronics and Measurement Systems	4
EE 264/L	Sophomore Design	2
<b>TOTAL</b>		<b>18</b>

### Junior Year

#### **First Semester**

ENGL 289	Tech Comm. II	3
EE 311/L	Systems	3.5
EE 320/L	Electronics I	4
EE 381	Electric and Magnetic Fields	3
EE 362	Electric and Magnetic Properties of Materials	3
<b>TOTAL</b>		<b>16.5</b>

### **Second Semester**

EE 312/L	Signals	3.5
EE 322/L	Electronics II	4
EE 330/L	Energy Systems	4
EE 382/L	Applied Electromagnetics	3
Approved Math Elective <sup>2</sup>		3
<b>TOTAL</b>		<b>17.5</b>

### Senior Year

#### **First Semester**

IENG 301	Basic Engr. Economics	2
ME 211	Thermodynamics	3
EE 464	Senior Design I	2
EE	Electrical Engr. Elective <sup>3</sup>	4
EE	Electrical Engr. Elective <sup>3</sup>	4
Free Elective		3
<b>TOTAL</b>		<b>18</b>

#### **Second Semester**

EE 465	Electrical Engr. Design II	2
EE	Electrical Engr. Elective <sup>3</sup>	3
Technical Elective <sup>5</sup>		3
Humanities or Social Sciences Elective(s)		3
Upper-level Humanities or Social Elective		3
Free Elective <sup>4</sup>		2
<b>TOTAL</b>		<b>16</b>

### **136 credits required for graduation**

#### **Curriculum Notes**

<sup>1</sup> Music ensemble courses, (MUEN 101, 121 or 122) may be substituted for physical education courses. Any other substitutions must be approved in advance by the physical education department head.

<sup>2</sup> MATH 381 and 441 are approved electives.

<sup>3</sup> Eleven electrical engineering elective credits required.

#### EE Electives

EE 421	Communications Systems	4
EE 431	Power Systems	4
EE 432	Power Electronics	4
EE 451	Control Systems	4
EE 481	Microwave Engineering	4
EE 483	Antennas for Wireless Communications	4
CENG 342	Digital Systems	4

CENG 420	Design of Digital Signal Processing Systems	4
CENG 440	VLSI Design	4
CENG 442	Microprocessor Design	4
CENG 444	Computer Networks	4
(credit for only one of CENG 444 or CSC 463 may be used)		
CENG 446	Advanced Computer Architectures	4
(credit for only one of CENG 446 or CSC 440 may be used)		
CENG 447	Embedded and Real-Time Computer Systems	4

<sup>4</sup> A free elective is any college level course 100 level or above that is acceptable toward an engineering or science degree. Military science courses, 100 level and above, apply as free electives only; substitution for departmental, technical, humanities, or social science electives is not permitted.

<sup>5</sup> A technical elective is any science or engineering course 200 level or above that does not duplicate the content of any other course required for graduation. Co-op credits may be used for technical elective credit. A maximum of 6 co-op credits may be used for the EE degree.

The Electrical Engineering program utilizes the Fundamentals of Engineering, (FE), exam taken by students prior to graduation for program assessment.



## Environmental Engineering B.S.



### Contact Information

**Dr. Henry V. Mott**, Program Coordinator  
Department of Civil and Environmental  
Engineering, Civil/Mechanical 123  
(605) 394-5170  
E-mail: [Henry.Mott@sdsmt.edu](mailto:Henry.Mott@sdsmt.edu)

### Management Committee

Professors Davis (GEOE), Gribb (CEE) and Mott (CEE); Associate Professors Menkhaus (CBE) and Stone (CEE); Assistant Professors Benning (CEE) and Cross (MET); Instructor Kanth (MEM).

### Environmental Engineering

Environmental engineers serve our society at the most fundamental level in caring for the air we breathe, the water we drink, and the soil in which we grow our food. Environmental engineers solve existing and prevent future environmental problems. Students in the B.S. Environmental Engineering program will be educated in higher mathematics, basic sciences, engineering sciences, and engineering design. The experience will be augmented by applied laboratory courses at the freshman through senior levels. Students will use computers in virtually all engineering coursework. Fundamental environmental engineering coursework will involve heat and mass transfer, classical and chemical thermodynamics, ground-water and surface-water hydrology, and

environmental systems analysis. Each student will participate in a two-semester capstone design experience that will involve work with a multidisciplinary team on the solution to a significant environmental problem. Achieving program educational outcomes will prepare the graduate to work in industry, consulting, or government, and to bring knowledge and principles to bear upon the solution to legacy and current as well as to the prevention of future environmental problems.

In order to develop a technical link with one of five disciplines closely related to environmental engineering, each student will complete a nine-credit elective set delivered by one of five supporting programs. This coursework prepares the student to cooperatively work alongside engineers of the supporting discipline in solution of environmental problems.

### **Supporting programs include**

1. Chemical Engineering — The application of chemical, chemical engineering, and environmental engineering principles to the environmentally safe production of a wide range of products including pharmaceuticals for human consumption, materials for electronic applications, and energy to power our society.
2. Civil Engineering — Engineering our society's infrastructure through treatment of water for potable use, renovation of waste waters generated by domestic and industrial users, safe handling (both disposal and recycling) of solid and hazardous wastes generated by society, clean-up of existing environmental pollution, and general stewardship of the Earth's land and water resources.
3. Geological Engineering — Engineering for the environmentally sound use and conservation of the Earth's natural resources including development of ground-water supplies, clean-up of contaminated aquifers, isolation of hazardous wastes, and exploration for and development of mineral or petroleum resources.

4. Materials and Metallurgical Engineering — development and implementation of environmentally sound processes for producing the metals, ceramics, and composite materials used by our society, and leadership in the area of recycling of materials for re-use by society.

5. Mining Engineering — The development of mining and reclamation plans that ensure environmentally sound mining operations and that the Earth and oceans are returned to environmentally acceptable conditions upon the completion of mining activities.

The objective of the environmental engineering program is to provide graduates with an educational foundation that will enable them to engage in the professional practice of environmental engineering within the public or private sector, or complete advanced studies in either environmental engineering or a related professional discipline.

The bachelor of science program in environmental engineering is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

#### **Graduates of this program are expected to:**

1. Ethically apply, as appropriate in applicable global and contemporary societal contexts, principles from mathematics, the natural sciences, engineering, humanities, and social sciences, to the definition, formulation, and solution of both existing and potential environmental problems.
2. Develop, interpret, and utilize appropriate laboratory process data; think critically; and use modern engineering skills, techniques, and tools in the iterative decision-making process associated with environmental engineering design.
3. Work and learn, on a lifelong basis, both independently and cooperatively with peers.
4. Communicate the results of their work and their ideas effectively, both orally and in written form, to peers and to non-technical audiences.

#### **Minor in Geospatial Technology**

Geospatial technology is a rapidly expanding field that covers the management and analysis of spatial data from many sources, such as satellites, airborne remote sensing, geographic information systems (GIS), global positioning systems (GPS), surveying, and more. Students in environmental engineering may find this minor a useful complement to their studies. Complete information on the requirements is given in the Geology B.S. section.

A minor is not available in environmental engineering.

#### **Cooperative Education Program**

Students may participate in the Cooperative Education Internship Program, but credits earned are not applicable for degree credit.

#### **Laboratories**

Laboratories maintained by the chemical and biological, civil and environmental, geological, materials and metallurgical, and mining engineering programs are equipped with modern analytical instrumentation. Descriptions of these laboratories are given elsewhere in respective sections of this catalog. These laboratories are utilized both in graduate and undergraduate research and in association with undergraduate courses to enhance student understanding of critical phenomena. Computational laboratories maintained by all 5 programs are equipped with modern personal and workstation computing equipment. These computers are networked with the university's file server.

#### **Environmental Engineering Curriculum/Checklist**

Students are responsible for checking with their advisors for any program modifications that may occur after the publication of this catalog.

### Freshman Year

#### **First Semester**

ENGL 101	Composition I	3
CHEM 112	General Chemistry I	3
CHEM 112L	General Chemistry I Lab	1
MATH 123	Calculus I	4
ENVE 111	Intro Chem Process Mod	2
General Education Goal 3 or 4 Elective <sup>5</sup>		3
PE	Physical Education <sup>4</sup>	1
<b>TOTAL</b>		<b>17</b>

#### **Second Semester**

CHEM 114	General Chemistry II	3
CHEM 114L	General Chemistry II Lab	1
MATH 125	Calculus II	4
PHYS 211	University Physics I	3
GEOE 221/L	Geology for Engineers	3
General Education Goal 3 or 4 Elective <sup>5</sup>		3
<b>TOTAL</b>		<b>17</b>

### Sophomore Year

#### **First Semester**

ENVE 217	Chem Engr I	3
MATH 225	Calculus III	4
CHEM 230	Anal Chem for Engr	2
CEE 284	Dig Comp Apps in CE	3
CHEM 332L	Anal Chemistry Lab	1
General Education Goal 3 or 4 Elective <sup>5</sup>		3
PE	Physical Education <sup>4</sup>	1
<b>TOTAL</b>		<b>17</b>

#### **Second Semester**

EM 216	Statics and Dynamics <sup>1</sup>	4
CBE 222	Thermodynamics I <sup>6</sup>	3
ENGL 279	Tech Comm I	3
MATH 321	Differential Equations	3
General Education Goal 3 or 4 Elective <sup>5</sup>		3
ENVE 390	Seminar	0.5
<b>TOTAL</b>		<b>16.5</b>

### Junior Year

#### **First Semester**

ENGL 289	Tech Comm II	3
ENVE 315	Fund of Heat Transfer	2
ENVE 326	Intro Env Engr Design	3
BIOL 341	Microbial Processes in Engr. and Nat Science	3
Technical Elective <sup>7</sup>		3

Science Elective	3
<b>TOTAL</b>	<b>17</b>

#### **Second Semester**

IENG 301	Basic Engr. Economics	2
ENVE 316	Fund of Mass Transfer	2
ENVE 325	Intro to Sustainable Design	3
ENVE 327	EnvE Proc Analysis	3
ENVE 327L	EnvE Process Analysis Lab	1
EM 328	Applied Fluid Mechanics <sup>2</sup>	3
ENVE 390	Seminar	0.5
Science Elective	3	
<b>TOTAL</b>		<b>17.5</b>

### Senior Year

#### **First Semester**

ENVE 421	Environ Systems Analysis	3
ENVE 428L	EnvE Ops and Processes Lab	1
ENVE 464	EnvE Project Design I	1
ENVE 475/L	Ground Water	3
Program Approved Elective <sup>3</sup>		3
Program Approved Elective <sup>3</sup>		3
3xx/*4xx Hum/SocSc Elective		3
<b>TOTAL</b>		<b>17</b>

#### **Second Semester**

ENVE 337	Engineering Hydrology	3
ENVE 390	Seminar	0.5
ATM 405	Air Quality	3
ENVE 425	Sustainable Engineering	3
ENVE 465	Envr Engr Design II	2
ENVE 466	EnvE Process Design	3
Program Approved Elective <sup>3</sup>		3
<b>TOTAL</b>		<b>17.5</b>

**136 credits are required for graduation**

#### **Curriculum Notes**

<sup>1</sup>A combination of EM 214/321, EM 214/215, or EM 214/ME 221 may replace EM 216.

<sup>2</sup>CBE 218, EM 331, or ME 331 will also satisfy fluid mechanics requirements.

<sup>3</sup>Six (6) of nine (9) program approved elective credits must be engineering topics. See your advisor for a listing of applicable engineering topics courses. The remainder must be 3xx or higher level, addressing natural science, applied science, mathematics, or engineering topics.

<sup>4</sup>Music Ensemble courses may be substituted for physical education courses for qualified students. Any other substitutions must be approved in advance by the physical education department head.

<sup>5</sup>Consult the section of the catalog addressing graduation requirements for a description of the combinations of lower level (1xx/2xx) social

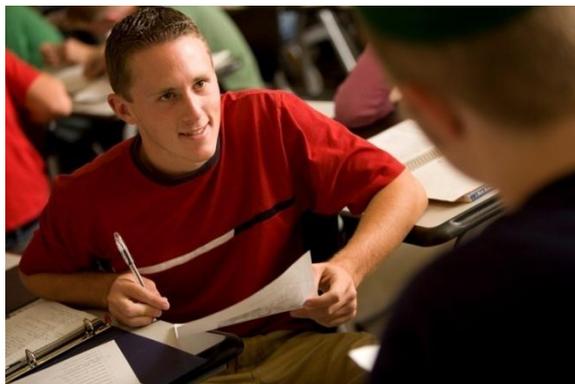
sciences and humanities courses meeting the SDBOR General Education Goals #3 and #4.

<sup>6</sup>ME 211 or Met 320 may replace CBE 222.

<sup>7</sup>A mathematics, basic or applied science, or engineering topics course (beyond stated curricular requirements) at any level that is allowed for engineering degree credit.



## General Studies, Associate of Arts Degree A.A.



### Contact Information

#### **Dr. Frank Van Nuys**

Department of Social Sciences

Classroom Building 319

(605) 394-2481

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The Associate of Arts Degree in General Studies is a two-year degree program that provides a student the opportunity to complete a curriculum in traditional fields of study. The curriculum offers a broad and varied background in general education as well as opportunities to explore a number of disciplines as a basis for entrance into a four-year degree program. Completion of the A.A. degree will fulfill the general education requirements for a baccalaureate degree at the state universities of South Dakota. Approved general education courses from other state universities may be used to satisfy the School of Mines general education requirements. The program of studies is as follows:

#### **Associate of Arts Degree**

##### **General Education Requirements**

Students are responsible for checking with their advisors for any program modifications that may occur after the publication of this catalog.

##### **A. Written and Oral Communication**

A minimum of 9 semester hours is required. This requirement can be met by taking one of two sequences of courses. Either:

ENGL 101	Composition I	3
ENGL 279	Technical Comm. I	3
ENGL 289	Technical Comm. II	3

##### **OR:**

ENGL 101	Composition I	3
ENGL 201	Composition II	3
SPCM 101	Fundamentals of Speech	3

Students who intend to continue at or return to Mines for a B.S. degree should take the first sequence—ENGL 101, 279, 289.

##### **B. Humanities**

Courses in history, literature, philosophy, religion, non-English languages, art, music, and theatre may be used. A minimum of 6 semester hours in two disciplines (i.e., two different course prefixes or a two-semester sequence in a foreign language, is required).

ART 111/112	Drawing and Perception I and II	3/3
ARTH 211	History of World Art I	3
CHIN 101	Introductory Chinese I	4/4
CHIN 102	Introductory Chinese II	4/4
ENGL 210	Introduction to Literature	3
ENGL 212	World Literature II	3
ENGL 221/222	British Lit. I and II	3/3
ENGL 241/242	American Lit I and II	3/3
ENGL 250	Science Fiction	3
GER 101/102	Intro German I and II	4/4
HIST 121/122	Western Civilization I and II	3/3
HUM 100	Intro. to Humanities	3
HUM 200	Connections: Humanities and Technology	3
MUS 100	Music Appreciation	3
MUS 110	Basic Music Theory I	3
PHIL 100	Intro. to Philosophy	3
PHIL 200	Intro. to Logic	3
PHIL 220	Intro. to Ethics	3
PHIL 233	Philosophy and Literature	3
SPAN 101/102	Intro. Spanish I and II	4/4

##### **C. Social Sciences**

Courses in anthropology, economics, geography, history, political science, psychology, and sociology may be used. A minimum of 6 semester hours in two disciplines (i.e., two

different course prefixes, is required).

ANTH 210	Cultural Anthropology	3
GEOG 101	Introduction to Geography	3
GEOG 210	World/Regional Geography	3
GEOG 212	Geography of North America	3
HIST 151/152	US History I and II	3/3
POLS 100	American Government	3
POLS 250	World Relations	3
PSYC 101	General Psychology	3
SOC 100	Introduction to Sociology	3
SOC 150	Social Problems	3
SOC 250	Courtship and Marriage	3

#### D. Mathematics

A minimum of 3 semester hours of college algebra or a math course with college algebra as a prerequisite is required.

MATH 102	College Algebra	3
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#### E. Natural Sciences

A minimum of 6 semester hours in the natural sciences is required including one semester hour of laboratory. The following courses in biology, chemistry, earth science, geology, and physics may be used.

BIOL 151/151L	General Biology I and Laboratory	3/1
BIOL 153/153L	General Biology II and Laboratory	3/1
CHEM 106/106L	Chemistry/Laboratory	3/1
CHEM 108/108L	Organic and Bio. Chemistry/Laboratory	4/1
CHEM 112/112L	General Chemistry I and Laboratory	3/1
CHEM 114/114L	General Chemistry II and Laboratory	3/1
GEOL 201/201L	Physical Geology/	

	Laboratory	3/1
PHYS 111/111L	Introduction to Physics I and Laboratory	3/1
PHYS 113/113L	Introduction to Physics II and Laboratory	3/1
PHYS 211	University Physics I	3
PHYS 213/213L	University Physics II and Laboratory	3/1

#### Electives

Total semester hours required to graduate is 64. The number of elective credits will vary depending on the courses selected in humanities, social sciences, mathematics, and natural sciences. All elective courses must be approved by the student's academic advisor.

#### Other Degree Requirements

Students are required to pass the CAAP proficiency examination. For additional information on this examination, contact the Office of the Registrar and Academic Services at (605) 394-2400.

Students must have achieved a minimum cumulative grade point average of 2.00 in order to graduate with this degree.

After completion of 48 credit hours, students may register for up to nine hours of 300 level courses.

Students must meet the Institutional Credit Requirements, which include completion of a minimum of 16 credits from School of Mines. In addition, 8 of the last 16 credits counted toward the degree must be taken from School of Mines.

This information and an A.A. worksheet may be found at: <http://is.sdsmt.edu>.

## Geology B.S. and Minor



### Contact Information

#### **Dr. Laurie Anderson**

Department of Geology and Geological Engineering  
Mineral Industries 307  
(605) 394-2461  
E-mail: Laurie.Anderson@sdsmt.edu

### Faculty

Professors Anderson, Duke, Paterson and Price; Associate Professor Uzunlar; Assistant Professors Pagnac and Terry; Professors Emeritus Fox, Lisenbee and Redden; Haslem Post-doctoral Fellow Wood.

### Supporting Faculty

Professors Davis and Stetler; Assistant Professors Katzenstein and Sawyer; Professor Emeritus Rahn; Adjunct Professors Benton, Martin and McCormick.

### Geology and Paleontology

The program in geology and paleontology fully utilizes the magnificent geologic setting of the Black Hills and Badlands, and the extensive fossil and mineral specimens in the Museum of Geology. We train students for careers in the geosciences including environmental applications, mineral and petroleum exploration, governmental agencies, museums, academic fields, teaching,

and entrepreneurship. Both undergraduate and graduate programs are available.

### **Choosing a career focus**

Many different types of career opportunities are open to students in the geosciences. Students complete a core of geology courses to solidly prepare them for one of the many potential careers in the geosciences. Additional electives are chosen to focus on a particular career path and best prepare the student for employment or graduate school. Students may focus in one of four career paths or select electives from two or more foci, depending on their career interests. Students are strongly encouraged to consult with their advisor in selecting a focus and electives.

### **Resource Geology**

This focus prepares students for careers with the traditional employers of geologists--the mining and petroleum industries. Graduates may work to find oil or mineral resources, assist with extracting them, or develop new types of resources such as coal bed methane or oil shales. Recommended electives for resource geology include:

MEM 201	Mine Surveying
MEM 433	Geoscience Modeling
GEOE 324	Eng Geophysics I <sup>#</sup>
GEOE 425	Eng Geophysics II
GEOE 451	Economic Geology
GEOE 452	Geochemical Exploration
GEOE 462	Drilling Engineering
GEOE 461	Petroleum Production
GEOL 351	Earth Resources
GEOL 442	Optical Petrology

### **Paleontology**

This focus area trains students for careers studying ancient organisms and their environments. Graduates will often go to graduate school to develop research careers, but opportunities are also available to work in museums, parks, or with consulting firms that survey and preserve fossil resources prior to construction projects. Paleontology students will

work closely with Museum of Geology facilities and personnel. Recommended electives for paleontology include:

BIOL 121/L	Anatomy
BIOL 151	Gen Biology I
BIOL 123	Physiology
BIOL 153	Gen Biology II
BIOL 311	Principles of Ecology
GEOL 371	Field Paleontology
GEOL 372	Dinosaurs
GEOL 472	Museum Conservation & Curation
GEOL 473	Museum Prep and Exhibit Design

### **Environmental Geology**

This focus prepares students for work developing and preserving natural resources including ground water and soils. Students may work for environmental firms, or could do environmental work for petroleum and mineral companies. Many government agencies also hire graduates with these skills. Recommended electives for environmental geology include:

GEOL 351	Earth Resources
GEOE 324	Eng Geophysics I
GEOE 425	Engineering Geophysics II
GEOE 466	Eng/Environmental Geol
GEOE 462	Drilling Engineering
GEOE 468	Geohazards
GEOE 475	Ground Water
GEOE 482	Applied Geomorphology

### **Geospatial Technology**

This focus supplies additional training for students interested in careers that involve remote sensing and Geographic Information Systems. Most geoscience careers require basic knowledge of GIS, but additional training opens new career options for students who enjoy mapping and computers. Graduates may work in traditional petroleum, mining, or environmental companies, for government agencies, or within the geospatial industry that provides and manages maps and imagery to the world. Recommended electives for geospatial technology include:

MEM 201	Mine Surveying
GEOE 475	Ground Water

GEOL 376	Geospatial Field Methods
GEOL 417	Geospatial Databases
GEOL 419	Adv Geospatial Analysis
GEOL 420	Remote Sensing

Geology majors can simultaneously satisfy elective requirements for the Geology B.S. and a Minor in Geospatial Technology by taking GEOL 417, GEOL 419, GEOL 420, and two courses from: MEM 201, MATH 281, GEOE 475\*, or GEOL 376. Students considering the geospatial minor should take GEOL 416 Intro to GIS by their junior fall.

### **Advanced Degrees**

This B.S. in Geology can provide a pathway to professional careers in teaching, law, or medicine. For careers in science education, students should consult teaching programs at other colleges for auxiliary education courses that would be needed for teacher certification. With some adaptation, this degree can provide a foundation for professional graduate degrees such as medicine or law.

Graduate programs, both master's and doctoral, are available and involve additional specialization in geology or paleontology. They commonly include research on regional or local problems. Analytical and computational facilities in the department and related departments include the electron microprobe, heating-cooling fluid inclusion stage, AA-ICP, XRD, SEM, TEM, the Geographic Information Systems/ Remote Sensing Laboratory. The Museum of Geology holds over 500,000 fossil and mineral specimens that are available for educational and research use. Completion of graduate degrees leads to higher-level professional employment including college-level instruction.

### **Professional Development**

The senior year culminates in an individual research project in which the student practices the professional accomplishments of project planning, organization, time management, and oral/written communication. Students are strongly encouraged

to participate in professional societies active on campus, including the Tech Geological Association, the Society of Economic Geologists and the Paleontology Club. Paleontology students will have opportunities to volunteer or work on archival and research projects at the Museum of Geology. Internships in industry and government are commonly available and highly recommended.

### **Minor In Geology**

Other science and engineering majors may pursue a minor in geology by completing eighteen (18) credit hours of geology courses including the following: GEOL 201, 201L, 212, 331, 341, and GEOE 322. GEOE 221 and one additional geology elective credit may be substituted for GEOL 201/L. No other substitutions are permitted for this minor.

### **Minor in Geospatial Technology**

Geospatial Technology is a rapidly expanding field that covers the management and analysis of spatial data from many sources, such as satellites, airborne remote sensing, geographic information systems (GIS), global positioning systems (GPS), surveying, and more. It has many applications in the sciences, engineering, business, planning, and transportation. Other science and engineering majors may pursue a Minor in Geospatial Technology by completing eighteen (18) credit hours of courses, including GEOL 416, GEOL 417, GEOL 419, and GEOL 420. Six additional credits taken from any of the groups below complete the minor. Up to three credits of a senior capstone, research, or design project with a significant proportion of geospatial content may be substituted for one elective, with permission of the program director.

ONE of these surveying courses may be applied to the minor:

- CEE 206 Civil Engineering Practice and Engineering Surveys (4 cr)
- MEM 201 Surveying for Mining Eng. (2 cr)

ONE of these statistics courses may be applied to the minor:

- ENVE 307 Environmental Geostatistics (2 cr)
- MEM 307 Mineral Exploration and Geostatistics (3 cr)
- MATH 281 Intro to Statistics (3 cr)
- MATH 381 Probability and Statistics (3 cr)
- MATH 441 Engineering Statistics (4 cr)

ONE of these programming courses may be applied to the minor:

- CBE 117 Professional Practices in Chemical Engineering (2 cr)
- GEOE 211 Earth Systems Engineering Analysis (2 cr)
- CEE 284 Digital Computation Applications in Civil Engineering (4 cr)
- CSC 150 Computer Science I (3 cr)

ANY of these courses may be applied to the minor:

- GEOE 475 Ground Water Modeling (3 cr)
- CEE 437 Watershed and Flood Plain Modeling (3 cr)
- CSC 250 Computer Science II (3 cr)
- CSC 284 Database Processing (3 cr)
- GEOL 376 Geospatial Field Methods (3 cr)

### **Geology/Paleontology Curriculum/Checklist**

It is the student's responsibility to check with his or her advisor for any program modifications that may occur after the publication of this catalog. When planning coursework, students are advised that the courses GEOL 212, GEOL 341, GEOE 322 and GEOL 410 form a critical sequence that must be taken in the order listed.

#### **Freshman Year**

<b>First Semester</b>		
MATH 123	Calculus I	4
CHEM 112	General Chemistry I	3
CHEM 112L	General Chemistry I Lab	1
ENGL 101	Composition I	3
GEOL 201	Physical Geology	3
GEOL 201L	Physical Geology Lab	1
IS 110	Explorations <sup>1</sup>	2
<b>TOTAL</b>		<b>17</b>

**Second Semester**

CHEM 114	General Chemistry II	3
CHEM 114L	General Chemistry II Lab	1
MATH 125	Calculus II	4
GEOE 211/L	Earth Sys Eng Analysis	2
Gen. Ed. Goal 3 and Goal 4 Electives <sup>2</sup>		6
<b>TOTAL</b>		<b>16</b>

**Sophomore Year****First Semester**

PHYS 211	University Physics I	3
One of <sup>3</sup>		3-4
MATH 225	Calculus III (4 cr)	
MATH 281	Intro to Statistics (3 cr)	
GEOL 323	Search for Our Past	3
Sophomore Electives <sup>4</sup>		3
Gen Ed Goal 3 and Goal 4 Electives <sup>2</sup>		3
<b>TOTAL</b>		<b>15-16</b>

**Second Semester**

PHYS 213	University Physics II	3
ENGL 279	Technical Comm I	3
GEOL 212/L	Mineralogy/Crystallography	3
Sophomore Electives <sup>4</sup>		3
Gen Ed Goal 3 and Goal 4 Electives <sup>2</sup>		3
PE	Physical Education	1
<b>TOTAL</b>		<b>16</b>

**Junior Year****First Semester**

ENGL 289	Technical Comm II <sup>1</sup>	3
GEOL 331/L	Stratigraphy/Sedimentation	3
GEOL 341/L	Igneous/Metamorphic Petrol	3
GEOL 416/L	Intro to GIS	3
Geology Electives <sup>4</sup>		3
<b>TOTAL</b>		<b>15</b>

**Second Semester**

GEOE 322/L	Structural Geology	3
GEOL 403	Regional Field Geology <sup>5</sup>	1
GEOL 461/L	Invertebrate Paleo <sup>**</sup>	3
One of:		3
GEOE 324/L	Engr. Geophysics I	
GEOE 482/L	Applied Geomorph <sup>**</sup>	
Geology Electives <sup>4</sup>		3
Humanities/Social Science electives		1
PE	Physical Education	1
<b>TOTAL</b>		<b>15</b>

**Summer**

GEOL 410	Field Geology	<b>6</b>
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**Senior Year****First Semester**

GEOL 464	Senior Research I	1
Geology Electives <sup>4</sup>		6
Free Elective(s) <sup>3</sup>		3
Humanities/Social Science electives		3
<b>TOTAL</b>		<b>13</b>

**Second Semester**

GEOL 465	Senior Research II <sup>6</sup>	3
Geology Electives		6
Free electives		5-6
<b>TOTAL</b>		<b>14-15</b>

**128 credits required for graduation**

\*\* Course offered in alternate years.

## Curriculum Notes

<sup>1</sup>Transfer students may substitute 2 credits of free electives for IS 110.

<sup>2</sup>Students must complete 27 credits of the general education core in their first 64 credit hours, including 6 credits of science, 3 cr math, 6 cr English/Technical Communication, 6 cr humanities, and 6 cr social science. ENGL 289 yields an addition 3 general education credits, for a total of 30.

<sup>3</sup>Students should consult an advisor when choosing math.

<sup>4</sup>Sophomore and Geology electives must be selected from the approved lists. At least 9 credits must be taken from 400-level courses.

Substitutions must be approved by dept head.

<sup>5</sup>Students may substitute Geol 371 Field Paleontology (0-2) for Geol 403; the extra credit is a geology elective.

<sup>6</sup>Under exceptional circumstances, a student may petition the department head to substitute geology electives for senior research.

Additional coursework in mathematics and statistics is recommended. Students planning to go to graduate school are advised take three semesters of calculus. MATH 381 and MATH 382 are recommended statistics courses; MATH

432 is recommended for students interested in numerical modeling of partial differential equations.

### **The Black Hills Natural Sciences Field Station**

The Black Hills Natural Sciences Field Station functions in cooperation with universities from South Dakota, North Dakota, Mississippi, and Wisconsin with the purpose of providing summer field courses in the Black Hills and nearby areas, as well as overseas. Field courses in geology, geological engineering and environmental science and engineering are offered. For descriptions of all courses offered, see the listings of the Department of Geology and Geological Engineering in this catalog.

The Field Station operates from five sites: School of Mines campus, Ranch A in the northern Black Hills of Wyoming, Taskesti in the country of Turkey, and the city of Chennai and the Andaman Islands in India, and the Himalayas of Nepal.

#### **Geology and Geological Engineering Field Camps:**

GEOL 410 Field Geology — five (5) weeks (six (6) semester hours) — Ranch A, Wyoming

GEOL 410 Field Geology — five (5) weeks (six (6) semester hours) --- Taskesti, Turkey

GEOE 410 Engineering Field Geology five (5) weeks (six (6) semester hours) — Rapid City, SD

GEOE 410 Engineering Field Geology five (5) weeks (six (6) semester hours) – Taskesti, Turkey

GEOL/GEOE 412/512 Science and Engineering Applications (3 to 6 semester hours), Rapid City - SD, Taskesti – Turkey, Chennai/Andaman Islands,-- India, and Himalayas, Nepal.

#### **Paleontology Field Camps:**

GEOL 371: Field Paleontology – two (2) weeks two (2) semester hours – held at one of several ongoing paleontology sites throughout South Dakota, Wyoming, Oregon, and the western

United States with department and Museum of Geology faculty and personnel

BHNSFS also offers youth and freshman geology field camps and field trips.

Further information may be obtained by calling (605) 394-2494, or go to the website:

<http://geologyfieldcamp.sdsmt.edu>.

Online registration or applications (available from the web page) should be received by March 1<sup>st</sup>. All deposit fees are non-refundable upon acceptance into the course.

### **Geographic Information Systems (GIS) and Remote Sensing Lab**

The Geographic Information Systems (GIS) and Remote Sensing Laboratory is a facility for generating and analyzing spatially-referenced digital information, including maps and remotely-sensed data. Undergraduate and graduate courses in GIS are offered through the Department of Geology and Geological Engineering. (See section on Research Centers and Related Activities for a full description.)

# Geological Engineering B.S.



## Contact Information

### **Dr. Laurie Anderson**

Department of Geology and Geological Engineering

Mineral Industries 307

(605) 394-2461

E-mail: Laurie.Anderson@sdsmt.edu

## Faculty

Professors Davis and Stetler; Assistant Professors Katzenstein and Sawyer; Professor Emeritus Rahn.

## Supporting Faculty

Professors Duke, Hladysz, Paterson and Price; Associate Professor Uzunlar; Assistant Professors

Terry and Antonov; Adjunct Professors M. Anderson and Long.

## Geological Engineering

Geological engineering is the development and conservation of natural resources in ways useful to humankind. It encompasses diverse fields such as ground-water resources, subsurface contamination, slope stability, environmental site design, petroleum exploration and production, and mineral resources. The instruction in geological engineering provides training at both the undergraduate and graduate levels through the Ph.D.

## Geological Engineering Program Objectives

The program educational objectives defined here describe the career and professional accomplishments that the geological engineering program is preparing graduates to achieve.

1. Graduates of the geological engineering program will perform competently in professional practice in the areas of:
  - ground water
  - environmental site planning and natural hazards
  - geomechanics and geotechnics
  - fuels or minerals
2. Graduates will demonstrate the ability to design and implement appropriate solutions to geological engineering problems, while exercising ethical responsibilities and continued professional development.

In support of these objectives, the program in geological engineering provides students with:

- a) an understanding of the fundamental principles of geological engineering, basic engineering, and geology,
- b) academic training and design experiences to prepare them for engineering practice and career advancement in the geological engineering profession during their first several years of work, and

c) an education that prepares them to pursue advanced studies if they so desire.

### **Geological Engineering Education**

An integral part of the educational experience is development of the ability to design solutions for meeting desired needs in geological engineering work. The design component of the curriculum is developed within geological engineering courses that integrate basic science (including geology, chemistry, and physics) and engineering science (including statics, mechanics of materials, fluid mechanics, soil mechanics, and thermodynamics). This engineering design experience includes a two-semester capstone design sequence. The capstone engineering design courses build upon and integrate previous coursework to prepare graduates for the professional practice of geological engineering.

The nature of geological engineering is continually evolving as the needs of employers change in response to advances in technology and economic forces. To prepare adequately for careers in geological engineering, students must be willing to engage in life-long learning in order to embrace new technologies and to stay current within the engineering profession. Graduates with a broad range of skills, flexibility in learning new technologies, and sound training in fundamental principles can expect a competitive advantage in the job market and workplace.

The bachelor of science program in geological engineering is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

A minor in geological engineering is not available.

### **Professional Development**

Students in geological engineering are encouraged to participate in the Student Chapter of the Association of Engineering Geologists as well as to become student members of the National Ground Water Association, the Society for Mining, Metallurgy, and Exploration (SME), and the Society of Petroleum Engineers (SPE). Students are strongly encouraged to take the

Fundamentals of Engineering examination, as the first step in becoming a registered professional engineer.

### **Geological Engineering Laboratories**

The Department of Geology and Geological Engineering has laboratory facilities that include a ground-water laboratory with digital and analytical modeling capabilities, a Geographic Information Systems (GIS) laboratory, a van-mounted geoprobe unit, wind engineering equipment, a geotechnics laboratory, a drilling fluids laboratory, a 3D photogrammetric camera system, a ground-based LIDAR camera, and an operational well field with data loggers and transducers. Instrumentation includes ground-probing radar, a hydrologic analysis system, a portable wind tunnel, a mobile drilling rig, and petroleum engineering equipment. The computing facilities are continually updated and contain high-speed computers with GIS and other analytical capabilities. Computer programs are available for digital modeling of ground-water flow and contaminant migration, petroleum engineering, slope stability, geophysical applications, geochemical modeling, and spreadsheet applications.

### **Black Hills Natural Sciences Field Station (BHNSFS)**

The BHNSFS serves as the residential base camp for geology and geological engineering summer programs. (See section under Geology B.S. and Minor for a full description.)

### **Geographic Information Systems (GIS) and Remote Sensing Laboratory**

The Geographic Information Systems (GIS) and Remote Sensing Laboratory is a facility for generating and analyzing spatially referenced digital information, including maps and remotely sensed data. Undergraduate and graduate courses in GIS are offered through the Department of Geology and Geological Engineering. (See section on Research Centers and Related Activities for a full description.)

## Geological Engineering Curriculum/Checklist

It is the student's responsibility to check with his or her advisor for any program modifications that may occur after the publication of this catalog.

### Freshman Year

#### **First Semester**

CHEM 112	General Chemistry I	3
MATH 123	Calculus I	4
ENGL 101	Composition I	3
GEOE 110/L	Intro to Geological and Mining Engineering	2
Gen. Ed. Goal 3 and Goal 4 Electives		6
<b>TOTAL</b>		<b>18</b>

#### **Second Semester**

CHEM 112L	General Chem. I Lab	1
CHEM 114	General Chemistry II	3
MATH 125	Calculus II	4
PHYS 211	University Physics I	3
GEOE 221/L	Geology for Engineers	3
CEE 117/L	Computer Aided Design and Interpretation in Civil Engr.	2
<b>TOTAL</b>		<b>16</b>

### Sophomore Year

#### **First Semester**

EM 214	Statics	3
MATH 225	Calculus III	4
MEM 201L	Surveying for Mineral Engineers	2
PE	Physical Education	1
PHYS 213	University Physics II	3
Gen. Ed. Goal 3 Electives		3
<b>TOTAL</b>		<b>16</b>

#### **Second Semester**

ENGL 279	Technical Communications I	3
EM 321	Mechanics of Materials	3
GEOE 212/L	Mineralogy/Crystallography	3
MATH 321	Differential Equations	3
PE	Physical Education	1
Gen. Ed. Goal 4 Electives		3
<b>TOTAL</b>		<b>16</b>

### Junior Year

#### **First Semester**

ENGL 289	Tech Communications II	3
GEOE 331/L	Stratigraphy & Sedimentation	3
GEOE 341/L	Igneous & Metamorphic Petrology	3
CEE 346/L	Geotechnical Engineering	3
MET 320	Met. Thermodynamics	4
<b>TOTAL</b>		<b>16</b>

#### **Second Semester**

GEOE 322/L	Structural Geology	3
GEOE 324/L	Engineering Geophysics I	3
EM 328	Applied Fluid Mechanics	3
GEOE 416/L	Intro to GIS	3
MEM 302	Mineral Econ. and Finance	3
Humanities or Social Sciences Elective		1
<b>TOTAL</b>		<b>16</b>

#### **Summer**

GEOE 410	Engineering Field Geology	6
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### Senior Year

#### **First Semester**

GEOE 466/L	Engr. and Env't Geology	3
GEOE 475/L	Ground Water	3
GEOE 464	Geol Engr Design Project I	3
Approved Elective <sup>2</sup>		3
Professional Elective <sup>1</sup>		3
<b>TOTAL</b>		<b>15</b>

#### **Second Semester**

MEM 304/L	Rock Mechanics	4
Professional Elective <sup>1</sup>		3
GEOE 465	Geol. Engr. Design Project II	3
GEOE 461	Petroleum Production	3
Upper-Level Humanities or Social Sciences		3
Free Elective		1
<b>TOTAL</b>		<b>17</b>

### **136 credits required for graduation**

#### **Curriculum Notes**

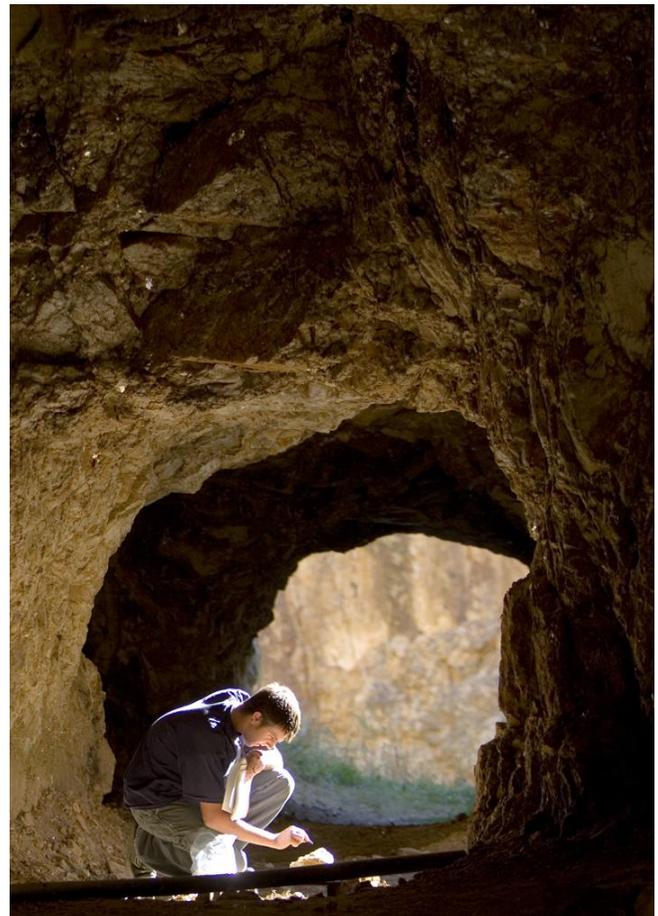
<sup>1</sup> Professional Electives. Students may choose two of the following courses:

GEOE 451	Economic Geology
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GEOE 462	Drilling Engineering
GEOE 468	Geohazards
GEOE 482	Applied Geomorphology
ENVE 327	Environmental Engineering Process Analysis
ENVE 421	Environmental Systems Analysis
CEE 337	Engineering Hydrology
CEE 347	Geotechnical Engineering II
CEE 437	Watershed and Floodplain Modeling
CEE 447	Foundation Engineering
CEE 474	Engineering Project Management
ME 351	Mechatronics and Measurement Systems (cross-listed with EE 351)
MEM 305	Introduction to Explosives Engineering
MEM 307	Mineral Exploration and Geostatistics
MEM 405	Mine Permitting and Reclamation
MEM 433	Computer Applications in Geoscience Modeling
MEM 450	Rock Slope Engineering

<sup>2</sup>Approved Elective. Must be a course approved by the Department of Geology and Geological Engineering.

Additional coursework in mathematics and statistics is encouraged. MATH 381 and MATH 382 are recommended statistics courses; MATH 432 is recommended for students interested in numerical modeling of partial differential equations.



## Humanities



### Contact Information

#### **Dr. Sue Shirley**

Departments of Humanities and Social Sciences  
Classroom Building 310  
(605) 394-2481  
E-mail: [Sue.Shirley@sdsmt.edu](mailto:Sue.Shirley@sdsmt.edu)

### Faculty

Professors Antonen, Boysen, Feiszli, Palmer, Rice, Shirley and Sneller; Associate Professors Hudgens, Lee and Mitchell; Assistant Professor Adkins; Instructor Drobnak.

### Humanities

The Department of Humanities provides study in the fields of communication, fine arts, foreign languages, literature, religion, western civilization, and philosophy. The curriculum provides a broad-based approach, which develops linkages between the humanities areas and the technological fields that are the mission of School of Mines. Interdisciplinary sciences degree candidates are required to complete 24 semester hours of humanities and social science courses. Other science and engineering degree candidates are required to complete 15-16 semester hours of humanities and social sciences courses — at least 6 credits in each area. Engineering majors are required to enroll in at least one upper-level humanities or social science course (of at least 3 credit hours).

All IS degree candidates must complete

ENGL 101, ENGL 279, ENGL 289, IS 110, IS 201, IS 401, and IS 498, which cannot be used to meet the humanities/social sciences requirements.

### Humanities

(Upper level courses are in bold print.)

#### **Art:**

ART 111, 112, ARTH 211, **321, 491, 492**

#### **English:**

ENGL 031<sup>1</sup>, 032<sup>1</sup>, 033<sup>1</sup>, 101<sup>2</sup>, 201<sup>3</sup>, 210, 212, 221, 222, 241, 242, 250, 279<sup>2</sup>, 289<sup>2</sup>, **300, 330, 343, 350, 360, 374, 383, 391<sup>3</sup>, 392<sup>3</sup>**

#### **Foreign Language:**

CHIN 101 102, GER 101, 102, SPAN 101, 102

#### **History:**

HIST 121, 122

#### **Humanities:**

HUM 100, 200, 291, 292, **350, 375, 491, 492**

#### **Music:**

MUAP 102, 120<sup>6</sup>, 121<sup>6</sup>, 130<sup>6</sup>, 131<sup>6</sup>, 200, 201, MUEN 100<sup>4</sup>, 101<sup>4</sup>, 121<sup>4</sup>, 122<sup>4</sup>, 260<sup>5</sup> MUS 100, 110, 217/217L<sup>6</sup>, 317/317L

#### **Philosophy:**

PHIL 100, 200, 220, 233

#### **Speech Communications:**

SPCM 101<sup>3</sup>

#### **Notes:**

<sup>1</sup> Does not meet general requirements for graduation.

<sup>2</sup> Meets general requirements for graduation, but not for humanities credits.

<sup>3</sup> May not be used as humanities credit, but may be used for free elective credit. Consult advisor for further details.

<sup>4</sup> May not be used as humanities credit, but may be used for PE or free elective credit. Consult advisor for further details.

<sup>5</sup>May not be used for credit.

<sup>6</sup>May be used for humanities credit but does not count as general education credit.

## Industrial Engineering and Engineering Management B.S.



### Contact Information

**Dr. Stuart D. Kellogg**

Industrial Engineering

Civil Mechanical 320

(605) 394-1271

E-mail: [Stuart.Kellogg@sdsmt.edu](mailto:Stuart.Kellogg@sdsmt.edu)

### Faculty

Ervin Pietz Professor Kellogg; Professor Kerk;  
Associate Professors Matejcek, Karlin and Jensen;  
Assistant Professor Piper.

Industrial engineering and engineering management is concerned with the design, improvement, installation, and management of integrated systems of people, material, and equipment. Graduates of the program employ a set of skills that includes mathematical modeling, probability and statistics, computer science, human factors, interpersonal skills, project management, and an ability to manage and administer large technical engineering and research projects. Thus, industrial engineering and engineering management may be thought of as applied problem solving, from inception to implementation and management.

### Program Objectives

The objectives of the industrial engineering and engineering management program are to produce graduates who:

- Contribute to the success of companies through effective problem solving.
- Design, develop, implement, and improve integrated systems that include people, materials, information, equipment, and environments.
- Effectively manage business operations and project management teams.
- Continue to develop holistically, including the personal and professional skills necessary to adapt to our changing societal, technological, and global environments.

Graduates of the industrial engineering and engineering management program are expected to meet the challenges for contemporary professional practice, be able to adapt and solve the increasingly complex problems faced by industry, embrace innovation through intellectual diversity and creative problem solving, and continue to develop holistically as a learner to become leaders of tomorrow.

### Education

The curriculum is designed to give students a thorough knowledge in the fundamental principles within the four primary stems of industrial engineering: operations research and optimization, manufacturing, statistical processes, and human engineering. In addition, through a variety of coursework and experiential learning activities, students develop an understanding of the engineering relationships with the management tasks of planning, leading, organizing, and controlling as well as the integrative nature of management systems.

Throughout the program of studies, special emphasis is placed upon application of systems principles in engineering design to assure proper integration of the individual (or individuals),

procedures, materials, and equipment. Service learning components, laboratories, case work, simulations, and the capstone design sequence reinforce the managerial aspects of systems integration, systems design, and the global, societal, and business context for product and process improvement.

Students may participate in the Cooperative Education Internship Program. The co-op credits may count as approved engineering elective courses.

The bachelor of science program in industrial engineering and engineering management is accredited for industrial engineering by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

### **Laboratories**

The Human Engineering Laboratory supports the minor in occupational safety and courses in work methods and measurement, ergonomics/human factors engineering, safety engineering, and industrial hygiene. Laboratories typically include an enterprise team or service learning component that provide real world work experience. The Manufacturing, Industrial Learning Laboratory (MILL) supports the computer controlled manufacturing course and operational strategies. Using modern equipment, students will utilize robots, material handling equipment, and computer numerically controlled machinery to design and fabricate a finished product as well as allowing students to simulate large production systems to explore flexible manufacturing systems and strategies for lean manufacturing.

### **Minor in Occupational Safety**

The minor in occupational safety is offered to students pursuing any B.S. degree program. The minimum math and science course requirements are CHEM 112/112L, MATH 123, PHYS 111 or 211, and MATH 281 or 381 or 441. Required courses are IENG 321/331/341, PSYC 331 or POLS 407, Senior Design or Senior Project in home department, and a minimum of 6 credit hours: BIOL 121/121L/123/123L, ENVE 7326,

CHEM 114/114L, CHEM 480, CP 297/397/497<sup>1</sup>, IENG 491<sup>1</sup>, ME 380, MEM 203, and PE 105. Thus, a total of at least 21 credit hours is needed for an occupational safety minor. A minor in occupational safety must be approved by the student's major department and the minor coordinator on a form available at the Office of the Registrar and Academic Services. Additional information may be found at the department website: <http://ie.sdsmt.edu>.

<sup>1</sup>Projects must be pre-approved and have significant safety content.

### **Certificate Programs**

Students may elect to add value to their transcript via certificate program offerings in Six Sigma Greenbelt, Engineering Management and Leadership, and Technology Innovation. The Six Sigma Greenbelt program provides the necessary components and training for greenbelt certification desired by industry. Students will gain an exposure to the six sigma quality management philosophy culminating in a project application of quality by design. The Engineering Management and Leadership program provides students an opportunity to complement their technical skills with modern management techniques, organizational theory, and change management practices required to effectively manage technical industries. The Technology Innovation certificate provides students with a value-added curriculum in creativity and innovation, product development, and business and entrepreneurial functions. Additional information may be found at the department website: <http://ie.sdsmt.edu>.

### **Industrial Engineering Curriculum/Checklist**

Students are responsible for checking with their advisors for any program modifications that may occur after the publication of this catalog.

### Freshman Year

#### **First Semester**

MATH 123	Calculus I	4
CHEM 112	General Chemistry I	3
Humanities or Social Sciences Elective(s)		3
PE	Physical Education <sup>1</sup>	1
ENGL 101	Composition I	3
CHEM 112L	General Chemistry I Lab	1
ME 110/L	Intro to Mechanical Engr	2
<b>OR</b>		
CEE 117/L	Computer Aided Design	2
<b>TOTAL</b>		<b>17</b>

#### **Second Semester**

MATH 125	Calculus II	4
PHYS 211	University Physics I	3
PE	Physical Education <sup>1</sup>	1
PSYC 101	General Psychology	3
IENG 241L	Production Tools for Quality Improvement	2
Humanities or Social Sciences Elective(s)		3
<b>TOTAL</b>		<b>16</b>

### Sophomore Year

#### **First Semester**

Engineering Fundamentals Elective		3
ENGL 279	Technical Communications I	3
MATH 225	Calculus III	4
IENG 381	Intro to Probability and Stats	3
PHYS 213	University Physics II	3
PHYS 213L	University Physics II Lab	1
<b>TOTAL</b>		<b>17</b>

#### **Second Semester**

IENG 382	Probability Theory and Stats II	3
MATH 321	Differential Equations	3
IENG 215/216/217	Cost Estimating for Engineers	3
Engineering Fundamentals Elective		3
IENG 302	Engineering Economics	3
Humanities or Social Sciences Elective(s)		3
<b>TOTAL</b>		<b>18</b>

### Junior Year

#### **First Semester**

ENGL 289	Technical Communications II	3
IENG 311/L	Work Methods and Measurement	3

IENG 486	Statistical Quality and Process Control	3
IENG 352	Creativity and Innovation	1
IENG 354	Marketing Technology Innovations	1
IENG 362	Stochastic Models	3
Humanities or Social Sciences Elective(s)		1
Professional Breadth Elective		3
<b>TOTAL</b>		<b>18</b>

#### **Second Semester**

IENG 355	Financing Technology Innovations	1
IENG 441	Simulation	3
MATH 353	Linear Optimization	3
IENG 321/L	Ergonomics/Human Factors Engineering	3
Engineering Fundamentals Elective		3
Professional Breadth Elective		4
<b>TOTAL</b>		<b>17</b>

### Senior Year

#### **First Semester**

IENG 425	Production and Operation	3
IENG 331	Safety Engineering <sup>2</sup>	3
IENG 471	Facilities Planning	3
IENG 464	Senior Design Project I	2
IENG 462	Industrial and Engineering Management Profession	1
Professional Breadth Elective		6
<b>TOTAL</b>		<b>18</b>

#### **Second Semester**

IENG 366	Engineering Management	3
IENG 465	Computer Controlled Manuf	3
IENG 475/L	Computer Controlled Manufacturing	3
Humanities or Social Sciences Elective(s)		3
Department Elective		3
<b>TOTAL</b>		<b>15</b>

### **136 credits required for graduation**

#### **Curriculum Notes**

<sup>1</sup> Music ensemble courses may be substituted for physical education courses for qualified students. Any other substitutions must be approved in advance by the physical education department head.

<sup>2</sup>IENG 341 (Industrial Hygiene) may be substituted during a second semester.

Elective courses must be chosen to satisfy all of the following requirements.

1. Sixteen semester hours in humanities or social science. At least 6 hours must be in humanities and at least 6 hours must be in social sciences. This may include PSYC 101, which is required.

2. Six hours of humanities or social science must be included in the list of approved cultural diversity courses.

3. At least 3 hours of humanities or social science must be at the 300 or 400 level.

A. Department Electives (3 credits)

- Human Engineering (3 credits) IENG 331 or 431
- Department Breadth IENG 353, 356, 451, 452, 466, or 492

B. Engineering Fundamentals (11 credits)

- Graphics (2 credits) ME 110 or CEE 117
- Fundamentals (9 credits from at least two different areas)
- Materials MET 231, MET 232
- Circuits EE 301 or EE 220
- Statics/Dynamics EM 214 or EM 216 or EM 214/215 or EM 214/ME 221
- Thermodynamics CBE 222, ENVE/MET 320, or ME 211
- Fluid Mechanics EM 327, EM 328, or EM 331 or ME 331
- Mechanics ME 216 or EM 321

C. Professional Breadth (12 credits)

- Courses in A beyond 6-credit requirement
- Courses in B beyond 11 credit requirement
- Engineering Breadth
- ME 262
- CENG 244
- GEOE 211, 221
- CP 297, 397, 497
- CSC 150, CSC 250
- CBE/EnE 217, EnvE 315/CBE 317, CBE/EnvE 318
- MEM 203

Mathematics and Science Breadth

- MATH 315, 373, 423, 431, 451, or 447
- GEOL 201
- BIOL 121, 121L, 123, 123L, 151, 151L, 153, 153L
- CHEM 114, 114L, 326, 326L, 328, 328L

Organizational Management Breadth

- PSYC 331
- ENGM xxx
- ACCT 210, 211
- BADM 350, 370, 407
- ECON 201, 202

Petitioned Courses

Students may petition the department to consider specific courses that are not on the approved list. Students must submit a formal petition in writing requesting that a specific course be considered for inclusion on the student's program of study. The petition must include the course prefix and number and specific, but concise, rationale as to how the course complements the student's professional development for a given career goal.

## Interdisciplinary



## Sciences B.S.

### Contact Information

#### **Dr. Sue Shirley**

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Classroom Building 310

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The bachelor of science degree in interdisciplinary sciences (IS) is a science degree program that seeks to serve the needs of students whose goals cannot be met within the other science departments. IS students choose from three areas of specialization: atmospheric sciences; pre-professional health sciences; and science, technology, and society. The IS degree program allows students to enroll in a wide variety of math and science courses, as well as carefully chosen electives in the humanities, fine arts, and social sciences.

**The Interdisciplinary Sciences degree is especially appropriate for the following individuals.**

- Students pursuing pre-professional and health services careers, including but not limited to law, medicine, physical therapy, and radiography.
- Students whose educational and career goals require courses in several departments and the integration of knowledge from diverse fields.

The benefits of the interdisciplinary sciences degree include

- Flexibility in a wide range of study;
- Individual design allowing the student to help select the content of the degree; and
- The opportunity to study natural sciences, social sciences, humanities, and liberal arts from a broad perspective, thus providing a well-rounded program.

### **Areas of Specialization**

Interdisciplinary sciences majors choose from three areas of specialization that will prepare them for graduate and professional programs.

- Atmospheric Sciences
- Pre-Professional Health Sciences
- Science, Technology, and Society

#### **1. Atmospheric Sciences:**

The atmospheric sciences specialization is designed for students whose career goal is meteorology or atmospheric research. Working with faculty from the Department of Atmospheric Sciences, students can take coursework to satisfy federal guidelines (e.g., for National Weather Service, US Bureau of Reclamation and US Geological Survey) for the title of meteorologist. This specialization also serves as excellent preparation for graduate study in meteorology, atmospheric sciences, and related fields. Courses range from those in traditional operational meteorology to those in earth system sciences. All students entering under the 2010 Catalog and later satisfy the United States Government's requirements to qualify as a meteorologist for federal employment.

#### **2. Pre-Professional Health Sciences:**

A strong background in science will prepare students in the pre-professional health sciences specialization for entry into a variety of graduate and professional programs, including medical and dental schools, physical and occupational therapy programs, physician assistant and chiropractic programs, optometry and ophthalmology specialties, and radiography programs. Internships in the community and complementary coursework in the humanities and social sciences are included to help students meet the admissions requirement of the professional schools.

Students planning to enter these professions should consult the programs of study of the schools they plan to attend. Working closely with their advisor, they will select the courses needed to fulfill the graduation requirements for the IS degree and to meet the entrance requirements for the professional schools in health science.

### **Radiologic Technology (RT):**

The School of Mines has an articulation agreement with Rapid City Regional Hospital, which has a fully certified RT program. Students take prerequisite coursework for RT at the School of Mines before applying to the program. Upon completion of the RT program, students may elect to complete the requirements for the IS degree, thus graduating with both a bachelor's degree in IS and the RT certification. A number of the courses needed to complete the RT program count toward the IS degree. Note: Faculty and staff from the School of Mines and the IS degree program are not involved in the selection of candidates for the RT program. School of Mines students are not guaranteed admission to the RT program.

### **3. Science, Technology, and Society:**

The science, technology, and society specialization combines a strong science background with a firm grounding in environmental, social, and science policy issues. Students pursue a science concentration, such as environmental science, or a minor in a science field, which is complemented by studies in areas such as political science, history, humanities, English, and philosophy. Coursework will prepare students for additional study in law school, in science policy or public policy programs, or in graduate programs in science. Careers can include positions in community and government agencies, in science and technology companies, in the military, or as science lobbyists.

### **Interdisciplinary Sciences Program Admission Policy**

After successful completion of at least 64 credit hours and at least one year prior to the intended graduation date, the student must apply for admission to the degree program by filing a

plan of study with the IS Steering Committee. The plan of study must be approved by the steering committee before a student will be formally admitted to the program. This plan of study consists of (1) a Letter of Intent stating the career goals to which the IS degree coursework is to be applied and (2) an IS worksheet showing the courses already taken and the courses to be completed prior to graduation. The Letter of Intent and worksheet must be reviewed and approved by the student's IS advisor before submission to the Steering Committee. The Letter of Intent form and worksheet are available from the IS office or may be accessed on the IS website.

The deadlines for submitting the Letter of Intent and worksheet to the IS office: For May graduates — April 30 of the preceding year; for August graduates — July 30 of preceding year; for December graduates — November 30 of preceding year. Students must have an approved Letter of Intent and IS worksheet on file in the IS office before registering for IS 498, the senior capstone project.

### **General Requirements for Graduation**

For all interdisciplinary sciences specializations, students are responsible to check with their advisors for any program modifications that may occur after the publication of this catalog.

I. IS Core Courses (IS 110, IS 201, IS 401, IS 498)	11 credits
II. English sequence (ENGL 101, 279, 289)	9 credits
III. Math, Computer Science, Sciences	
Math and Computer Sciences <sup>1</sup>	min. 12
Biology <sup>2</sup>	min. 3
Chemistry <sup>2</sup>	min. 3
Additional Natural Sciences <sup>3</sup>	min. 24
Other Math, CSC, Science	min. 18
<b>SUBTOTAL</b>	<b>60</b>

IV. Humanities and Social Sciences	
Humanities general education	6
Humanities upper division	6
Social Sciences general education	6
Social Science upper division	6
<b>SUBTOTAL</b>	<b>24</b>
V. Physical Education	2
VI. Program Approved Electives <sup>4</sup>	22

### 128 credits required for graduation

<sup>1</sup>All IS specializations require MATH 123 Calculus I and a minimum of 3 credit hours in computer science.

<sup>2</sup>Chemistry must be at the CHEM 112 level or higher. Biology must be at the BIOL 121 level or higher. Some specializations require additional coursework in chemistry and biology.

<sup>3</sup>All IS specializations require a minimum of 30 credit hours in the natural sciences, including 6 hours in sequence (e.g., BIOL 151/BIOL 153) and 12 hours at the upper division.

<sup>4</sup>Engineering courses may be counted toward graduation as electives only.

Thirty-six of the required 128 credits must be at the junior or senior level (courses numbered 300 and above.)

### Interdisciplinary Sciences Core Courses

All IS students take a sequence of four core courses, spread out over the course of four years:

- IS 110: Explorations in the freshman year;
- IS 201: Introduction to Science, Technology, and Society in the sophomore year;
- IS 401: Writing and Research in the Interdisciplinary Sciences in the first semester of the senior year; and
- IS 498: Undergraduate Research/Scholarship (senior project) in the second semester of the senior year.

### Science Minors available to IS Students

When possible, students pursuing the IS

specializations are strongly encouraged to complete a minor in another science field at School of Mines as part of their 128 total credits. Minors are available in computer science, geology, geospatial technology, mathematics, physics, or occupational safety. Students should consult the policy on minors and the specific courses required for each minor, provided elsewhere in the catalog. The IS degree is not available as a minor.

### Transfer Studies

Students who reside in local communities can achieve considerable savings in their education costs by completing a portion of their studies close to home before transferring to another institution to complete their desired major. Students who do not intend to pursue a degree offered at the School of Mines are encouraged to take courses appropriate for the two-year associate of arts (A.A.) degree in general studies. Through this program of access and transfer, students still experience the excellent educational environment found on the School of Mines campus. Students should consult the programs of study for the school from which they plan to graduate and then work closely with their A.A. advisor to select courses with the highest likelihood of transferability. Completion of the A.A. degree will fulfill the general education requirements for a baccalaureate degree at the other state universities of South Dakota (BHSU, DSU, NSU, SDSU, and USD).

### Pre-law/Pre-medicine Study at School of Mines

While the IS specializations in pre-professional health sciences and science, technology, and society (STS) are especially designed to help students meet the entrance requirements for medical or law school, a particular baccalaureate degree is not required for admission into most law and medical programs. Graduates from the School of Mines with degrees in several of the science and engineering programs have successfully completed these professional programs. Students are encouraged to consult the admissions requirements and policies for those law and medical schools to which they intend to apply.

### Pre-Nursing Study at Mines

The IS degree program does not include a pre-nursing track. Students interested in earning a nursing degree from SDSU (four-year B.S.N.) or USD (two-year A.D.N.) should apply to the degree-granting university. Upon acceptance to SDSU or USD, students can take courses offered by School of Mines that meet pre-nursing requirements. For more information visit <http://sdmines.sdsmt.edu/nursing>.

### Teaching Opportunities and Certification

Students who are interested in teaching science at the secondary education level should contact education programs at the other state universities for information on the auxiliary courses required for certification. Project SELECT, an intensive one-year certification program offered through the Black Hills State University College of Education, may be of interest to students completing the IS and other science degrees at the School of Mines. Information on this program can be obtained from the BHSU website.

### Minor in Geospatial Technology

Geospatial technology is a rapidly expanding field that covers the management and analysis of spatial data from many sources, such as satellites, airborne remote sensing, geographic information systems (GIS), global positioning systems (GPS), surveying, and more. Students in interdisciplinary sciences may find this minor a useful complement to their studies. Complete information on the requirements is given in the Geology B.S. section.

### Minor in Entrepreneurial Studies

A 25-credit minor in entrepreneurial studies is available to all School of Mines students through collaboration with the Black Hills State University College of Business and Technology. The requirements for the minor are BADM 406 or ACCT 210/ACCT 211, BADM 336, BADM 438, BADM 334, BADM 360, BADM 370, BADM 474, and BADM 489. The minor must be approved by the student's major department. Information on this minor can be obtained from the BHSU website.

### Interdisciplinary Sciences

(Upper level courses are in bold print)

IS 110<sup>1</sup>, 191, 192, 201<sup>1</sup>, 291, 292, **380, 391, 392, 401<sup>1</sup>, 491, 492, 498<sup>1</sup>, 691, 692**

<sup>1</sup>IS degree core courses.

### Specialization in Atmospheric Sciences: Curriculum/Course Checklist

Course sequences vary by student entry year, math/science placements, availability of ATM courses, and career objectives. Students should consult with an atmospheric sciences / interdisciplinary sciences advisor for a more personalized course of study based on career goals within the atmospheric sciences.

#### Freshman Year

##### First Semester

CHEM 112	General Chemistry I <sup>1</sup>	3
CHEM 112L	General Chemistry I Lab <sup>1</sup>	1
ENGL 101	Composition I	3
IS 110	Explorations	2
MATH 123	Calculus I <sup>2</sup>	4
Gen Ed Humanities/Social Science Elective		3
<b>TOTAL</b>		<b>16</b>

##### Second Semester

CHEM 114	General Chemistry II <sup>1</sup>	3
CHEM 114L	General Chemistry II Lab <sup>1</sup>	1
CSC 150/L	Computer Science I/Lab <sup>2</sup>	3
MATH 125	Calculus II <sup>2</sup>	4
PE	Physical Education	1
Gen Ed Humanities/Social Science Elective		3
<b>TOTAL</b>		<b>15</b>

#### Sophomore Year

##### First Semester

ATM 301	Intro to Atmospheric Science	3
ENGL 279	Technical Communications I	3
MATH 225	Calculus III <sup>2</sup>	4
PE	Physical Education	1
PHYS 211	University Physics I	3
Gen Ed Humanities/Social Science Elective		3
<b>TOTAL</b>		<b>17</b>

## Second Semester

ENGL 289	Technical CommunicationsII	3
IS 201	Introduction to Science, Technology, and Society	3
MATH 321	Differential Equations <sup>2</sup>	3
PHYS 213	University Physics II <sup>1</sup>	3
PHYS 213L	University Physics II Lab <sup>1</sup>	1
Gen Ed Humanities/Social Science Elective		3
<b>TOTAL</b>		<b>16</b>

## Junior Year

### First Semester

ATM 450/L	Synoptic Meteorology I/Lab	3
ATM 460	Atmospheric Dynamics I	3
BIOL 311	Principles of Ecology <sup>1</sup>	3
ATM/SCI/MATH/ENG Elective <sup>3</sup>		4
Upper Division HU/SS Elective		3
<b>TOTAL</b>		<b>16</b>

### Second Semester

ATM 403	Global Environmental Change	3
ATM 430	Radar Meteorology	3
ATM 455/L	Synoptic Meteorology II/Lab	3
ATM/SCI/MATH/ENG Electives <sup>3</sup>		3
Upper Division HU/SS Elective		3
<b>TOTAL</b>		<b>15</b>

## Senior Year

### First Semester

ATM 401	Atmospheric Physics	3
IS 401	Writing and Research in the Interdisciplinary Sciences	3
ATM/SCI/MATH/ENG Electives <sup>3</sup>		6
Upper Division HU/SS Elective		3
<b>TOTAL</b>		<b>15</b>

### Second Semester

ATM 404	Atmospheric Thermodynamics	3
ATM/SCI/MATH/ENG Electives <sup>3</sup>		9
IS 498	Undergrad Res/Scholarship	3
Upper Division HU/SS Elective		3
<b>TOTAL</b>		<b>18</b>

128 credits required for graduation

## Curriculum Notes

<sup>1</sup>All IS specializations require a minimum of 30 semester hours of natural sciences, including a minimum of 3 semester hours in chemistry, 3

semester hours in biology, 6 semester hours in a science sequence, and 12 semester hours at the upper division. The atmospheric sciences/meteorology specialization requires one year of general chemistry with labs, one year of university physics with lab, and one semester of BIOL 311: Principles of Ecology. Students should consult with their advisors to determine additional science courses appropriate for their career paths.

<sup>2</sup>All IS specializations require Math 123 or a math course requiring Math 123 as its prerequisite. Atmospheric sciences/meteorology requires CSC 150/150L and additional math coursework beyond Math 123. Math 102 and Math 120 may be used toward graduation requirements.

<sup>3</sup>Students should consult with their atmospheric sciences/interdisciplinary sciences advisors on the most appropriate ATM/science/math/ engineering electives for their career paths. See also p. 62.

## Specialization in Pre-Professional Health Sciences Curriculum/Course Checklist

Students should consult with their advisors for a more personalized course of study based on career goals within the health sciences. Course requirements vary according to professional program, e.g., medical school, radiographic technology, physical therapy. Course sequence may also vary by student entry year, math/science placements, course availability, and career objectives.

## Freshman Year

### First Semester

BIOL 121/121L	Human Anatomy & Lab	4
ENGL 101	Composition I	3
IS 110	Explorations	2
Math/CSC Elective <sup>1</sup>		3
Gen Ed Humanities/Social Science Elective		3
<b>TOTAL</b>		<b>15</b>

### Second Semester

BIOL 123/123L	Basic Physiology and Lab	4
CHEM 112/112L	Gen Chemistry I and Lab	4

Math/CSC Elective	3
PE Physical Education	1
Gen Ed Humanities/Social Science Elective	3
<b>TOTAL</b>	<b>15</b>

### Sophomore Year

<b>First Semester</b>	
BIOL 151/151L Gen Biology I and Lab	4
CHEM 114/114L Gen Chemistry II and Lab	4
ENGL 279 Technical Comm I	3
IS 201 Introduction to Science, Technology, and Society	3
Gen Ed Humanities/Social Science Elective	3
<b>TOTAL</b>	<b>17</b>

<b>Second Semester</b>	
BIOL 153/153L Gen Biology II and Lab	4
ENGL 289 Technical Comm II	3
Math/CSC Elective	3
Gen Ed Humanities/Social Science Elective	3
Electives <sup>2</sup>	4
<b>TOTAL</b>	<b>17</b>

### Junior Year

<b>First Semester</b>	
Math/CSC Elective	3
Upper Division Science Elective	3
Upper Division HUM/SS Elective	3
Electives	7
<b>TOTAL</b>	<b>16</b>

<b>Second Semester</b>	
Science Electives	4
Upper Division HUM/SS elective	3
Upper Division Science Elective	3
Electives	7
<b>TOTAL</b>	<b>17</b>

### Senior Year

<b>First Semester</b>	
IS 401 Writing and Research in the Interdisciplinary Sciences	3
Science Elective	4
Upper Division HUM/SS Elective	3
Upper Division Science Elective	3
PE Physical Education	1
Electives	1
<b>TOTAL</b>	<b>15</b>

<b>Second Semester</b>	
IS 498 Undergrad Res/Scholarship	3
Science Electives	4
Upper Division HU/SS Elective	3
Upper Division Science Elective	3
Electives	3
<b>TOTAL</b>	<b>16</b>

### **128 credits required for graduation**

#### **Curriculum Notes:**

<sup>1</sup>All IS specializations require Math 123 or a math course requiring Math 123 as its prerequisite. Math 102 and Math 120 may be used toward graduation requirements. Students should consult with their advisors on the most appropriate math/computer science courses for their career paths.

<sup>2</sup>Elective credits may include additional coursework at the 100 level or above in math, computer science, natural and physical sciences, humanities, social sciences, business, military science, or engineering as needed to meet the required minimums or to meet admissions requirements for professional programs in health science. Students should consult with their advisors on the most appropriate courses for their career goals.

#### **Science, Technology, and Society: Curriculum/Course Checklist**

Course sequence may vary by student entry year, math/science placements, course availability, and career objectives. Students should consult with their advisors for a more personalized course of study based on career plans.

### Freshman Year

<b>First Semester</b>	
ENGL 101 Composition I	3
IS 110 Explorations	2
Math/CSC Elective <sup>1</sup>	3
Science Elective <sup>2</sup>	4
Gen Ed Humanities/Social Science Elective	3
<b>TOTAL</b>	<b>15</b>

<b>Second Semester</b>	
Math/CSC Elective	3
PE Physical Education	1
Science Electives	7
Gen Ed Humanities/Social Science Elective	3
Elective <sup>3</sup>	3
<b>TOTAL</b>	<b>17</b>

### Sophomore Year

<b>First Semester</b>	
ENGL 279 Technical Comm I	3
IS 201 Introduction to Science, Technology, and Society	3
PE Physical Education	1
Science Elective	4
Gen Ed Humanities/Social Science Elective	3
Elective	3
<b>TOTAL</b>	<b>17</b>

<b>Second Semester</b>	
ENGL 289 Technical Comm II	3
Math/CSC Elective	3
Science Elective	4
Gen Ed Humanities/Social Science Elective	3
Elective	3
<b>TOTAL</b>	<b>16</b>

### Junior Year

<b>First Semester</b>	
Math/CSC Elective	3
Science Electives	7
Upper Division HUM/SS Elective	3
Elective	3
<b>TOTAL</b>	<b>16</b>

<b>Second Semester</b>	
Science Electives	7
Upper Division HUM/SS elective	3
Elective	6
<b>TOTAL</b>	<b>16</b>

### Senior Year

<b>First Semester</b>	
IS 401 Writing and Research in the Interdisciplinary Sciences	3
Science Electives	8
Upper Division HUM/SS Elective	3
Elective	1

**TOTAL 15**

<b>Second Semester</b>	
IS 498 Undergrad Res/Scholarship	3
Science Electives	7
Upper Division HUM/SS Elective	3
Elective	3
<b>TOTAL</b>	<b>16</b>

### **128 credits required for graduation**

#### **Curriculum Notes**

<sup>1</sup>All IS specializations require Math 123 or a math course requiring Math 123 as its prerequisite. Math 102 and Math 120 may be used toward graduation requirements. Students should consult with their advisors on the most appropriate math/computer science courses for their career paths.

<sup>2</sup>All IS specializations require a minimum of 30 semester hours of natural sciences including a minimum of 3 semester hours in chemistry at the CHEM 112 level or higher, 3 semester hours in biology at the BIOL 121 level or higher, 6 semester hours of a science sequence, and 12 semester hours at the upper division level. Students pursuing the science, technology, and society specialization are expected to choose a science concentration. A minor in a science field (e.g., atmospheric science, computer science, geology, geospatial technology, mathematics, physics, occupational safety) is highly encouraged. Students should consult with their advisors to determine the most appropriate science courses and sequence for their career paths.

<sup>3</sup> Elective credits may include additional college coursework at the 100 level or above in math, computer science, sciences, humanities, interdisciplinary sciences, social sciences, business, military science, or engineering as needed to meet the required minimums or to qualify for a science minor. Students should consult with their advisors to determine the most appropriate elective courses for their career goals.

This information and additional information on the IS degree program can be found at: <http://is.sdsmt.edu>

## **Applied and Computational Mathematics B.S. and Minor**



### **Contact Information**

#### **Dr. Kyle Riley**

Department of Mathematics  
and Computer Science

McLaury 308

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### **Faculty**

Professors Corwin, Johnson, Logar and Teets;  
Associate Professors Braman, McGough,  
Kowalski and Riley; Assistant Professors Caudle,  
Dahl, Deschamp, Fleming and Geary; Instructors  
Lofberg and Trimble; Emeritus Faculty Carda,  
Grimm and Opp.

### **General Information**

Mathematics is a broad field of study that is foundational to many areas of Science and Engineering. The Department of Mathematics and Computer Science offers a bachelor of science degree in applied and computational mathematics. This degree program emphasizes computational methods and the use of technology applied to the mathematical problems in industry and the sciences. Students who desire to major in this program should announce their intention to the Department of Mathematics and Computer Science as early as possible and should consult

advisors in the department at each registration period before selecting electives to round out the courses of study outlined in the departmental curriculum. Any student who is pursuing a double major and whose designated advisor is in another department should consult an advisor in the mathematics and computer science department at each registration to ensure that reasonable progress is being made and that conflicts are avoided.

### **Prerequisite and Placement Information**

Before registering for any course in mathematics, a student must either have met all prerequisites and be enrolled in all co-requisites, passed the appropriate placement examinations, or have obtained permission from the head of the mathematics and computer science department. Placement examinations, however, may only be used for initial mathematics course placement (exception — students successfully completing Math 021 may skip Math 101 and proceed to Math 102 if they have obtained the written permission of the Vice President for Academic Affairs and earned a successful Algebra Placement Examination score.) Please see the course descriptions in this catalog for all information related to prerequisites and placement. Again, placement exams (with the exception noted above) may only be used for initial placement. For example, a student enrolled in (MATH 120: Trigonometry), must pass this course with at least a “C” before being allowed to enroll in MATH 125; a student receiving below a “C” in trigonometry may not use a placement examination to skip a repeat of Trigonometry. Placement examinations are given prior to registration each semester.

Students transferring from other institutions or returning to the School of Mines after interrupting studies for a period of one year or more should consult the head of the Department of Mathematics and Computer Science to discuss proper placement.

## **Departmental Courses**

MATH 021 and 101 may not be used for credit toward any bachelor's degree at School of Mines. College algebra, trigonometry, and pre-calculus courses may not be counted toward any mathematics, computer science, or engineering degree. Other majors should consult their departments on policies regarding these courses.

In an attempt to help students plan their future semesters, the following information is presented. This reflects the best available knowledge at the time of the preparation of this document. This is not meant as a guarantee of when classes will be offered. Students concerned about when classes will be offered should contact the department head for any changes to the following. Courses not listed below have no defined rotation and will be offered contingent upon demand and staff availability. Summer offerings are highly dependent on staffing. An attempt will be made to offer MATH 120, MATH 123, MATH 125, MATH 225, MATH 321, and MATH 381 during the summer session.

Classes that are typically offered every semester include MATH 102, MATH 120, MATH 123, MATH 125, MATH 225, MATH 315, MATH 321, MATH 373, and MATH 381. Classes that are typically offered every fall semester include MATH 281 and MATH 486.

Classes that are typically offered every spring semester include MATH 382 and MATH 353.

Classes that are typically offered in the fall semester of even numbered years, for example fall 2012, include MATH 413 and MATH 431.

Classes that are typically offered in the spring semester of odd numbered years, for example spring 2013, include MATH 421 and MATH 463.

Classes that are typically offered in the fall semester of odd numbered years, for example fall 2011, include MATH 432 and MATH 423.

Classes that are typically offered in the spring semester of even numbered years, for example spring 2012, include MATH 424, MATH 451, and MATH 447.

## **Applied and Computational Mathematics Major**

Students majoring in mathematics will use the accompanying applied and computational mathematics curriculum. The curriculum includes 5 credits of mathematics courses, 11 credits of computer science, 10 credits of sciences, and at least 9 credits of additional science and engineering courses that fall in a specific field (see emphasis area below). Any student majoring in mathematics who desires a minor in another field should consult his or her advisor in the Department of Mathematics and Computer Science as early in the program of study as possible. In addition, the student must contact the Office of the Registrar and Academic Services in order to declare a minor. Departmental majors contemplating a career in actuarial science should prepare for the examinations given by the Society of Actuaries. It is recommended that this preparation be attained, in part, by electing courses from: MATH 353, MATH 381, MATH 382, MATH 463, MATH 447, IENG 362, and IENG 301 or IENG 302. Information concerning these examinations can be obtained from the Department of Mathematics and Computer Science.

The primary goal of the applied and computational mathematics program is to give graduates a firm understanding of mathematics and its applications to science and engineering. Graduates are expected to develop a strong foundation of knowledge and skill in the core areas of analysis, differential equations, numerical methods, and modeling. They are also expected to attain a basic understanding of probability, statistics, and algebra. Because applied mathematicians are problem solvers, graduates must develop the ability to formulate and solve problems arising from scientific and engineering applications. This entails acquiring fundamental knowledge in the basic sciences, which School of Mines students accomplish by taking courses in an emphasis area. The student will take three courses in an external discipline that will provide exposure and depth in an application area of mathematics. Information on emphasis areas and the associated courses is available from the

department or advisor.

Graduates must be prepared to continue learning throughout their careers. In the two-course sequence of MATH 498 and MATH 402, students will have the opportunity to work with individual faculty members on research and develop their communication skills. This work will result in a technical paper and an oral presentation.

Upon graduation, some graduates pursue careers in fields such as computer software development, actuarial science, applied statistics, data analysis, and operations research. Others go on to pursue advanced degrees or seek certification to teach mathematics at the elementary or secondary levels.

An applied and computational mathematics major must complete a minimum of 16 credit hours in humanities and social sciences with at least 6 credit hours in humanities and at least 6 credit hours in social sciences. Refer to the humanities and social sciences section of this catalog for a list of courses satisfying these requirements. It is also important to refer to the general education core requirements under bachelor of science graduation requirements for further information. Students must complete the general education core requirements within the first 64 credits.

The accompanying sample schedule lists all required classes for the degree in their proper prerequisite sequence. Students should consult course listings for prerequisites and should consult their advisors at each registration.

### **Minor in Mathematics**

The core requirements for a minor in mathematics are MATH 123, MATH 125, MATH 225, and the completion of CSC 251 or MATH 221. In addition, students must also successfully complete MATH 423 or MATH 413 plus the completion of at least 6 credit hours from: MATH 315, MATH 381, MATH 382, or any MATH course 400-level and above, excluding Special Topics and Independent Studies courses. Thus, a total of at least 23 semester credit hours is needed for a Math minor. MATH 423 and MATH 413 are offered in alternate years so plans for a minor should be made early.

A minor in the Department of Mathematics and Computer Science must be approved by the student's major department. A form for declaring a minor is available at the Office of the Registrar and Academic Services. The form must be completed and signed by the department heads from both departments involved in this minor.

### **Double Major with Mathematics**

Due to the large number of courses that many majors have in common with the mathematics major, many students find it attractive to pursue a double major. Students are encouraged to pursue the double major and should contact their advisor for details.

### **Applied and Computational Mathematics Curriculum**

For the bachelor of science in mathematics, a student must:

1. Take all of the courses listed in the applied and computational mathematics curriculum checklist;
2. Take 3 emphasis area courses (information about emphasis areas and supporting courses is available from the department); and
3. Have a departmental grade point average of at least 2.00 in all mathematics courses 300 level or higher. (Courses taken more than once will have only the higher grade counted for computing the departmental grade point average.)

### **Applied and Computational Mathematics Curriculum/Checklist**

It is the student's responsibility to check with his or her advisor for any program modifications that may occur after the publication of this catalog. Additional information about the program may be found at: [www.mcs.sdsmt.edu/](http://www.mcs.sdsmt.edu/).

### Freshman Year

#### **First Semester**

ENGL 101	Composition I	3
IS 110	Explorations	2
MATH 123	Calculus I	4
CSC 150/L	Computer Science I	3
Elective <sup>2</sup>		3
PE <sup>4</sup>	Physical Education	1
<b>TOTAL</b>		<b>16</b>

#### **Second Semester**

MATH 125	Calculus II	4
Science Elective/Science Lab <sup>1</sup>		4
CSC 250	Computer Science II	4
Elective <sup>2</sup>		3
PE <sup>4</sup>	Physical Education	1
<b>TOTAL</b>		<b>16</b>

### Sophomore Year

#### **First Semester**

ENGL 279	Technical Comm I	3
MATH 225	Calculus III	4
MATH 321	Differential Equations	3
PHYS 211	University Physics I	3
Elective <sup>2</sup>		3
<b>TOTAL</b>		<b>16</b>

#### **Second Semester**

MATH 315	Linear Algebra	3
CSC 251	Finite Structures	4
ENGL 289	Technical Comm II	3
PHYS 213	University Physics II	3
Elective <sup>2</sup>		3
<b>TOTAL</b>		<b>16</b>

### Junior Year

#### **First Semester**

MATH 413	Abstract Algebra	3
MATH 381	Probability and Statistics	3
MATH 431	Dynamical Systems	3
MATH 373	Intro to Numerical Analysis	3
Elective/Emphasis <sup>3</sup>		4
<b>TOTAL</b>		<b>16</b>

#### **Second Semester**

MATH 382	Probability and Statistics II	3
MATH 463	Scientific Computing	3

MATH 421	Complex Analysis	3
Elective/Emphasis <sup>3</sup>		7
<b>TOTAL</b>		<b>16</b>

### Senior Year

#### **First Semester**

MATH 423	Advanced Calculus I	4
MATH 432	Partial Differential Equations	3
MATH 498	Undergraduate Research I	1
Elective/Emphasis <sup>3</sup>		8
<b>TOTAL</b>		<b>16</b>

#### **Second Semester**

MATH 424	Advanced Calculus II	4
MATH 451	Math Modeling	3
MATH 402	Communicating Mathematics I	1
Elective/Emphasis <sup>3</sup>		8
<b>TOTAL</b>		<b>16</b>

### **128 credits required for graduation**

#### **Curriculum Notes**

<sup>1</sup>The science requirement for this major consists of PHYS 211, PHYS 213, one course from among BIOL 151, CHEM 112, GEOL 201, plus a lab associated with one of the science courses taken – either BIOL 151L, CHEM 112L, GEOL 201L, or PHYS 213L.

<sup>2</sup>Students should consult the “General Education Requirements” section of this catalog for a complete listing of all general education requirements. It is important to note that all general education requirements must be completed within the first 64 credits taken. Math majors are additionally required to take a total of at least 16 semester hours of electives in humanities and social sciences.

<sup>3</sup>Math majors must complete 3 courses in a science or engineering emphasis area. Any double major automatically satisfies this emphasis area requirement with their other major. Further information about possible emphasis areas is available from the department.

<sup>4</sup>MUEN 101, 121, 122 can be used to substitute for one or two of the required two physical education credits.

## Mechanical Engineering B.S.



### Contact Information

#### **Dr. Michael Langerman**

Department of Mechanical Engineering

Civil Mechanical 172

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### Faculty

Professors Abata, Dolan, Kalanovic, Kjerengtroen, Korde, Muci-Kuchler and Langerman; Associate Professor Bedillion; Assistant Professors Ellingsen, Shahbazi, Simmons and Widener; Professors Emeritus Gnirk and Pendleton; Instructor Ash.

### Mechanical Engineering

Mechanical engineering (ME) is a very broad field that provides opportunities for interesting and challenging work in every phase of modern technology. The curriculum in the mechanical engineering department is designed to give students a thorough knowledge of the fundamental principles of engineering and science within the major areas of mechanical engineering: thermal science, mechanics, and robotics and controls. Beyond this basic foundation, the curriculum also develops:

1. The various aspects of engineering design including design theory and teamwork;

2. An effective integration of computer technology;
3. Communication skills and effective presentations; and
4. Improved understanding of engineering theory through practical laboratory experience.

In the senior year, students select from course electives that best reflect their interests and career objectives. Students may select courses from one or more of the following general areas:

1. Manufacturing, e.g., control, design, development, and manufacture of diverse equipment and processes;
2. Thermal Science/Energy, e.g., design of power systems and heating/air conditioning systems.
3. Mechanical Systems/Design, e.g., design of machines, structures, and systems.

### Vision

Our vision is to become one of the leading undergraduate mechanical engineering programs in the nation by offering a premier engineering design curriculum and by providing our graduates with a superior educational experience through teaching and learning, research and development, and service and responsibility. Most immediately, our goal is to be recognized as the mechanical engineering program-of-choice within South Dakota and among our peer groups of specialized science and engineering schools across the nation.

### Mission

The mission of the mechanical engineering program is to prepare our graduates for leadership roles in the mechanical engineering profession by:

- Offering a quality education to foster a distinctive curriculum accentuating design and project-based learning;
- Committing to individual development while emphasizing the values of teamwork in a

culturally diverse, multidisciplinary environment; and

- Encouraging undergraduate and graduate research to nurture creative solutions to complex engineering problems.

### **Objectives**

Building upon the department's tradition of excellence requires continual development of active partnerships among the faculty, the students, and our constituents. In keeping with this tradition, the mechanical engineering program produces graduates who are able to perform at a level that meets or exceeds industry expectations. ME students will be able to achieve the objectives listed below within a few years of graduation through attainment of the outcomes listed below at the time of graduation.

**OBJECTIVE 1:** Lead and/or manage effective engineering design analyses

Outcomes

- Apply skills in engineering, science, and mathematics
- Practice effective analysis
- Conduct data analyses and analyses verification

**OBJECTIVE 2:** Lead and/or manage effective engineering design teams

Outcomes

- Apply effective engineering design skills
- Demonstrate teaming proficiency
- Participate in research and professional development

Students may participate in the Cooperative Education Internship Program. In some instances, credits earned during the co-op may be applied toward department elective requirements. The mechanical engineering department does not offer a minor.

The bachelor of science program in mechanical engineering is accredited by the Engineering Accreditation Commission of ABET,

<http://www.abet.org>

### **Mechanical Engineering Laboratories**

There are several undergraduate laboratories in the department, including mechanical systems and instrumentation, thermal and fluid systems, manufacturing, robotic systems, and vibrations. Laboratories are updated with personal computers, peripherals, and data acquisition equipment. Graduate research laboratories and resources include advanced workstation computer facilities, equipment for modern digital controls, machine vision systems, image analysis equipment, structural testing and analysis equipment, compliant structures and computational solid mechanics, fluid mechanics, and heat transfer codes on the workstation facilities.

### **Mechanical Engineering Curriculum/Checklist**

Students are responsible for checking with their advisors for any program modifications that may occur after the publication of this catalog. To graduate, students must attain a grade of C or better in all ME core courses (noted below with an \*)

#### **Freshman Year<sup>1</sup>**

##### **First Semester**

MATH 123	Calculus I	4
CHEM 112	General Chemistry I	3
CHEM 112L	General Chemistry I Lab	1
ME 110/L	Intro to Mechanical Engr.	2
ENGL 101	Composition I	3
PE	Physical Education	1
	1 Humanities or Social Sciences Elective(s)	3
<b>TOTAL</b>		<b>17</b>

##### **Second Semester**

MATH 125	Calculus II	4
PHYS 211	University Physics I	3
CSC 150/L	Computer Science I	3
PE	Physical Education	1
	Humanities or Social Sciences Elective(s)	6
<b>TOTAL</b>		<b>17</b>

## Sophomore Year

### **First Semester**

EM 214	Statics	3
ENGL 279	Technical Communications I	3
ME 262	Product Development	2
ME 264/L	Sophomore Design	2
MATH 225	Calculus III	4
Humanities or Social Sciences Elective(s)		3
<b>TOTAL</b>		<b>17</b>

### **Second Semester**

ME 221*	Dynamics of Mechanisms	3
ME 211*	Intro to Thermodynamics	3
PHYS 213	University Physics II	3
PHYS 213L	University Physics II Lab	1
MATH 321	Differential Equations	3
ME 216*	Intro to Solid Mechanics	3
<b>TOTAL</b>		<b>16</b>

## Junior Year

### **First Semester**

MET 231	Properties of Materials Lab	1
MET 232	Properties of Materials	3
ENGL 289	Technical Comm II	3
ME 316*	Solid Mechanics	3
EE 301/L	Intro Circuits, Machines, Systems	4
ME 331*	Thermo Fluid Dynamics	3
<b>TOTAL</b>		<b>17</b>

### **Second Semester**

ME 312*	Thermodynamics II	3
ME 313*/L	Heat Transfer	3
ME 352*	Intro to Dynamic Systems	3
MATH 373	Intro to Numerical Methods	3
ME 322*	Machine Design I	3
ME 351*/L	Mechatronics and Measurement Systems	4
<b>TOTAL</b>		<b>19</b>

## Senior Year

### **First Semester**

ME 477	Mechanical Engr Design I	2
IENG 302	Engineering Economics	3
MATH 381	Probability/Statistics	3
ME 4XX	Mechanical Engr Elective #1	4
ME 481L	Advanced Prod Dev Lab II	1
ME 4XX	Mechanical Engr Elective #2	3
<b>TOTAL</b>		<b>16</b>

### **Second Semester**

ME 479	Mechanical Engr. Design II	2
ME 482L	Advanced Prod Dev Lab II	2
ME 4XX	Mechanical Engr Elective #3	3
ME 4XX	Mechanical Engr Elective #4	3
Humanities or Social Sciences Elective(s)		4
Free Elective		3
<b>TOTAL</b>		<b>17</b>

### **136 credits required for graduation**

\* A minimum grade of C required for graduation

### **Curriculum Notes**

<sup>1</sup> Many courses are prerequisites for other courses, and their sequencing is important. A faculty advisor should be consulted for any deviation from the above schedule.

### **Supersonic Wind Tunnel**

The Advanced Fluid Mechanics Laboratory at the South Dakota School of Mines and Technology has designed and constructed a supersonic wind tunnel of the in-draft type, with an extremely low level of free stream turbulence ( $Tu < 0.01$  percent). The test section area is 16 in<sup>2</sup> (4 inch x 4 inch) with full view Schlieren quality glass windows and removable access plugs for ease of model and sensor installation. Novel implementation of a solid desiccant drying system permits a measured test section Mach number of 2.8, with no evidence of condensation, for the current nozzle geometry. A two-stage vacuum system allows for pump down times less than 30 minutes between runs, with an ultimate low pressure capability of several tenths of a psi absolute, which should allow start-up at Mach numbers up to 5 with an appropriately designed nozzle geometry. For pedagogical purposes, the current Mach 2.8 nozzle was also designed to permit schlieren viewing of the flow acceleration from stagnation conditions to the test section supersonic condition along with static pressure measurements at various locations along the length of the nozzle, for comparison with classroom theory. Because of the low free-stream

noise level attendant to the indraft design, the facility is ideally suited for basic research studies of supersonic flow stability and transition mechanisms.



## **Metallurgical Engineering B.S. and Minor (Materials Science – Metals)**



### **Contact Information**

#### **Dr. Jon J. Kellar**

Department of Materials and Metallurgical Engineering

Mineral Industries 112

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### **Faculty**

Douglas W. Fuerstenau Professor Kellar; Professors Howard and Salem; Associate Professor Cross; Assistant Professors West and Widener; Research Scientist Hong; Adjunct Professors Jasthi, Sears and Medlin; Distinguished Professor Emeritus Han; Professor Emeritus Stone.

### **Supporting Faculty**

Assistant Professor Hower.

### **Materials and Metallurgical Engineering**

Materials and metallurgical engineering is the branch of engineering that develops and supplies the materials for virtually every other engineering field. Three-fourths of all elements are metals, so metals play a vital role in nearly every aspect of modern life. Metallurgical engineers transform the Earth's mineral resources into finished products by extracting metals from ores,

producing ceramics from metal compounds, and fabricating composite structures.

Modern materials are exotic and so are the methods of producing them. Metallurgy is based upon the principles of chemistry, physics, and mathematics. These sciences provide an understanding of the methods of metal production processes and the behavior of materials. In addition to familiar materials such as steel, aluminum, copper, glass, gold, and silver, metallurgical engineers produce many exotic materials such as metals with shape memories, ultrahigh-purity materials for integrated circuits, materials for surgical implants, ceramics for space vehicles, nano-scale metal particles and superconductors. There are 3 areas of specialization in metallurgical engineering: mineral processing, extractive metallurgy, and materials engineering. Mineral processors concentrate ores and recycled materials so that extractive metallurgists can produce pure, high-quality metals and non-metallics for use by materials engineers who transform these materials into the marvels of our advanced civilization, ranging from space craft to thin diamond films. Metallurgical engineers are actively involved in nanotechnology and the production and utilization of nano-scale materials.

Advances made by metallurgical and material engineers make advances possible in other engineering fields. This happens because virtually every engineering field is in constant search of higher-performing materials. Metallurgical engineers are responsible for the production of materials and also for the evaluation of metals, ceramics, and polymer-based composites. The evaluation of materials includes tests to determine strength, hardness, toughness, corrosion behavior, and many other properties. It is the role of metallurgical engineers to develop processing methods to create materials with specific and exacting properties for every conceivable application.

The primary source for materials continues to be extracted as ores and petroleum from the Earth. However, recycled materials are an increasingly important material source for metallurgical engineers.

Materials and metallurgical engineers are

employed throughout the nation and the world.

The Bachelor of Science Degree in Metallurgical Engineering is accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

### **The Objectives of the B.S. Metallurgical Engineering Degree Program**

The program graduates will:

- Successfully apply metallurgical engineering principles in their employment
- Meet societal needs through science and technology
- Grow professionally and personally
- Serve their profession and community

### **Materials and Metallurgical Engineering Laboratories**

Laboratory facilities in metallurgical engineering are equipped for instruction in mineral processing, chemical metallurgy, physical metallurgy, and mechanical metallurgy. Sample preparation facilities, laser light scattering particle size analyzers, gravitational separation equipment, laser Doppler particle size and zeta potential measurement equipment are available for mineral and materials processing. Induction melting and vacuum furnaces, fluidized-bed reactors, corrosion potentiostat, contact angle goniometer, and high pressure autoclaves are available for chemical metallurgy. X-ray diffraction spectrometer, Fourier transform infrared spectrometer, Raman spectrometer, Langmuir-Blodgett trough, metallographs, atomic force microscope, controlled atmosphere furnaces, quantitative image analyzer, scanning and transmission electron microscopes, universal testing machine (MTS), Charpy impact testing machine, and micro hardness, Rockwell and Vickers hardness testers are available for measuring material performance.

Modern laboratory facilities for welding and joining are available within the metallurgical engineering laboratories. These facilities include traditional joining (fusion welding) as well as advanced joining (friction stir joining) equipment.

### **Co-Curricular Opportunities**

Co-curricular opportunities in blacksmithing and the artistic aspects of metallurgy are also available. Where appropriate, these co-curricular activities are integrated into the metallurgical engineering curriculum.

The program hosts the summer Research Experiences for Undergraduates (REU) Site: *Back to the Future!* The REU Site is sponsored by the National Science Foundation.

### **Minor in Materials Science — Metals**

The requirements for a minor in materials science — Metals are MET 232, 330, 332, 443, and two classes from MET 430, 440 and 445, for a total of 18 credits. MET 330, MET 332, MET 440, MET 443 and MET 445 are offered in alternate years, so plans for a materials science-metals minor should be made early. This minor is designed for students in engineering and science disciplines that desire focused training in the field of materials science with special emphasis on metals. Students completing the minor in materials science-metals will demonstrate the following outcomes:

1. A proficiency in materials science concepts covering metals and alloys;
2. The ability to develop and improve new metals/alloys;
3. The ability to predict and evaluate the performance of metals and alloys.

Given the redundancy in the B.S. metallurgical engineering core curriculum, the minor in materials science-metals is not available to those students who receive a B.S. degree in metallurgical engineering. A minor in materials science-metals must be approved by the student's major department. The Office of the Registrar and Academic Services has forms that should be completed and signed by the department heads from both departments involved in this minor.

**Metallurgical Engineering Curriculum/Checklist**

Students are responsible for checking with their advisors for any program modifications that may occur after the publication of this catalog.

**Freshman Year**

**First Semester**

MATH 123	Calculus I <sup>5</sup>	4
CHEM 112	General Chemistry I <sup>6</sup>	3
ENGL 101	Composition I <sup>1</sup>	3
MET 110/L	Intro to Met Eng Design	2
PE	Physical Education	1
Humanities or Social Sciences Elective(s) <sup>3,4</sup>		3
<b>TOTAL</b>		<b>16</b>

**Second Semester**

MATH 125	Calculus II	4
CHEM 114	General Chemistry II <sup>6</sup> <b>OR</b>	3
BIOL 151	General Biology I <sup>6</sup> <b>OR</b>	3
BIOL 153	General Biology II <sup>6</sup>	3
PHYS 211	University Physics I	3
CHEM 112L	General Chem Lab	1
PE	Physical Education	1
Humanities or Social Sciences Elective(s) <sup>3,4</sup>		3
Humanities or Social Sciences Elective(s) <sup>3,4</sup>		3
<b>TOTAL</b>		<b>18</b>

**Sophomore Year**

**First Semester**

MET 232	Properties of Materials	3
MET 231	Structures and Properties of Materials Lab	1
MATH 321	Differential Equations	3
PHYS 213	University Physics II	3
CHEM 114L	General Chem II Lab <b>OR</b> 1	
BIOL 151L	General Biology I Lab <b>OR</b>	1
BIOL 153L	General Biology II Lab	1
ENGL 279	Technical Comm <sup>11</sup>	3
EM 214	Statics	3
<b>TOTAL</b>		<b>17</b>

**Second Semester**

MATH 225	Calculus III	4
EM 321	Mechanics of Materials <b>OR</b>	3
ME 216	Intro to Solid Mechanics	3
PHYS 213L	University Physics II Lab	1
MET 220	Min Proc and Res Recov	3

MET 220L	Min Proc and Res Recov Lab	1
Humanities or Social Sciences Elective(s) <sup>3,4</sup>		4
<b>TOTAL</b>		<b>16</b>

**Junior Year**

**First Semester**

ENGL 289	Technical Comm II <sup>2</sup>	3
MET 320	Metallurg Thermodynamics	4
MET 351	Engineering Design I	2
Set A or C		7
<b>TOTAL</b>		<b>16</b>

**Second Semester**

MET 352	Engineering Design II	1
MATH 373	Intro to Numerical Analysis	3
Free Elective		3
Set B or D		11
<b>TOTAL</b>		<b>18</b>

**Senior Year**

**First Semester**

MET 464	Engineering Design III	2
IENG 301	Basic Engineering Econ	2
Science Elective <sup>7</sup>		3
Humanities or Social Sciences Elective(s)		3
Set A or C		7
<b>TOTAL</b>		<b>17</b>

**Second Semester**

MET 433	Process Control	3
MET 465	Engineering Design IV	1
Science Elective <sup>7</sup>		3
Set B or D		11
<b>TOTAL</b>		<b>18</b>

**136 credits required for graduation**

**Curriculum Notes**

- <sup>1</sup> Satisfies General Education Goal #1
- <sup>2</sup> Satisfies General Education Goal #2
- <sup>3</sup> Satisfies General Education Goal #3
- <sup>4</sup> Satisfies General Education Goal #4
- <sup>5</sup> Satisfies General Education Goal #5
- <sup>6</sup> Satisfies General Education Goal #6
- <sup>7</sup> See Advisor for approved Science Electives
- <sup>8</sup> See Advisor for approved Directed Met Electives

**Set A-Fall Even Years**

MET 422	Transport Phenomena	4
Free Elective		3

**Set B-Spring Odd Years**

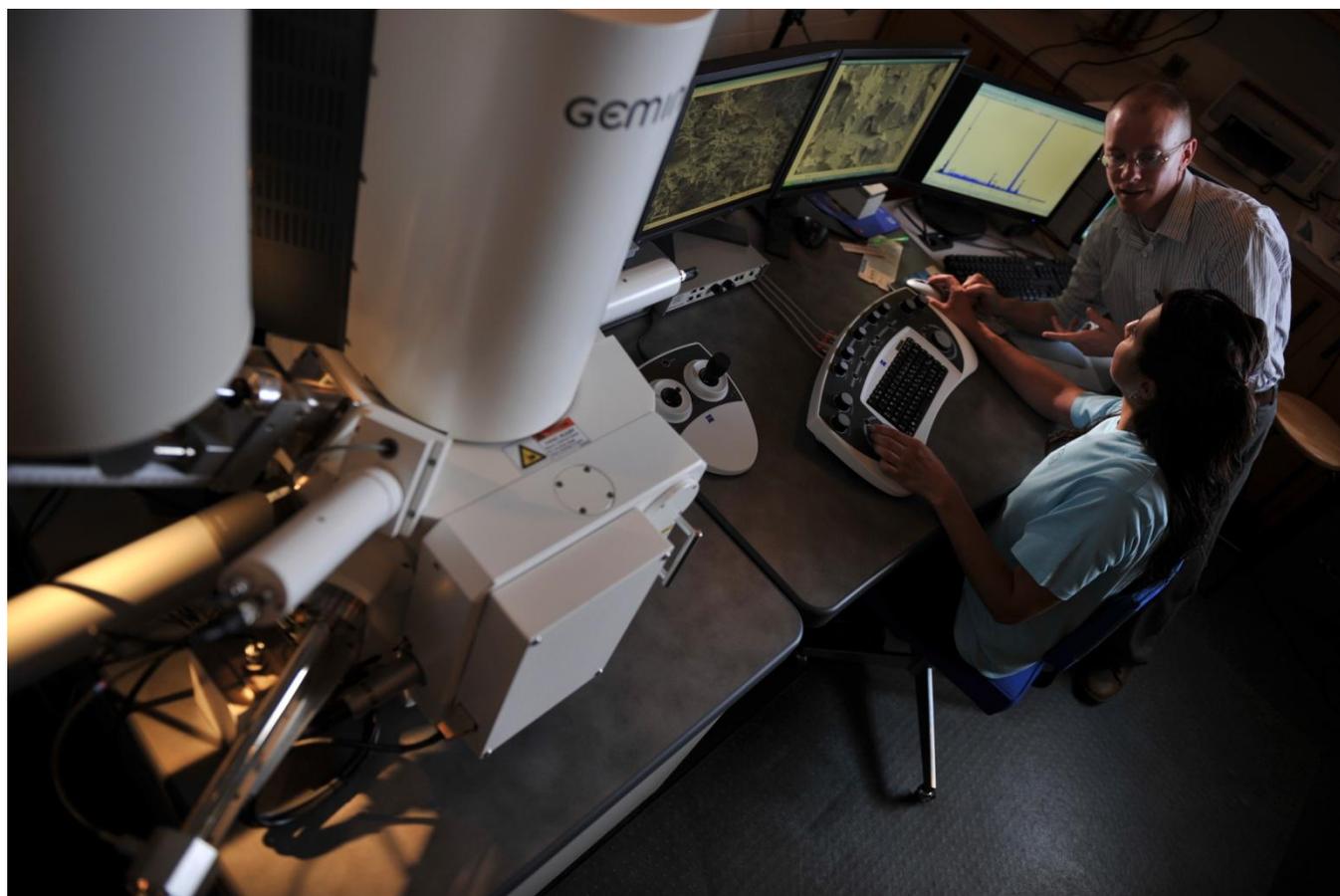
MET 321/321L		
High Temp Extract/Conc/Rec		4
Directed Met Elective <sup>8</sup>		3
EE 301	Intro Circuits, Machines, Syst	4

**Set C-Fall Odd Years**

MET 330	Physics of Metals	3
MET 330L	Physics of Metals Lab	1
MET 332	Thermomechanical Treatment	3

**Set D-Spring Even Years**

MET 440	Mechanical Metallurgy	3
MET 440L	Mechanical Metallurgy Lab	1
Directed Met Elective <sup>8</sup>		3
MET 310	Aqueous Extract/Conc/Rec	3
MET 310L	Aq Extract/Conc/Rec Lab	1



## Military Science



### Contact Information

#### **Lieutenant Colonel Oliver Hasse**

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### Faculty

Professor LTC Oliver Hasse; Assistant Professors  
LTC Charles Blasdell, CPT Jeremy Bryan and  
MSG Jeremy Hart.

### General Information

The School of Mines maintains a unit of the senior division of the Army Reserve Officers Training Corps (ROTC). The unit was established in 1950 and is administered by commissioned and noncommissioned officers of the United States Army nominated by the Department of the Army and approved by the president of the university. The ROTC program is open to both men and women. Military Science and Leadership (MSL) courses complement any course of study providing leadership training unavailable anywhere else on campus. Participation in the ROTC Basic Course (MSL 101 to MSL 202) incurs no military obligation.

ROTC training opportunities include Engineering Internship Programs, Airborne School (Ft. Benning, GA), Air Assault School, Cadet Troop Leadership Training with active duty

units, Cadet Field Training (West Point, NY), Leadership Development and Assessment Course (Ft. Lewis, WA), Leadership Training Course (Ft. Knox, KY), Ranger Challenge (Camp Ripley, MN), and Bataan Memorial Death March (White Sands, NM).

### Curriculum

ROTC provides leadership training and experience demanded by both corporate America and the U.S. Army. ROTC consists of Basic and Advanced Courses of instruction. The Basic Course consists of the first four semesters of MSL (MSL 101 to MSL 202). It is designed to provide all college students with leadership and management skills that complement any course of study. There is no obligation or commitment to continue in ROTC or serve in the Armed Forces.

The Advanced Course consists of the last four semesters of the ROTC program (MSL 301 to MSL 402). The Advanced Course is offered to students possessing the potential to become Army officers and who desire to serve as commissioned officers and lead U.S. Army Soldiers in the Active Army, U.S. Army Reserve, or the Army National Guard. The objective of the Advanced Course is to select, train and prepare students for military service.

The ROTC program is designed to provide an understanding of the fundamental concepts and principles of military art and science; to develop leadership and managerial potential and a basic understanding of associated professional knowledge; to develop a strong sense of personal integrity, honor, and individual responsibility; and to develop an appreciation of the requirements for national security. Attainment of these objectives will prepare students for commissioning as a second lieutenant and will establish a sound basis for future professional development and effective performance in the Army or any chosen career field. In the traditional four-year program, students enroll in eight consecutive semesters of MSL courses, 2 credit hours each semester the first two years, and 4 credit hours each semester the last two years. Leadership laboratories are offered concurrently with each of the classroom courses.

Non-traditional two-year programs include eligible veterans with prior military service, current members of the U.S. Army Reserve or Army National Guard, and students who have had high school junior ROTC or Civilian Air Patrol experience. A two-year program is available for any student having four academic semesters remaining or enrollment into a School of Mines master's degree program after attending a summer ROTC Leadership Training Course at Ft. Knox, Kentucky. Participation at the basic course does not carry any commitment to participate in ROTC but it does satisfy the prerequisites necessary to enter the final four semesters of ROTC. Students must additionally complete a course in the following areas to satisfy commissioning requirements: 1) American Military History, 2) Communications, and 3) Computer Literacy.

### **Tuition, Credit, and Equipment**

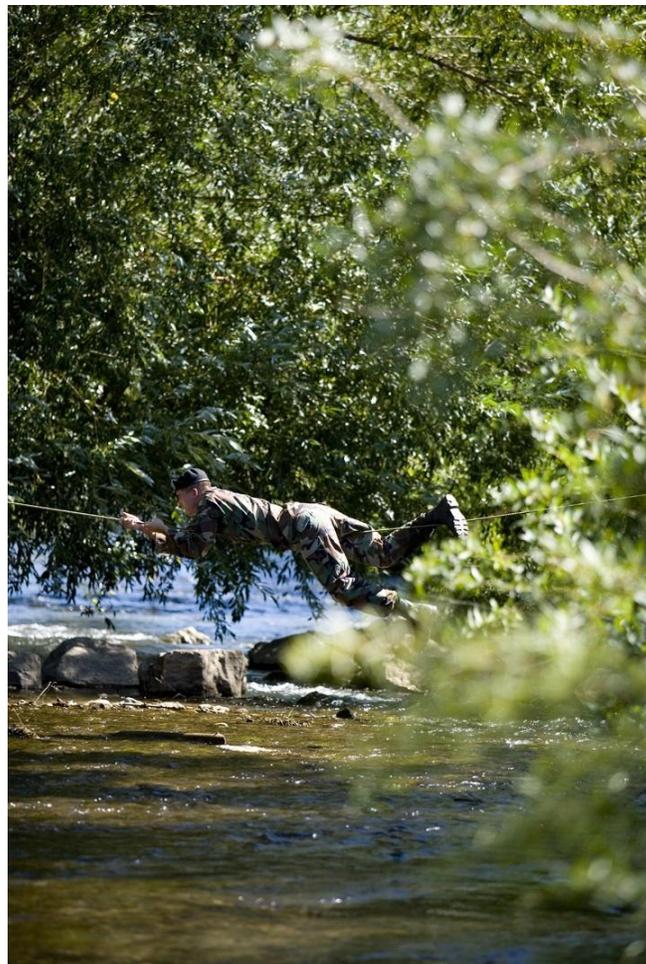
Military science and leadership courses are tuition free. Books and equipment are provided by the department. Associated fees assessed for all courses do apply. MSL credit may be applied as free electives toward graduation. MSL 101L or MSL 102L may be used to meet physical education requirements. Tuition is charged for courses when used to meet physical education requirements.

### **Financial Information**

Financial support of \$300 freshman, \$350 sophomore, \$450 junior, and \$500 senior subsistence per month for up to ten months of the academic school year is paid to contracted students enrolled in the ROTC Advanced and Basic Courses. Students attending the four-week ROTC Leadership Training Course or the 32-day Leaders Development and Assessment Course (LDAC) receive approximately \$800 plus room, board, and travel expenses.

Additional financial aid is available to eligible freshman, sophomore, and junior students in the form of four-year, three-year, and two-year Army ROTC scholarships. The scholarship provides tuition, fees, and a textbook allowance, in addition to the monthly subsistence allowance paid during

the school year. In addition, all non-scholarship, South Dakota resident advanced-course cadets receive a 50 percent reduction in tuition costs.



## Mining Engineering B.S.



### Contact Information

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### Faculty

Professors Kliche and Hladysz; Instructor Kanth.

### Supporting Faculty

Professor Hansen; Associate Professor Klasi.

### Mining Engineering

The mining engineering and management program, introduced as a new program in 2003, is designed to better meet the needs of the mining industry. It combines traditional mining engineering education with selected management-related concepts in order to better prepare the graduates for the modern mining industry.

Mining engineering is the application of engineering and scientific principles to the discovery, appraisal, and extraction of minerals from the Earth and sea. Mining engineering and management takes traditional mining engineering education one step farther by including management-related education in the curriculum.

The curriculum provides students with fundamental training in the basic sciences,

engineering sciences, engineering design, geology, the humanities, and mining engineering. Principles of mine operations, mine planning, mining technology, advanced 3-D design and modeling, rock mechanics, explosives technology and computer applications receive special emphasis. Key management-related concepts are introduced at all levels of the curriculum.

Significant design experience is built into the curriculum and is enhanced by the use of sophisticated 3-D design software in many of the mining courses. Teamwork is stressed in the program. As students work together in small, specialized teams during many of the laboratory exercises and to complete the final capstone design project. The students present their final design project both orally and in written form.

The mining engineering degree is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; telephone (410) 347-7700.

A minor in mining engineering is not available.

### Mining Engineering Program Objectives

The program in mining engineering is designed to meet the changing needs of the mining industry all over the nation and the world by providing graduates who are technically sound in mining engineering and can progress quickly through supervision and into management.

The curriculum has been designed to meet accreditation requirements in mining engineering. The core mining engineering curriculum provides technical training in areas such as rock mechanics, mine ventilation, ore reserve evaluation, mine design, explosive application, mining equipment selection, mining method selection, and mine land reclamation. The curriculum also includes a strong emphasis on management-related topics: health and safety, economics and finance, labor relations, project management, environmental management, international business, and communication skills.

The educational objectives of the program are:

- Graduates from the mining engineering program will have the analytical, technical and mine design abilities necessary to

work effectively in the field of mining engineering and will be informed of recent technical advances in the field.

- Graduates from the mining engineering program will be cognizant of societal issues and their role as future professional engineers working for the general benefit of society.

### **Professional Development**

Students in the program are encouraged to become student members of their primary professional organization-the Society for Mining, Metallurgy, and Exploration (SME). Upon graduation, they are further encouraged to continue professional membership in SME. In addition, the students can become student members of the International Society of Explosives Engineers (ISEE). Both SME and ISEE have local chapter meetings, which students are encouraged to attend.

During their senior year, students in the mining engineering program are encouraged to take the Fundamentals of Engineering (FE) examination. Passing the FE examination is the first step toward registration as a Professional Engineer (PE). The second and final step in the registration process is the successful completion of the Professional Engineering examination, which is normally taken at least four years after graduation.

The mining engineering program participates in a cooperative education program that provides an opportunity for students to combine coursework with meaningful work experience in industry. Participating companies in the program provide jobs for students during semesters scheduled for work. A student in the cooperative program should plan on four and one half to five years to graduate.

### **Mining Engineering Laboratories**

Laboratory facilities exist in the department for rock mechanics, ventilation, GPS surveying and computer-aided mine design. Laboratory equipment available for student use includes equipment for rock specimen preparation, uniaxial

and triaxial rock strength testing machine, direct shear machine, computerized data acquisition system, ventilation network model, and modern GPS-based surveying equipment.

The computer laboratory consists of a new (2007) lab sponsored by industry leader in mine design software (MAPTEK) with personal computers. Available software packages are routinely used by undergraduate and graduate students for the solution of problems in rock mechanics, geostatistics, management, mineral economics, ventilation, blasting, mapping, and mine design. Contemporary geoscience modeling and mine planning software is used by students for surface and underground mine design.

### **Mining Engineering Curriculum/Checklist**

Students are responsible for checking with their advisors for any program modifications that may occur after the publication of this catalog.

#### **Freshman Year**

##### **First Semester**

CHEM 112	General Chemistry I	3
CHEM 112L	General Chemistry I Lab	1
MATH 123	Calculus I	4
Humanities or Social Sciences	Elective(s)	3
MEM 110/L	Intro to Engineering	2
ENGL 101	Composition I	3
PE	Physical Education	1
<b>TOTAL</b>		<b>17</b>

##### **Second Semester**

CHEM 114	General Chemistry II	3
MATH 125	Calculus II	4
PHYS 211	University Physics I	3
MEM 120	Introduction to Mining and Sustainable Development	2
PE	Physical Education	1
Humanities or Social Sciences	Elective(s)	3
<b>TOTAL</b>		<b>16</b>

#### **Sophomore Year**

##### **First Semester**

MATH 205	Mining and Management Math I (Calc III)	2
PHYS 213	University Physics II	3

EM 216	Engineering Mechanics (Statics and Dynamics)	4
MEM 201L	Surveying for Mineral Engineers	2
MEM 203	Introduction to Mine Health and Safety	1
ENGL 279	Technical Comm. I	3
ECON 201	Microeconomics	3
<b>TOTAL</b>		<b>18</b>

### **Second Semester**

MATH 211	Mining and Management Math II (Diff Eq)	3
GEOE 221/L	Geology for Engineers	3
ENGL 289	Technical Comm. II	3
Humanities/Social Science Elective(s)		3
MEM 202	Materials Handling and Transportation	2
MEM 204	Surface Mining Methods and Unit Operations	2
<b>TOTAL</b>		<b>16</b>

### **Junior Year**

#### **First Semester**

MEM 301/L	Computer Applications in Mining	2
MEM 303	Underground Mining Methods and Equipment	2
MEM 305	Introduction to Explosives Engineering	3
EE 303/L	Circuits (for Mining)	3
IENG 366	Engineering Management	3
MEM 307	Mineral Exploration and Geostatistics	3
ATM 404	Atmospheric Thermo (for Mining)	2
<b>TOTAL</b>		<b>18</b>

#### **Second Semester**

GEOL 314/L	Mineralogy and Petrology for Mining Engineering	4
MEM 302	Mineral Economics and Finance	3
MEM 304/L	Theoretical and Applied Rock Mechanics	4
EM 328	Applied Fluid Mechanics	3
MEM 4XX	Mining Technical Elective <sup>1</sup>	1

MET 220	Mineral Processing and Resource Recovery	3
<b>TOTAL</b>		<b>18</b>

### **Senior Year**

#### **First Semester**

BADM 407	International Business	3
MEM 401/L	Theoretical and Applied Ventilation Engineering	4
MEM 466	Mine Management	2
Free Elective		4
Hum/Soc. Sci. (Language)		4
<b>TOTAL</b>		<b>17</b>

#### **Second Semester**

MEM 464	Mine Design and Feasibility Study	4
ECON 304	Managerial Economics	3
GEOE 322/L	Structural Geology	3
MEM 405	Mine Permitting and Reclamation	3
HRM 417	Human Resource Management	3
<b>TOTAL</b>		<b>16</b>

### **136 credits required for graduation**

#### **Curriculum Notes**

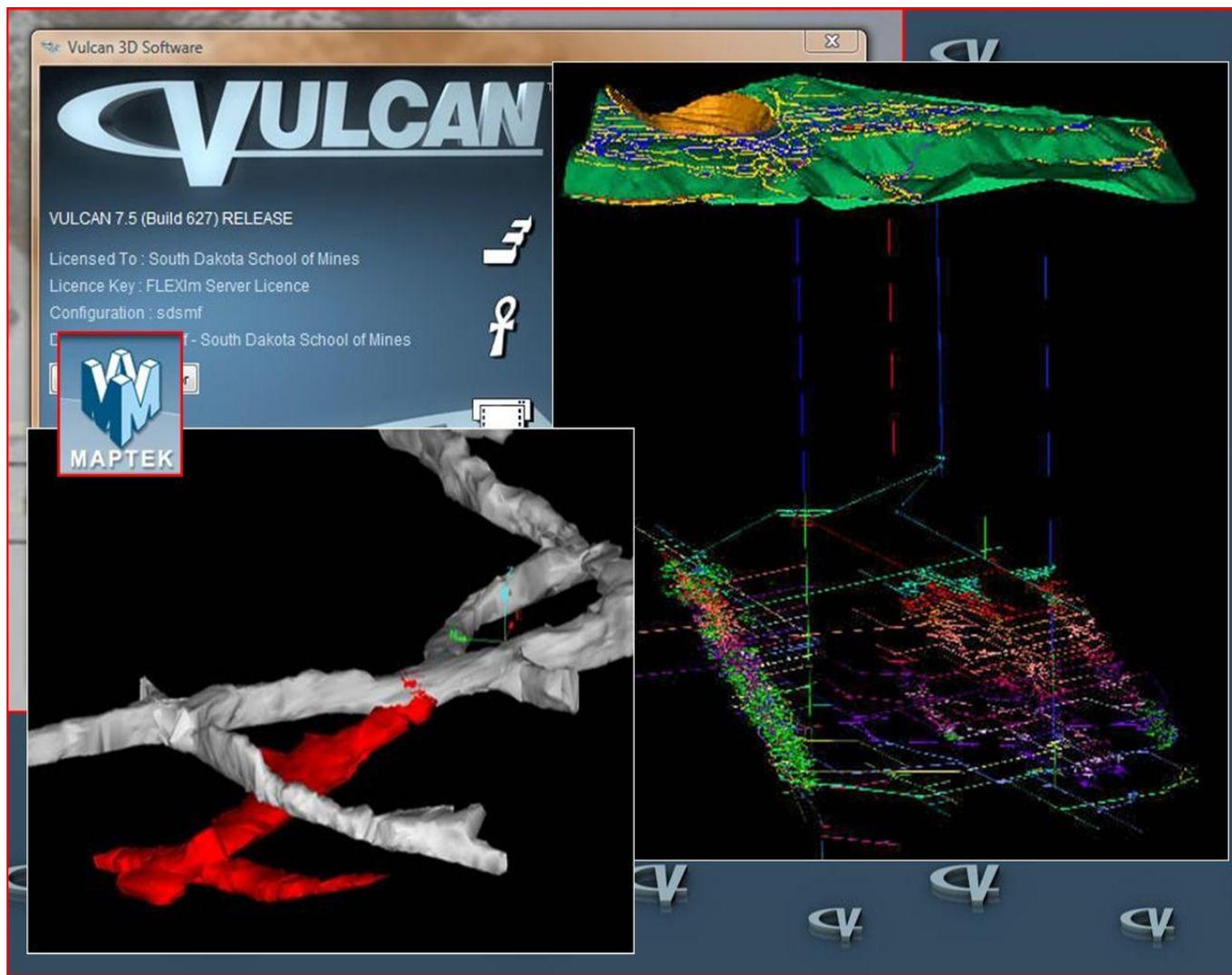
<sup>1</sup>Elective chosen from a list of approved mining or business courses.

#### **MAPTEK Lab**

The MAPTEK Advanced Mine Design and Global Communications Center is a modern computer design lab that is fully equipped with the world's most popular Mine Design Software – VULCAN from MAPTEK. This program is the leading design software used by the majority of mining operations worldwide. It enables students to design, review, analyze and perform extremely complex mine design tasks that are commonly performed daily at mining operations.

In addition, the lab is equipped with all of the requisite audio-video equipment to conduct video conference sessions with any organization across

the globe. The set-up also allows for easy integration to distance learning modules and participation from industry executives worldwide.



*Mines Matters:* 3-D modeling Vulcan software donated by Maptek helps students learn advanced technical design aspects of the mining industry. The Maptek Advanced Mine Design Center enhances the faculty's ability to promote and teach advanced technical aspects of the mining industry, with emphasis on 3D-modeling and design.

## Physical Education



### Contact Information

#### **Ms. Barbara Felderman**

Department of Physical Education

King Center 152

(605) 394-2602

E-mail: [Barbara.Felderman@sdsmt.edu](mailto:Barbara.Felderman@sdsmt.edu)

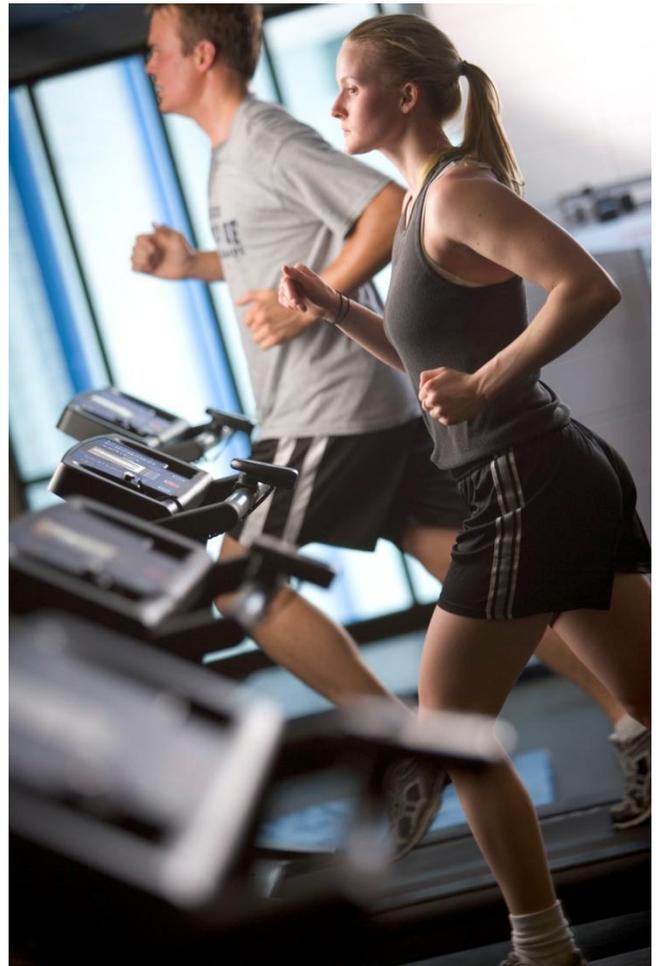
### Faculty

Professor Felderman; Associate Professor Schafer; Assistant Professor Kratzer; Instructor Henry.

### Physical Education

The physical education program is administered as a phase of a student's general education with the primary mission of the department being to provide physical activity for each student. The main objective is to assist in developing a healthy and active lifestyle for each student.

The specific objectives are to create an interest in physical fitness and physical skills and to develop those skills as much as time and facilities permit, while fulfilling the physical education requirement for graduation.



*Mines Matters:* The School of Mines offers a number of free on-campus recreation activities, including a pool, racquetball courts, gymnasium, and Wellness Center, which offers weights and cardio equipment.

## Physics B.S. and Minor



### Contact Information

#### **Dr. Andre G. Petukhov**

Department of Physics  
Electrical Engineering/Physics 223  
(605) 394-2364  
E-mail: [Andre.Petukhov@sdsmt.edu](mailto:Andre.Petukhov@sdsmt.edu)

### Faculty

Professors Foygel, Petukhov and Sobolev;  
Associate Professor Corey; Assistant Professor  
Bai.

### Physics

The goal of a program of study in physics is to provide students with an understanding of the basic laws of physics and to develop skills that will enable students to further explore physical phenomena and to solve related problems.

Students should have a sense of curiosity about their surroundings and a strong desire, not only to find solutions to problems that are encountered, but also to develop a deeper understanding of the basic principles involved. Students will be expected to develop a high level of mathematical skills and to become proficient in oral and written communications. Laboratory skills are also emphasized.

At the bachelor of science level, students will not be expected to specialize in any branch of physics. However, the curriculum does have room for electives, providing an opportunity to develop a minor in other fields of science or in an

engineering discipline. It provides a background in applications of physics for students seeking employment in industry and also provides a solid foundation for graduate study in physics or in other fields such as geophysics, meteorology, metallurgy, computer science, mathematics, materials science, and many branches of engineering.

Because physics is the basis of most engineering disciplines, understanding basic principles of physics can help one become a better engineer. An increasing number of students are choosing a double major, consisting of physics plus some field of engineering. Students going this route often end up in industrial research and development. In a rapidly changing economy where one field of engineering may be in a slump while others are not, understanding physics can assist students in moving across disciplines. For these reasons, students are encouraged to consider double majors.

Graduate studies leading to the degree of Master of Science in Physics and Materials Science and Ph.D. in Materials Science and Nanoscience are offered. Research is primarily in condensed matter and particle physics. At this level of study, students are expected to assume much of the responsibility for carrying out a research project. For details of graduate programs in physics, see the graduate section.

### Minor in Physics

A minor in physics requires a minimum of 18 hours of courses in physics, which must include PHYS 213, and at least 15 hours of physics courses numbered higher than PHYS 213. All minors in physics must be approved by the department and must conform to the institutional policies and guidelines for minors.

### Physics Laboratories

The facilities in the EE-Physics building are ample for all aspects of the department's experimental work from the introductory laboratories through graduate research. They are equipped to enable students to observe physical phenomena, demonstrate physical principles, and

learn techniques for making quantitative measurements in the fields of mechanics, heat, optics, electricity and magnetism, atomic, particle, and solid state physics. The equipment is the type that students will likely to encounter after graduation, with emphasis on computer-based data acquisition and control of experiments.

### Physics Curriculum Checklist

Students are responsible for checking with their advisors for any program modifications that may occur after the publication of this catalog.

#### Freshman Year

##### **First Semester**

MATH 123	Calculus I	4
CHEM 112	General Chemistry I	3
CHEM 112L	General Chemistry I Lab	1
ENGL 101	Composition I	3
PE	Physical Education	1
IS 110	Explorations	2
Humanities or Social Sciences Elective(s)		3
<b>TOTAL</b>		<b>17</b>

##### **Second Semester**

MATH 125	Calculus II	4
PHYS 211	University Physics I	3
PE	Physical Education	1
CHEM 114	General Chemistry II	3
CHEM 114L	Gen Chemistry II Lab	1
CSC 150/L	Computer Science I	3
<b>TOTAL</b>		<b>15</b>

#### Sophomore Year

##### **First Semester**

MATH 225	Calculus III	4
PHYS 213	University Physics II	3
PHYS 213L	University Physics II Lab	1
PHYS 275	Relativity	3
ENGL 279	Technical Comm I	3
Humanities or Social Sciences Elective(s)		3
<b>TOTAL</b>		<b>17</b>

##### **Second Semester**

MATH 321	Differential Equations	3
EE 220/L	Circuits I	4
ENGL 289	Technical Comm II	3
Humanities or Social Sciences Elective(s)		6
<b>TOTAL</b>		<b>16</b>

#### Junior Year

##### **First Semester**

MATH 432	Partial Differential Equations	3
PHYS 341	Thermodynamics	2
PHYS 343	Statistical Physics	2
PHYS 312	Exper. Physics Design I	2
CENG 244/L	Intro to Digital Systems	4
PHYS 451	Classical Mechanics	4
<b>TOTAL</b>		<b>17</b>

##### **Second Semester**

MATH 315	Linear Algebra	3
PHYS 471	Quantum Mechanics	4
PHYS 314	Exper. Physics Design II	2
Physics/Math/Computer Science Electives		6
<b>TOTAL</b>		<b>15</b>

#### Senior Year

##### **First Semester**

PHYS 421	Electromagnetism	4
PHYS 361	Optics <sup>1</sup>	3
PHYS 412	Advanced Design Projects I	2
PHYS 481	Mathematical Physics <sup>1</sup>	4
Humanities or Social Sciences Elective(s)		3
<b>TOTAL</b>		<b>16</b>

##### **Second Semester**

PHYS 433	Nuclear and Particle Physics <sup>1</sup>	3
PHYS 439	Solid State Physics <sup>1</sup>	4
PHYS 414	Advanced Design Projects II	2
Math/Physics Electives		3
Humanities or Social Sciences Elective(s)		3
<b>TOTAL</b>		<b>15</b>

### **128 credits required for graduation**

#### **Curriculum Notes**

At the end of the sophomore year 12 hours of electives must include 6 hours in humanities (in two disciplines or in a sequence of foreign language courses) and 6 hours in social sciences (in two disciplines).

The electives must contain a minimum of 16 hours in social sciences and humanities and 3 hours of mathematics or computer science at the 200 level or above. 10 credit hours of military science may also be used as electives.

<sup>1</sup> Courses offered alternate years.

## Social Sciences



### Contact Information

#### **Dr. Sue Shirley**

Departments of Humanities and Social Sciences  
Classroom Building 310  
(605) 394-2481  
E-mail: [Sue.Shirley@sdsmt.edu](mailto:Sue.Shirley@sdsmt.edu)

### Faculty

Professor Goss; Associate Professors Dendinger, McReynolds and Van Nuys; Assistant Professor Dreyer; Devereaux Library Director Andersen; Associate Librarian Collection Development Davies.

### Social Sciences

The Department of Social Sciences provides study and understanding of the branch of science that focuses on the institutions and functioning of people in society. By utilizing empirical and quantitative methods in the study of human beings, the curriculum reflects the technical and scientific nature and mission of the university.

Interdisciplinary sciences degree candidates

are required to complete 24 semester hours of humanities and social sciences courses. Other science and engineering degree candidates are required to complete 15-16 semester hours of humanities and social sciences courses — at least 6 credits in each area. Engineering majors are required to enroll in at least one upper-level humanities or social science course of at least 3 credit hours.

### Social Sciences

(Upper-level courses are in bold print.)

#### **Anthropology:**

ANTH 210

#### **Geography:**

GEOG 101, 210, 212, **400, 492**

#### **History:**

HIST 151, 152, **492**

#### **Political Science:**

POLS 100, 250, **350, 407, 492**

#### **Psychology:**

PSYC 101, **319, 323, 331, 391, 392, 451, 461**

#### **Sociology:**

SOC 100, 150, 250, **391, 392**

#### **Business and Economics Courses:**

Business courses are available from Black Hills State University. ECON 201 or 202 may be used toward fulfillment of the general education requirements in Social Sciences. BADM 350 and 360 may be used as upper division Social Science courses. All other BADM and ACCT courses are counted toward graduation as electives only.

## Graduate Student General Information

South Dakota School of Mines and Technology offers graduate degree programs at the master's and doctoral levels. The graduate program provides opportunities for advanced study and research in the fields of engineering and science. Each individual degree program of study is designed to broaden and extend the student's knowledge within the chosen field, to develop the power of independent, critical thinking and to promote individual and cooperative research skills.

The first Master's Degree program was authorized at the South Dakota School of Mines and Technology in October 1935, and the first degree was granted in 1937. Permission to offer the first Ph.D. program was granted in January 1967 to the Department of Geology and Geological Engineering. Six additional Ph.D. programs have been authorized since that time with the most recent addition being a Ph.D. in Mechanical Engineering in 2009. The Graduate Office was created in the 1950-51 academic year.

The policies of the Graduate Office are formulated with the assistance of the Council on Graduate Education, which is advisory to the Dean of Graduate Education. The policies are approved by the Faculty Senate and the Board of Regents and are administered by the Graduate Dean.

Forms mentioned in the catalog are available at the Graduate Office or on the graduate education website.

### The Council on Graduate Education

The Council on Graduate Education consists of representatives from each graduate program and the Dean of Graduate Education or his/her designee. (The Vice President for Academic Affairs serves in an ex-officio capacity.)

### Graduate Programs

**Master of Science degrees** are offered in:

- Atmospheric Sciences
- Biomedical Engineering
- Chemical Engineering
- Civil Engineering

- Construction Management
- Electrical Engineering
- Engineering Management
- Geology/Geological Engineering
- Materials Engineering and Science
- Mechanical Engineering
- Paleontology
- Physics
- Robotics and Intelligent Autonomous Systems

**Doctor of Philosophy degrees** are offered in:

- Atmospheric and Environmental Sciences
- Biomedical Engineering
- Chemical and Biological Engineering
- Geology/Geological Engineering
- Materials Engineering and Science
- Mechanical Engineering
- Nanoscience and Nanoengineering

### Admission to the Graduate School

The Graduate Office encourages applications from qualified students holding bachelor's degrees in engineering or science from accredited four-year colleges and universities. A student desiring admission should obtain an application form from the Graduate Office or via the website at: <http://graded.sdsmt.edu>. The completed form and a non-refundable application fee of \$35 (for all applicants) are required to be submitted to the Graduate Office. Required supporting documents are specified on the application and on the web site. Application materials from domestic applicants should be received by June 1 for fall semester admission or by October 1 for spring semester admission. International applicants must submit all of their materials by March 15 for fall semester admission or by August 1 for spring semester admission. Applicant files will not be considered for acceptance until all of the application items are received.

Three letters of recommendation are required from students who have not previously attended the South Dakota School of Mines and Technology. These should be requested by the applicant from three persons familiar with the scholastic ability and interests of the applicant. Applications from students who currently attend

or who have graduated from the South Dakota School of Mines and Technology need only obtain references from two faculty members familiar with the applicant's academic performance unless otherwise specified on the application form.

If the applicant has not completed an undergraduate program, evidence of graduation must be submitted prior to enrollment.

The Graduate Record Examination (GRE) may be required by a graduate program (see program specific requirements). If the GRE is required, it should be taken in advance of application so that the scores are available at the time the student's application is reviewed. Please use school code 6652 for the results to be sent to the School of Mines. This examination is prepared by the Educational Testing Service, Princeton, New Jersey.

The descriptions that follow provide information on requirements for specific graduate programs. When an application for admission to a graduate program is received, the faculty of the program in which the applicant expects to major will evaluate the applicant's academic qualifications. The head/coordinator, on behalf of the faculty, will recommend whether or not the applicant should be accepted into the graduate program and whether the admission should be as an unconditional, conditional, probationary, or special student. The Dean of Graduate Education will review this recommendation and provide a letter of decision to the applicant.

Admission to the Graduate school for study toward a master's degree does not imply that the student will be allowed to work toward a doctorate. A separate application and evaluation of the student's qualifications are necessary before acceptance into a doctoral program. It should be noted further that admission to the graduate school for study toward a Ph.D. degree does not constitute admission to candidacy for the Ph.D. degree. Refer to a later section for information on admission to candidacy.

A student who is admitted to the Graduate School but is unable to attend in the semester in which he/she was accepted may request a deferment for up to two years. The request must be made in writing to the Office of Graduate Education and must specify the revised start date.

Deferments must be approved by the Dean of Graduate Education. Students must reapply if the anticipated start date is more than two years after the acceptance date.

## **International Student Admissions**

### **English Proficiency**

All international applicants must provide evidence of English proficiency, with the exception of applicants from countries where English is the native language. Applicants who have a prior degree from a college or university in the US may also be exempted, based on English courses taken and grades received in those courses.

The School of Mines has established minimum scores for admission for TOEFL, IELTS and the Pearson Test of English-Academic, listed below. We recognize a variety of valid English proficiency tests which will be evaluated on an individual basis. English proficiency test results must be sent to the Graduate Office. Please use school code 6652 for TOEFL results to be sent to the School of Mines.

Detailed information about the English requirement is available on the web site at <http://international.sdsmt.edu/new-students/admissions/English/>.

<b>Test</b>	<b>Minimum score*</b>	<b>Upper level score**</b>
TOEFL – iBT (internet based test)	68	83
TOEFL – CBT (computer based test)	190	220
TOEFL – PBT (paper based test)	520	560
IELTS	5.5	6.5
Pearson Test of English - Academic (PTE)	47	56

\*Minimum scores require English proficiency testing upon arrival at the university.

\*\*Upper level scores indicate that no additional proficiency testing is required by the university. However, additional testing and instruction may

be required based on a student's performance on other placement exams, in the classroom, or by the academic department.

### **English Proficiency Conditional Admission**

Applicants who are planning to attend an intensive English as a Second Language (ESL) program in the US prior to attending the School of Mines may be eligible for conditional admission. Conditional admission may be granted if the applicant meets admission requirements with the exception of the minimum English score as indicated above. The School of Mines also recognizes the difficulty for ESL students in taking standardized exams that are offered only in English, such as the SAT, ACT and GRE. Students in ESL programs may be required to take such tests after they have advanced to a certain level in ESL. Requirements will be specified in a conditional admission letter sent to the graduate applicant. Once the student has completed the ESL program with satisfactory grades and meets any additional requirements, the student may be eligible for unconditional admission.

### **Visa Requirements**

An international applicant will not be issued the U.S. Department of Justice Form I-20, Certificate of Eligibility for Non-immigrant (F-1) student status, until admission to Graduate school for study toward a specific advanced degree has been granted. Form I-20 is usually necessary for admission to the United States for college attendance. Conditions of issuance of this form include documented evidence of financial ability to cover the projected annual costs of education at this university including living allowance. This institution will issue a DS-2019 Form only when appropriate.

International students are advised that full-time status at this university is necessary in order to satisfy F-1 status requirements.

As a result of the regulations that became effective on January 1, 2003, the Family Educational Rights and Privacy Act (FERPA) is waived for F and J students with respect to reporting requirements specific to student status. The regulations will be strictly enforced by the

appropriate bureau(s) within the US Department of Homeland Security (DHS) and information will be reported electronically to DHS via Student and Exchange Visitor Information System (SEVIS). The consequences to students for non-compliance with the new regulations are severe. For more information, e-mail the Ivanhoe International Center at [Ivanhoe@sdsmt.edu](mailto:Ivanhoe@sdsmt.edu) or go to <http://international.sdsmt.edu>.

### **Application Fees and Medical Insurance**

All applicants are required to submit the \$35 application fee with the application. In addition, at the time of first registration on campus, a \$120.95 international student enrollment fee must be paid. Both charges are non-refundable.

Each international student (and any dependents accompanying him/her to the United States) is REQUIRED to enroll in the Major Medical Hospitalization/Surgical Insurance Plan provided through South Dakota School of Mines and Technology. No outside policies will be accepted as substitutes. The only exception to this rule is if the student is sponsored by his/her home country government (documentation of this policy is required). Life insurance is also strongly recommended.

### **Graduate Student Support**

#### **Graduate Assistantships**

South Dakota School of Mines and Technology has funds available from various sources for graduate assistantships and fellowships. Such awards are usually made on the basis of scholastic merit and the availability of funds. Assistantships are not available to students on probation unless an exception is granted by the Dean of Graduate Education.

Financial assistance is available for graduate teaching assistants (GTA) and for graduate research assistants (GRA). A GTA assists with instruction within laboratory sections, grades papers, or performs other assigned instructional duties. A GRA is compensated to conduct supervised research, generally relating to the student's thesis or dissertation research.

The Dean of Graduate Education grants the

award, acting upon the recommendation of the department head, program coordinator, or major professor after evaluation of the student's academic record, overall qualifications, and programmatic progress. Graduate assistants are required to attend GTA/GRA training each semester prior to any release of funds. The following rules apply to all graduate assistants:

1. An assistant receiving a full-time stipend (50 percent academic study, 50 percent research or teaching) must be registered for a minimum of 9 credit hours during the fall or spring academic semester in which the assistantship is in effect. Reduced tuition is available for students meeting these criteria.
2. An assistant receiving a three-quarter time stipend (62.5 percent academic study, 37.5 percent research or teaching) must be registered for a minimum of 7 credit hours during the academic semester in which the assistantship is in effect. Registering for 7 credits does **not** qualify for reduced tuition. Only students registered for 9 credits in the fall or spring and receiving a qualifying assistantship may receive reduced tuition.
3. An assistant receiving a half-time stipend, (75 percent academic study, 25 percent research or teaching) must be registered for a minimum of 5 credit hours during the academic semester in which the assistantship is in effect. Registering for 5 credits does **not** qualify for reduced tuition. Only students registered for 9 credits in the fall or spring and receiving a qualifying assistantship may receive reduced tuition.
4. The minimum compensation, established annually by the Board of Regents and currently set at \$2,779, must be awarded in each semester to qualify for reduced tuition. As noted above, a student registered for a minimum of nine 9 credit hours in the spring or fall semester and receiving a qualifying assistantship may receive reduced tuition.
5. Summer assistantships. The minimum registration required to receive reduced tuition with a qualifying assistantship in the summer is 2 credits.

6. Self-support classes, including English remediation classes, are not eligible for reduced tuition.

Note that graduate students are assessed the same campus fees as undergraduates (see "Tuition and Fees"). State law does not permit reduction or remission of fees under any circumstances.

Graduate assistants under state contract are subject to institutional policies set forth in the Faculty/Staff Handbook. Research assistants are required to sign an "Employee Agreement to Disclose Inventions" form. Teaching assistants are required to sign a "Family Educational Rights and Privacy Act Compliance Sheet".

A student receiving an assistantship and tuition remission is required to maintain 9 credits throughout the semester in which the support is received. If a student drops to fewer than 9 credits, the student will immediately lose the assistantship and will be required to repay the institution for the tuition remission on the dropped class.

A student with a research assistantship (GRA) should recognize that the prescribed hours of research work are minimum expectations mandated by employment practices and may not represent the effort that will be actually necessary to produce a satisfactory thesis or dissertation within a reasonable period of time.

Students must register before assistantships and fellowships are processed for the semester for which they are authorized in order to prevent payment delays.

Graduate assistants who are eligible for reduced tuition at 1 institution are also eligible at other South Dakota Regental institutions. Graduate Special Students (non-degree-seeking students) are not eligible to receive assistantships.

### **Graduate Fellowships**

A number of fellowships from industrial and governmental agency sources are currently available. Eligibility requirements and restrictions are parallel to those for research assistantships. A fellowship award usually does not include reduced tuition as a benefit. Pre-

registration by continuing students is required to prevent payment delays.

### **Other Resources**

Graduate students who are U.S. citizens or eligible non-citizens may be eligible for other forms of financial aid such as Federal Stafford Student Loans, Federal Perkins Student Loans, or Federal Work-Study. Application and requests for additional information on these programs should be made to the Financial Aid Office.

### **Graduate Student Registration**

A graduate student will report to the advisor specified in the admission letter and thereafter will follow the registration procedure for all South Dakota School of Mines and Technology students. The advisor is responsible for counseling the graduate student in the formulation of a program of study until the student has selected a major professor. In some programs, the advisor may continue to work with the student and the major professor to ensure that all degree requirements have been satisfied.

### **Full-Time/Half-Time Defined**

A full-time graduate student is defined as a student registered for 9 or more credit hours per semester at any of the 6 universities in the South Dakota Regental system during the academic year. All international students must be registered full-time to maintain student status with the U.S. government.

A three-quarter-time graduate student is defined as a student registered for at least 7 credits but less than 9 credit hours per semester during the academic year.

A half-time graduate student is defined as a student registered for at least 4.5 credits and less than 7 credit hours per semester during the academic year.

2 credits are considered full-time during the summer for purposes of receiving an assistantship. To qualify for federal student aid or to qualify for in-school deferment status (for federal or private alternative student loans), a student must be registered for at least 4.5 credits during any semester, including summer.

Audited credits do not apply toward the above definitions. Remedial English classes count toward the determination of full-time status.

### **Continuing Registration**

Degree-seeking graduate students must be registered on a continuing basis during each fall and spring semester of the regular academic year. The number of credits required is specified in the next section, "Minimum Registration". This applies regardless of whether the graduate student is in residence, is off-campus, or is pursuing a degree on a part-time basis. Failure to maintain continuing registration will result in deactivation of the graduate student's program. Therefore, graduate students who fail to comply and subsequently wish to return to their same program of study will be required to obtain written permission from the Dean of Graduate Education and may be required to reapply.

Students may petition for a leave of absence if they are unable to fulfill the continuing registration requirement (see "Leave of Absence" section).

Graduate Special Students (non-degree-seeking students) are exempt from the continuing registration rule.

### **Minimum Registration**

Degree seeking graduate students must enroll for a minimum of 2 credits during the spring, fall and summer semesters if the student is using departmental or institutional resources. This includes any semester in which a student schedules or takes exams, conducts research, or completes a degree. The number of credit hours taken in excess of the minimum should accurately reflect the extent of the graduate student's coursework and research activities.

Graduate students must meet this minimum registration requirement during the specific semester or summer in which they complete all requirements for their degree and become eligible for graduation. There will be no grace period; hence, students who fail to complete all degree requirements prior to the official closure date for a given semester or summer will be required to register for a minimum of 2 credits during a subsequent semester or summer in order to

graduate.

### **Academic Loads**

13 credit hours per semester are considered to be the maximum graduate load. Higher loads must be approved by the Dean of Graduate Education and the major professor. Students wishing to take a higher course load must complete a Course Overload Request form. Appropriate course loads should be determined in conjunction with the advisor or major professor and should reflect the effort required for students working as GTAs or GRAs.

Please refer to the section “Graduate Student Support” for additional information on the number of credit hours required during a semester to be eligible for assistantships and financial aid.

Up to 8 semester hours of research credit may be awarded for 1 summer of work.

### **Leave of Absence**

A student who is unable to continue his/her program of graduate study due to unanticipated circumstances may request a leave of absence from his/her program of study by completing and submitting a “Request for Leave of Absence” form, available in the Graduate Office or at the graduate education website. The form must be completed and signed by the student, the student’s advisor, department head or program coordinator and then submitted to the Graduate Office for each semester of absence. The Dean of Graduate Education will evaluate the request and either approve or deny it. If the request is approved, the student will not be subject to continuing registration, and the leave of absence will not count toward the time limits to complete his/her program of study. A leave of absence is determined on a semester-by-semester basis and is usually limited to a maximum of 1 calendar year. International students are not eligible for a leave of absence if they intend to remain in the U.S.

### **Change of Program**

A student admitted to the graduate school in a specified program must complete at least 1 semester in the original program before being allowed to transfer. A student who wishes to

change programs should request the change using an “Intent to Transfer” form. The current program must be notified prior to seeking the transfer. Approval from the proposed program is required. If admittance to the new program is not granted the possibility of a discontinuation from study in any area at SDSM&T is possible. Upon favorable recommendation from the new program, the Dean of Graduate Education will issue a letter of transfer and notify the appropriate offices and the student of the change.

### **Dual Enrollment in Ph.D./M.S. Programs**

Concurrent enrollment in a Ph.D. program and an M.S. program in a different department is normally not allowed. Students who are pursuing a Ph.D. may not take more than 15 graduate credits in a second department. If a student leaves the Ph.D. program and is admitted to a second department, no more than 15 credits may be counted toward a M.S. degree.

### **Exception Policy**

A student who seeks an exception to the above policy must follow the procedure set forth below. Students must be aware that exceptions to this policy will only be granted under extraordinary circumstances.

1. The Ph.D. student must obtain prior written approval for this dual-degree plan from his/her major professor and the head/coordinator of the relevant Ph.D. program.
2. If approval is granted in Step 1, then the Ph.D. student must obtain written approval for the M.S. degree plan from the head of the corresponding M.S. program.
3. If approval is granted for Step 2, then the student will need to establish a second graduate committee and file a separate program of study for the M.S. degree with the Graduate Office.
4. The Dean of Graduate Education will have authority to either approve or disapprove this second program of study. If the M.S. program of study is approved by the Dean of Graduate Education, then the major professor of the student’s Ph.D. program will be appointed as

the representative of the graduate school of the student's M.S. graduate committee.

5. The first 2 semesters of the dual program will be considered probationary. The second program of study can be terminated based on recommendations of the Ph.D. major professor and/or M.S. major professor to the Dean of Graduate Education.

### **Dual Majors**

South Dakota School of Mines and Technology does not permit, in general, credit hours that have been used to satisfy requirements for one Master of Science degree to be applied toward another master's degree from this institution. Under exceptional circumstances however, a student may petition the Council on Graduate Education through his/her advisory committee for a variance from this policy.

### **Special Students**

An individual who holds a Baccalaureate degree and wishes to pursue further study without a commitment to advanced degree candidacy may apply to the Graduate Office for admission as a special student at the graduate level. The applicant must provide evidence of the baccalaureate degree. Upon admission as a special student, he/she will be subject to Graduate Office policies. A maximum of 12 credit hours may be accumulated, after which the student must either apply for admission as a degree-seeking student or must petition for a variance from this policy. A course with a grade of "Incomplete" counts toward the 12 credit maximum. Graduate students classified as special students are not eligible for assistantships.

### **Graduate Grading System:**

The grades listed in this section can be assigned to all courses with course numbers of 500 or greater. Plus and minus grades are not used.

## **1. Coursework Final Grades**

### **A Exceptional**

4.00 grade points per semester hour.

### **B Good**

3.00 grade points per semester hour.

### **C Average**

2.00 grade points per semester hour.

### **D Unsatisfactory**

1.00 grade points per semester hour.

### **F Failure**

0.00 grade points per semester hour.

### **S Satisfactory**

Does not calculate into any GPA. This is the grade that will appear on a transcript for a successfully completed course taken with the pass/fail option or for research credits (see below).

### **U Unsatisfactory**

Does not calculate into any GPA. This is the grade that will appear on a transcript for failing to complete a pass/fail course or research credits (see below).

### **W Withdrawal**

Does not calculate into any GPA, no credit granted.

### **AU Audit**

Does not calculate into any GPA. An audit (AU) grade may be granted only when the student has elected the AU option on or prior to the census date of the term.

## **2. Incomplete Grades**

### **I Incomplete**

Does not calculate into any GPA. An incomplete (I) grade may be granted only when all of the following conditions apply:

- a. A student has encountered extenuating circumstances that do not permit him/her to complete the course.
- b. The student must be earning a passing grade at the time the Incomplete is requested. Anticipated course failure is not a justification for an incomplete.
- c. The student does not have to repeat the course to meet the requirements.
- d. The instructor must agree to grant an incomplete grade.
- e. The instructor and student must agree on a plan to complete the coursework.
- f. The coursework must be completed within one calendar year; extensions may be granted by the Dean of Graduate Education.
- g. If the student completes the course within the specified time, the grades that may be assigned are A, B, C, D, F, S, or U.
- h. If the student does not complete the course within the specified time the incomplete grade remains on the transcript.

### **IP In Progress**

Does not calculate into any GPA. An in progress (IP) grade may be granted only when all of the following conditions apply:

- a. The requirements for the course (for every student enrolled in the course) extend beyond the current term.
- b. The extension beyond the current term must be defined before the class begins.
- c. The instructor must request permission to award IP grades for a course from their department head/coordinator and from the Dean of Graduate Education. Then approval must be obtained from the Vice President for Academic Affairs.
- d. A definite date for completion of the course must be established in the course syllabus.

### **3. Research Grades**

#### **S Satisfactory**

Does not calculate into any GPA. This is a final grade for a research course (including thesis or dissertation research).

#### **U Unsatisfactory**

Does not calculate into any GPA.

This is a final grade for a research course (thesis or dissertation research).

#### **NP Normal Progress**

Does not calculate into any GPA. A normal progress (NP) grade calculates into attempted credits but does not calculate into completed credits. Research grades do count toward attempted credits once a final grade of S or U is assigned. A normal progress (NP) grade may be granted by an instructor when the instructor determines that a graduate student is making normal progress in a graduate Thesis/Dissertation course. This is intended to be an intermediate grade which should be changed to 'S' or 'U' upon completion of the course requirements.

### **4. Additional Grading Options**

#### **NR Grade not reported by the Instructor**

Does not calculate into any GPA.

#### **EX Credit by Exam**

Does not calculate into any GPA. An examination for credit (EX) grade may be granted only for non-course credit validation obtained through a validation process. This grade is not used for any Regental university course.

#### **CR Credit**

Does not calculate into any GPA. A credit (CR) grade may be granted only for non-course credit that is not related to an examination or to equating transfer grades to the BOR grading system. This grade is not used for any Regental university course.

#### **TR Transcribed**

Does not calculate into any GPA and no credit is granted.

#### **LR Lab grade linked to Recitation Grade**

0 credit course.

## **Advanced-Degree Grade Requirements**

To qualify for any advanced degree, the faculty has stipulated that the following requirements must be satisfied:

1. The student must earn a minimum 3.00 GPA in **all** 300- through 800-numbered courses taken in all departments which appear on the graduate transcript. In addition, the student must also have a minimum GPA of 3.00 in courses taken in his/her major department after admission to the graduate program, or taken for graduate credit at the School of Mines as an undergraduate or special student. Note that thesis and dissertation research credit hours and grades will not be counted in the determination of these grade-point averages. Only courses transferred to the graduate transcript are used for computing the graduate GPA.
2. The student must earn a "C" grade or better in any graduate course (500 through 800 level), which is to be credited toward advanced degree requirements.
3. The student must earn a "B" grade or better in any 300 or 400 level course, which is to be credited toward advanced degree requirements.
4. The student's thesis or dissertation research must be of a quality to earn a final grade of "S."
5. Students who fail any course must repeat the course with a passing grade as defined above. The student may petition, through their advisor or major professor, and the Dean of Graduate Education for an exception to this rule.
6. The student cannot apply any credit hours or grades for 100- and 200-level courses (which are usually taken to overcome academic deficiencies) toward advanced degree requirements. If, in the opinion of the student's advisor, major professor and advisory committee, progress in these courses is unsatisfactory, additional work may be required to demonstrate proficiency.
7. Of credits counted for an advanced degree, not more than 50 percent of the credit hours in any graduate program can be at the 500 level or

below. Exceptions must be approved by the Dean of Graduate Education.

If a course is repeated for a passing or improved grade, only the grade for the last attempt will be included in the computation of the cumulative grade-point average shown on the graduate student's transcript.

Advanced degree credit given for "Special Topics in," "Advanced Topics in," or "Seminar in" is limited to nine 9 credits. Refer to the specific course description for any other restrictions.

All graduate research credit hours are graded according to regular grading standards. However, for graduate research credits (courses numbered 788, 798, and 898) the final grades for a completed program will be issued as either "U" for Unsatisfactory or "S" for Satisfactory. These S and U grades will not be used in the computation of grade-grade point averages.

Research credit may be applied toward the fulfillment of credit-hour requirements. The number of credit hours so applied is identified in the relevant sections under Master of Science and Doctor of Philosophy degree programs.

## **Undergraduates Taking Graduate Courses/Graduates Taking Undergraduate Courses**

1. Graduate-level credits (500 level or above) taken as an undergraduate student are automatically placed on a graduate transcript and may not be used toward an undergraduate degree unless appropriate approvals and credit transfers are obtained through Academic and Enrollment Services. Graduate-level credits taken as an undergraduate and used to fulfill requirements for the undergraduate degree may not be used toward a graduate degree.
2. Up to 12 semester hours of graduate-level credits taken as an undergraduate and not used to fulfill requirements for the undergraduate degree may be used toward a graduate degree only after the courses in question are included on the student's program of study with all necessary approvals listed thereon. Upon written justification by the head/coordinator of

the graduate student's major department/program, the Dean of Graduate Education may approve a minor variance from this rule.

3. Undergraduate-level credits (300 or 400 level) taken as a graduate student are automatically placed on an undergraduate transcript and may not be used toward a graduate degree except under the following circumstances:
  - a. The courses in question are outside the student's major department but are included on the student's program of study with all necessary approvals listed thereon. (See also individual department restrictions on 300-400 level courses.)
  - b. The courses in question are within the student's major department, appear on the waiver list pre-approved by the Council on Graduate Education, and are included on the student's program of study with all necessary approvals listed thereon. (See also individual department restrictions on 300-400 level courses.)
  - c. The courses in question are at the 400 level, are within the student's major department, do not appear on the waiver list pre-approved by the Council on Graduate Education, but are included on the student's program of study along with a petition of support from the student's major professor, with all necessary approvals listed thereon.
  - d. The student must have earned a "B" grade or better in any 300- or 400-level course which is to be credited toward advanced degree requirements.
  - e. The student cannot apply any credit hours or grades for 100- and 200-level courses (which are usually taken to overcome academic deficiencies) toward advanced degree requirements. If, in the opinion of the student's advisor, major professor and advisory committee, progress in these courses is unsatisfactory, additional work may be required to demonstrate proficiency.

The number of undergraduate credits not used to fulfill requirements for the undergraduate

degree that may be applied toward a master's degree is limited to 9 hours.

### **Work Taken at Another Institution**

A minimum of 60% of the credit hours in the graduate degree program must be completed from the institution granting the degree. Credit for up to 12 semester hours of graduate-caliber coursework taken at another institution may be transferred toward the requirements for the Master's degree at the South Dakota School of Mines and Technology.

Domestic graduate transfer courses and transfer grades are recorded and evaluated by the School of Mines, calculated into grade point averages according to the South Dakota Regental grade scheme, and recorded on the student's academic transcript ONLY if these transfer courses are equivalent to a specific graduate course at South Dakota School of Mines and Technology. International transfer courses will appear on the transcript along with the number of credits earned, but no grade will appear or be calculated into grade point average.

Such credit from institutions external to the South Dakota Regental system must be reviewed and approved by the student's committee and by the Dean of Graduate Education. The Dean of Graduate Education shall notify the Registrar and Director of Academic Services in writing of the credits to be accepted and placed on the student's transcript. An official transcript received directly from the issuing institution to support the request is required. The transferred course number, title, and semester hours will be entered on the student's transcript.

### **Course Retake Policy**

A student will be allowed a total of two registrations for any particular graduate course (course numbers of 500 and above) for which credit is to be counted toward graduation. The student must petition the Dean of Graduate Education and obtain the Dean's approval to be permitted to take a graduate course more than two times. Only the LAST attempt of the course will count in the grade point average calculations.

A student will be allowed multiple registrations for certain graduate courses for which credit toward graduation may be received more than once (e.g., Independent Study, Thesis, Research, etc.). Grades for all such courses will be used for grade point average calculations. Please note that individual departments/programs may limit the number of credits allowed toward graduation in these types of courses.

### **Pass-Fail Option for Graduate Students**

The following policy pertains to the pass/fail option at the graduate level:

1. 100- and 200-level courses, either within or outside of the department, which cannot be applied for credit toward a graduate degree may (with the consent of the student's major professor and advisory committee) be taken on a pass-fail basis under the same rules that apply to undergraduate students.
2. 300- through 800-level courses outside of the student's department/program may (with the consent of the student's major professor and advisory committee) be taken on a pass-fail basis except that a "C" grade shall be considered the lowest passing grade. The maximum number of hours of pass-fail work for which a master's degree candidate may receive credit will be 6 for the thesis option and 9 for the non-thesis option.
3. No 300- through 800-level courses offered by the student's major department/program may be taken for credit under the pass-fail option. Beyond the master's level, the pass-fail option may be exercised at the discretion of the candidate's graduate advisory committee but must still be approved by the Dean of Graduate Education.

### **Probation and Reinstatement Policy**

An applicant who has a large number of deficiencies, or whose undergraduate record is relatively weak, may be admitted to the graduate program on probationary status. For a student admitted on probation, a deficiency in grade requirements during the first semester of

enrollment may be considered sufficient grounds for terminating the student's enrollment in the graduate program. Such a termination decision will be made by the Dean of Graduate Education after consulting with the student's major professor and the department head or relevant program coordinator.

A current graduate student who does not meet the following requirements (items 1-7 below) during any semester will be placed on probation and will be so informed by the Dean of Graduate Education. A failure to remove the deficiencies during the following semester may be considered sufficient grounds for terminating the student's enrollment in the graduate program. For further information regarding restrictions on financial assistance to graduate students on probation, refer to the section entitled "Graduate Student Support." Probation imposed because of grade deficiencies in specific courses (items 2-3 below) will continue each semester until the course(s) has been retaken and an acceptable grade(s) has been received. Probation imposed because of overall GPA deficiencies (item 1 below) will continue each semester until the GPA reaches the acceptable level.

A student will be placed on probation for a "U" grade received for research credit(s). Since a "U" is a final grade, probation will be maintained until at least one subsequent "S" credit is awarded. A student may graduate with "U" grades, but must also accumulate "S" grades for the required minimum number of research credits in a given advanced degree program. A student who has transferred from a thesis to a non-thesis program and who has received "U" grades as the last research grades in the thesis program will be admitted to the new program on a probationary status. Such probation may be removed by satisfactory progress (according to the usual performance criteria) during the first semester in the new program.

In addition to probation triggered by academic performance, a student may be placed on probation for failing to meet programmatic or institutional requirements. This includes failure to meet the required deadline for filing the required program of study with the graduate office and/or failure to meet the deadlines for taking and

passing applicable qualifying, comprehensive, and final exams. Probation for such deficiencies will be removed after the requirement(s) has been satisfied. A student's probationary status will be reviewed at the close of each semester for appropriate action: removal from probation, continuation of probation, or termination. A student may petition the Dean of Graduate Education for reconsideration of a termination decision. (Refer to section on "Appeal Procedure.")

1. A student must maintain a "B" (3.00) or better grade point average in all 300- through 800-level courses taken for graduate credit at the School of Mines. Thesis and dissertation research credit hours and grades will not be counted in the determination of this GPA.
2. A student must earn no less than a "C" (2.00) grade in any graduate course (500 through 800 level) taken for graduate credit, and which is to be credited toward advanced degree requirements.
3. A student must earn no less than a "B" (3.00) in any 300- or 400-level course taken for graduate credit, and which is to be credited toward advanced degree requirements.
4. A student's thesis or dissertation research must be of a quality to warrant the issuance of a semester grade of "S" or an interim grade of "NP." A research grade of "U" will result in the student being placed on probation.
5. A student must earn no less than a "B" (3.00) in any 100- or 200-level course required by the student's advisory committee even though the course cannot be applied toward a graduate degree.
6. A student must pass all courses taken on the pass-fail basis. (Refer to section on "Pass-Fail Option for Graduate Students.")
7. A student must remove all other program deficiencies, such as meeting stated deadlines for applicable qualifying, comprehensive, and final examinations; selection of a graduate advisory committee; and filing of a satisfactory program of study in the graduate office.

## **Appeal Procedure**

Procedures for appealing or petitioning for a variance from certain policies are set forth in the relevant sections of this document when such variances are permitted in unusual or exceptional circumstances. Appeals or petitions involving such matters as grade changes from "F" or "I" to "W" should be lodged with the Academic Appeals Committee through the Vice President for Academic Affairs, after review by the Dean of Graduate Education.

Appeals concerning probation, suspension, or potential variances in academic graduate policy should first be lodged with the student's major department/program. Before rendering a decision on the appeal, the department head or program coordinator will seek a recommendation from the student's graduate advisory committee. If the student is not satisfied with the decision on the appeal, the student may petition the Dean of Graduate Education for reconsideration of the appeal. The Council on Graduate Education may be called upon to render a decision in such cases.

For situations not covered above, or if the student is dissatisfied with a prior appeal decision, he/she should seek the advice of the Dean of Graduate Education or the Dean of Students to determine what recourse is available to assist in seeking a solution to such problems.

## **Supervision of Advanced Degree Programs**

The supervision of the general study program of each student, including compliance with all the various Board of Regents, institutional, and Graduate Division policies, is primarily the responsibility of the advisor. The graduate advisory committee assists in this role. The Advisory Committee consists of:

- a major professor,
- a graduate division representative, (must not be from the student's department/program),
- 1 additional member for master's students,
- 3 additional members for doctoral students.

The major professor is primarily responsible for supervision of the graduate student's research

and thesis/dissertation preparation, as well as ensuring that academic standards and requirements are met and satisfied. The advisor and the major professor may or may not be the same person, depending on restrictions or requirements within the student's program and/or department.

The major professor serves as chairperson of the Graduate Advisory Committee and assists the student in selection of other members of the committee. The graduate division representative must be chosen from outside the major department/program.

To be eligible to serve as a major professor on a student's advisory committee, the person must be a faculty member at SDSM&T with a terminal degree. Individuals without a terminal degree may be granted an exception to this policy if the department notifies the Graduate School of its approval in writing.

Off-campus advisors must be appointed as adjunct faculty to be eligible to serve as a major professor. The department/program must notify the graduate office in writing of this appointment and approve the individual to direct research work. In such cases, a co-major professor located on campus should be selected to assist with administrative guidance.

To be eligible to serve as the Graduate Representative on a student's advisory committee, the person must be a faculty member at SDSM&T with a terminal degree.

A change in advisor may be accomplished at the student's request by submitting a "Request to Change Advisor" form, with all appropriate approval signatures, to the Dean of Graduate Education.

If staff changes or other valid reasons dictate a change in major professor, such a transition can be made at the request of the student and with the consent of the student's committee as evidenced by filing a revised "Program of Study" with the graduate office. A written appeal by a student for a change in major professor may be filed with the Council on Graduate Education through the Dean of Graduate Education in contested cases. The decision by the Council on Graduate Education is final.

If a student completes the M.S. degree and wishes to continue for a Ph.D. the student must apply to the doctoral program. If a student is enrolled in an M.S. program and wishes to enter the doctoral program without completing the M.S. degree, the student must apply for a transfer of programs.

If a master's candidate elects to transfer, the student's department/program shall determine by qualifying examination or by review of his/her record to date whether the student shall be permitted to transfer to the doctoral degree. Upon approval of the transfer, the department head or program coordinator, after consultation with the student and the existing advisory committee, shall expand the student's committee to a total of five members who will assist with the student's doctoral program.

### **Program of Study**

The student's advisory committee will assist the student in formulating a "Program of Study" leading to the advanced degree. A copy of the Program of Study form and advisory committee assignments must be filed with the student, the student's department/program, and the graduate office no later than the mid-term of the semester after which 9 credit hours have been completed or for which a grade of "Incomplete" has been issued. This is usually the second semester of study for full-time degree-seeking students. A copy of any amended program must be filed in a timely manner by the student and with the same offices as the original schedule. Each Program of Study form, or amendment thereof, must have the signature approval of the student and all members of the student's committee before it will be reviewed for final approval by the Dean of Graduate Education.

Students who have been granted a leave of absence before submission of a POS will be required to submit a POS by mid-term of the semester after completion of 9 credit hours.

### **Language Requirements**

There is no standard language requirement within the Graduate Division; however,

departments/programs may establish their own language requirement.

### **Certification for the Degree**

Before a diploma can be released, the Dean of Graduate Education must certify that the candidate has fulfilled all degree requirements. For certification of the degree for a given semester, ALL requirements must be complete on or before the scheduled due dates published by the Graduate Education Office. Note that ALL KEYS MUST BE RETURNED to the Physical Plant before the degree is granted.

Candidates are cautioned not to make travel plans or other arrangements that will be difficult or costly to change until they are certain that all degree requirements can and will be satisfied. It is the responsibility of the candidate to know and comply with these degree requirements.

### **MASTER OF SCIENCE PROGRAMS**

Master of Science programs at SDSM&T may offer three options by which a student may complete the requirements for a degree. They are the thesis option, the non-thesis option, and the coursework-only option. Professional degrees are contained within the coursework-only option.

In the following descriptions the term “program” refers to a division in a department such as the Environmental Engineering program within the Department of Civil and Environmental Engineering, or a non-departmental unit such as Engineering Management, Materials Engineering and Science, or Atmospheric and Environmental Sciences.

Students are encouraged to read the sections “Advanced-degree Requirements”, “Undergraduates Taking Graduate Courses/Graduates Taking Undergraduate Courses” and “Work Taken at Another Institution” for additional information about limitations on coursework that may be applied toward the degree.

### **Thesis Option Requirements**

The M.S. degree minimum requirements for the thesis option are:

1. A program of at least 30 credit hours of coursework and research.
2. At least 15 credit hours of graduate coursework approved by the program (500-level courses and above).
3. At least 6 credit hours of thesis research are required for the thesis option. No more than nine 9 credit hours of thesis research will count toward degree requirements. However, the student may register for additional research credits for continuing registration purposes.
4. A satisfactory thesis based upon individual research. (see below)
5. Meeting or exceeding academic standards prescribed elsewhere in this bulletin, including maintaining at least a 3.0 GPA.
6. Passing an examination on general knowledge and successfully defending the thesis.

#### *Thesis Requirements*

The thesis should represent an effort of such quality and construction that it can be displayed in the school library with similar scholarly works, as well as providing material for publication(s) in an appropriate professional journal(s).

The thesis is written under the direction of the major professor, but the student should feel free to seek guidance from all members of his/her advisory committee. Before starting to write the thesis, the student is urged to consult “Instructions for the Preparation of Theses and Dissertations” on the graduate education website (<http://resources.sdsmt.edu/forms/grad-ed/thesis-and-dissertation-instructions.pdf>) and to consult style manuals online or in the SDSM&T Devereaux Library. In general, the thesis may follow the style of captions, footnotes, and bibliographical references used by the leading technical journal in the student’s field. Students are urged to review carefully copyright ownership provisions in the “Instructions” document.

A final draft of the thesis should be submitted by the student to each member of his/her advisory

committee a minimum of 2 full weeks before the time and date of the student's scheduled defense. Earlier submission deadlines may be required by the advisory committee.

The Dean requires that the final draft of the thesis be submitted to the graduate office by the published deadline, approximately 21 calendar days before graduation, to allow adequate time for review, corrections and revisions. The final draft of the thesis, after all revisions recommended by the committee have been made, must be signed by the author and approved and signed by the major professor, the head/coordinator of the student's major department/program, and the Dean of Graduate Education before final reproduction. Signatures of other committee members are allowed but not required.

The institution requires 4 copies of the thesis in final form: the original (unbound) manuscript and 1 bound copy for the Devereaux Library, and 2 bound copies for the student's department/program, one of which will be forwarded to the major professor. 2 electronic versions of the thesis will also be required in digital format, 1 for the department and 1 for the graduate office. Contact the graduate office for instructions and requirements for this digital version. In case of a proprietary thesis, the original hard copy and digital version will be retained without reproduction in secured graduate office files throughout the specified proprietary period.

### *Thesis Defense*

A student pursuing the thesis option must defend the thesis in an oral examination. The thesis defense will normally be held during the last six weeks of the student's last term, but it may be given at any time after the thesis has received committee approval. No thesis defense may be scheduled during the period of university final examinations. The Final Examination and thesis research defense may be combined. The procedures listed in the section titled "Final Examination" apply to both the thesis defense and the Final Examination.

### **Non-thesis Option Requirements**

Students enrolled in a non-thesis program may have the option of completing a non-thesis research project or taking additional course credits in place of the research project credits. The latter option is often referred to as a "coursework only" option and is common in professional degree programs. Students electing a non-thesis program should check with their program or department to determine which non-thesis options are available to them.

The M.S. degree minimum requirements for the non-thesis option are:

1. A program of at least 32 credit hours of coursework (refer to specific program requirements for exact number of minimum coursework credit hours).
2. At least 20 credit hours of graduate coursework approved by the program (500 level and above).
3. The number of non-thesis research project credits that may be used for the degree is limited to 6 credits.
4. Meeting or exceeding academic standards prescribed elsewhere in this bulletin, including maintaining at least a 3.0 GPA.
5. Passing an examination on general knowledge in the field.

### **Final Examination**

All Master of Science degree candidates **will** be given a final examination covering course material. The examination may be written, oral, or both at the discretion of the major department or program. A portfolio may be used to satisfy the final examination requirement if the program and the Dean of Graduate Education have approved this approach.

A student pursuing the thesis option must also defend the thesis in an oral examination. The final examination and thesis defense may be combined.

Oral examinations, including a thesis defense, are open to all interested faculty members. Departmental or program policy shall determine

whether non-faculty persons may attend the examination.

The student shall obtain and complete the relevant Graduate Office form to schedule the final examination and/or thesis defense and, in conjunction with the major professor, shall seek the approval of all committee members and shall file the form with the Graduate Office no less than five working days before the exam. The Graduate Office will announce this information to the campus community.

The thesis defense oral examination will normally be held during the last 6 weeks of the student's last term, but it may be given at any time after the thesis has received committee approval. No final examination or thesis defense may be scheduled during the period of university final examinations.

The student's committee constitutes the examining board for a final oral examination. The major professor will head the session. The major professor is responsible for ensuring that a majority of the committee, as well as the Graduate Representative, is present. The examination will not be held if these conditions cannot be met. A negative vote by any two or more members of the student's committee or a negative vote by the Graduate Office representative will signify failure of the examination. All committee members must be given the opportunity for input to and evaluation of a written non-thesis final examination. Refer to the Graduate Office policies for information on committees and exam procedures for proprietary thesis programs.

Results of all written or oral examinations will be attested to by all committee members on a form furnished to the Graduate Representative by the Graduate Office. The original form with signatures and dates will be filed with the Graduate Office and a copy with the department/program. If the student passes with reservation or pending correction, a **copy** of the form will be filed with both offices. The originals will be filed with both offices, with the appropriate affirming signatures, when final corrections have been made and accepted.

If the candidate fails to satisfy the examiners on either coursework or thesis, written or oral examinations, the committee may schedule a re-

examination over general background, thesis, or both. The re-examination will be scheduled at the discretion of the candidate's advisory committee, normally 8 to 12 weeks after the date of the first examination. The student may petition his/her committee for re-examination prior to the eight week limit.

### **Participation in Commencement**

A student must apply to graduate by completing the Application for Graduation form on the Graduate Education website and must meet the program requirements before the degree is awarded. The Application for Graduation form also serves as a request to participate in the commencement ceremonies. In general, for each degree earned, a student is allowed to participate in commencement once and have his or her name in the commencement program once. Note that participation in the commencement ceremony does not equate to the conferring of a degree. The degree is conferred when all requirements are met and the release of diploma process is completed.

By default, the names of all students who have completed the requirements for graduation by the designated spring date will be included in the May program and students who have completed the requirements by the designated fall date will be included in the December program. The student's name will appear in the program in the semester of completion, whether the student is participating in the ceremony or not, except as noted below.

### **M.S. Candidates Participating in Commencement prior to Completion of all Requirements**

M.S. Students who will finish in August may request permission, in writing, to participate in May commencement and his or her name will appear in the May program. If the student is scheduled to graduate in August and does not participate in the May graduation, the student's name will, by default, appear in the December program and the student is welcome to participate in the December commencement ceremony.

Students who will complete the requirements for a degree after December but substantially before the end of the spring term may request

permission, in writing, to participate in December commencement and will be listed in the December program.

A student who wishes to participate in a commencement ceremony later than the semester in which the degree is completed must notify the Graduate Office of his or her intent prior to the end of the semester in which the degree requirements are met. In general, a student is allowed to participate in a commencement ceremony within one year of completing the requirements for the degree.

### **Time Limitation**

A Master of Science degree program must be completed within 5 calendar years dating from the student's formal entrance into a degree-seeking program. Courses taken by the student at any institution that are requested to be part of the degree program and that were taken more than five years prior to the date of anticipated graduation must be reviewed by the student's major department/program and the Dean of Graduate Education for possible acceptance. Following this review, the student's major department/program and the Dean of Graduate Education will determine whether a reduction in credits applicable toward the degree, a re-examination, or both is required for the student to complete his or her degree program. In exceptional circumstances, students may petition the Dean of Graduate Education for an extension to the 5 year time limit.

A student who is granted a Leave of Absence (see section on "Leave of Absence") will not be subject to continuing registration, and the leave of absence will not count toward the time limits to complete his/her program of study.



## **DOCTOR OF PHILOSOPHY PROGRAMS**

### **Nature and Purpose of the Doctoral Programs**

The doctoral program is designed to prepare a student for a lifetime of intellectual inquiry that manifests itself in creative scholarship and research, often leading to professional careers in social, governmental, business, industrial organizations, and academia. The program emphasizes freedom of inquiry and expression and development of the student's capacity to make significant contributions to knowledge. An essential element is the development of the ability to understand and evaluate critically the literature of the field and to apply appropriate principles and procedures to the recognition, evaluation, interpretation, and understanding of issues and problems at the frontiers of knowledge. These goals are most effectively accomplished in close association with those experienced in research and teaching.

A central purpose of doctoral programs is the extension of knowledge, but this cannot be accomplished on all fronts simultaneously. Students must choose an area in which to specialize, a faculty member with whom to work, and a research topic of mutual interest to the student and the faculty advisor. Individualized programs of study are then developed, and committee members are selected cooperatively as coursework and research are undertaken. When all coursework has been completed, the research finished, the dissertation written, and all examinations passed, the student will have acquired the knowledge and skills expected of a scholar and will have extended knowledge and research capability in the field.

### **Ph.D. Degree Requirements**

The requirements for the Doctor of Philosophy degree are:

1. Satisfactory completion of a Comprehensive Examination.
2. A minimum total of 80 semester credits beyond the bachelor's degree, 50 of which should be coursework credit hours. (A

maximum of 24 semester credits are allowed from appropriate M.S. coursework to apply to the Ph.D. credit requirement. See individual program requirements for further details.)

3. A minimum of 20 semester credit hours of appropriate research credits. A maximum of 6 semester credits of acceptable M.S. research credits can be applied to the Ph.D. research credits upon approval of a corresponding petition by the student's department/program and the Dean of Graduate Education.
4. Satisfaction of academic standards as prescribed elsewhere in this bulletin, including maintaining at least a 3.0 GPA.
5. At least two consecutive semesters of residence as a full-time student.
6. Satisfaction of any departmental language or other specific requirements.
7. A dissertation written in grammatical English that represents results from at least the equivalent of one academic year of full-time research.

Between three and four academic years of full-time graduate study beyond the baccalaureate degree normally are required to earn a doctorate.

A candidate who has entered a Ph.D. program directly from a Baccalaureate program may be allowed to use up to 12 credits of upper-division undergraduate 400-level courses (which have not been applied toward the Baccalaureate) toward the 50 credit-hour course requirement for the degree with the same restrictions and procedures as those specified for master's degrees.

Ph.D. candidates already holding an M.S. degree may use up to 6 credits of 400-level coursework toward the remaining 26 credit coursework requirement. (This assumes the student has applied 24 credits from an M.S. to the Ph.D. and must complete an additional 26 credits of coursework for a total of 50 credits.) The head of the student's major department must petition the Council on Graduate Education through the Dean of Graduate Education for use of 300-level credits for Ph.D. programs.

The Graduate Advisory Committee approves the total number of research credits that the candidate may carry, consistent with

departmental, continuing registration, and other requirements. The student's advisory committee can recommend to the Dean of Graduate Education a program requiring more credits than the minimum indicated above if it believes that this is in the best interests of the student.

Furthermore, the committee may approve a plan for the student to undertake work at some other institution of recognized standing, but may not reduce the two-semester residence requirement.

### **Residence Requirements**

At least 2 consecutive semesters of residence as a full-time student are required at South Dakota School of Mines and Technology. The comprehensive examination may not be taken before the last half of the second semester of residence. The final defense of the dissertation will not be permitted within the first five months following the successful completion of the comprehensive examination.

### **Supporting Fields**

In order to foster the principles upon which a Doctor of Philosophy degree is based, as set forth in the introductory paragraphs to this section on doctoral programs, a Ph.D. student and his/her advisory committee are strongly encouraged to formulate a program of study that comprises, minimally, one-quarter of the required coursework in minor or supporting fields. These courses may be completed in one or more departments in areas of study consistent with the student's major program. Because individual program requirements may exceed these minimum institutional guidelines, the student is urged to review carefully the curriculum for his or her field of study.

### **The Qualifying Examination**

Doctoral students admitted into all Ph.D. disciplines must pass a qualifying examination, normally to be taken no later than the second semester of residence. A master's student who proposes to continue into a doctoral program

should so advise his/her major professor. Thereupon, the student will be given an examination by the advisory committee to determine whether to permit the student to proceed to the doctoral level of graduate study. This qualifying examination may be scheduled in the semester during which it is expected that 36 hours of credit beyond the B.S. degree, (which are deemed acceptable toward the student's doctoral program) will be accumulated. The examination for the master's degree may be used as the forum for the qualifying examination, at the discretion of the department/program.

### **The Comprehensive Examination**

When the student's program of coursework has been substantially completed, he/she will undertake the comprehensive examination for admission to candidacy. This examination will consist of written and oral examinations covering his/her field of study and related subjects. It will be prepared by the student's advisory committee, with potential suggestions from any faculty member from whom the student has taken a graduate course.

The student's advisory committee schedules and arranges the written and oral examinations. Review of the examinations will be accomplished as soon as possible by all members of the committee, and the results will be reported to the Dean of Graduate Education on the appropriate form supplied by the graduate office.

Satisfactory completion of the comprehensive examination requires that no more than one member of the advisory committee votes against passing. If the student passes with conditions, such as failure to pass a part of the examination, the committee shall inform him/her promptly as to how and when the conditions may be removed. If, in the opinion of two or more members of the advisory committee, the student has failed the comprehensive examination, another such examination may not be attempted during the same semester. After failure to pass a second time, work toward the doctorate can be continued only with the consent of the advisory committee, the Council on Graduate Education, and the Dean of Graduate Education.

The comprehensive examination should normally be passed at least five months before the dissertation is defended.

### **Admission to Candidacy**

At least 4 months before the dissertation defense, the doctoral student should apply to his/her major professor for admission to candidacy on a form available from the graduate office. If the advisory committee and department head/program coordinator approve the application by certifying that the candidate has passed the comprehensive examination, the signed form must be returned to the Dean of Graduate Education who, in turn, will admit the student to candidacy.

### **The Dissertation**

It is expected that the dissertation will represent the culmination of at least the equivalent of one academic year of full-time research.

The dissertation need be of no specific length, but it must be written in grammatically proper English. It must also advance or modify knowledge and demonstrate the candidate's technical mastery of the field. The dissertation can consist of a compilation of three published and/or submitted journal manuscripts that are derived from the candidate's doctoral research and are either authored or co-authored by the candidate. Dissertations submitted in this form must have an introduction and conclusion to tie the journal papers into a cohesive research paper. The more conventional dissertation format is also acceptable if recommended by the candidate's major department and the major professor. The final dissertation must be accompanied by an abstract of 250 to 600 words and vitae of the candidate.

The dissertation and abstract shall be approved by all members of the student's advisory committee, and a preliminary acceptance page of the dissertation shall bear the signed initials of each member of the committee.

The final draft of the dissertation, after all revisions recommended by the committee have been made, must be signed by the student and approved and signed by the major professor, the

head/coordinator of the student's major department/program, and the Dean of Graduate Education before final reproduction. Signatures of other committee members are allowed but not required. The Dean of Graduate Education requires the final draft of the dissertation to be submitted to the graduate office by the published deadline, approximately 21 calendar days before graduation, to allow adequate time for review, corrections and revisions.

The institution requires 4 copies of the dissertation in final form: the original, unbound manuscript and 1 bound copy for the SDSM&T Devereaux Library; and 2 bound copies for the student's major department/program, 1 of which will be forwarded to the major professor. 2 digital versions should also be submitted in electronic format, 1 for the graduate office and 1 for the department. Contact the graduate office for guidance in regard to the required digital format.

A final draft of the dissertation must be submitted by the candidate to each member of his/her advisory committee a minimum of 2 full weeks before the scheduled dissertation defense. Earlier submission deadlines may be required by the advisory committee.

### **Defense of the Dissertation**

The defense of the dissertation is an oral examination open to the public except in proprietary programs. It will be scheduled at the convenience of the candidate's advisory committee at any time after the student has completed the required coursework and after the major professor is satisfied that the dissertation is an acceptable manuscript, both in terms of technical quality and proper expression. The student shall obtain and complete the graduate office form to schedule the defense, and in conjunction with the major professor, shall seek the approval of all committee members, and shall return the form to the graduate office no less than 5 working days before the defense date. The graduate office will announce the defense to the campus community.

While the student's committee determines the character and length of the examination, sufficient time should be devoted to a consideration of

matters relating to the dissertation to test thoroughly the ability of the candidate to defend his/her work. Questions will, in general, be confined to the dissertation and to background material related to it.

Satisfactory completion of the final examination requires a “pass” vote from the graduate office representative and no more than one “fail” vote from the other members of the advisory committee. If the student fails, another examination can be scheduled only with the approval of the student’s advisory committee and the Dean of Graduate Education.

### **Participation in Commencement**

A student must apply to graduate by completing the Application for Graduation form on the Graduate Education website and must meet the program requirements before the degree is awarded. The Application for Graduation form also serves as a request to participate in the commencement ceremonies. In general, for each degree earned, a student is allowed to participate in commencement once and have his or her name in the commencement program once. Note that participation in the commencement ceremony does not equate to the conferring of a degree. The degree is conferred when all requirements are met and the release of diploma process is completed.

By default, the names of all students who have completed the requirements for graduation by the designated spring date will be included in the May program and students who have completed the requirements by the designated fall date will be included in the December program. The student’s name will appear in the program in the semester of completion, whether the student is participating in the ceremony or not, except as noted below.

A Ph.D. candidate is expected to have successfully defended his or her dissertation and be substantially finished with all degree requirements by the designated date to participate in the hooding ceremony. A request to participate in commencement prior to completion of all requirements may be made to the Dean of Graduate Education.

A student who wishes to participate in a commencement ceremony later than the semester in which the degree is completed must notify the Graduate Office of his or her intent prior to the end of the semester in which the degree requirements are completed. In general, a student is expected to participate in a commencement ceremony within 1 year of completing the requirements for the degree.

### **Time Limitation**

If the requirements for the Doctor of Philosophy degree are not completed within a maximum period of 8 calendar years from the date of original enrollment in the doctoral program, the student’s program is subject to review by the staff of the student’s major department/program and the Dean of Graduate Education to determine whether a reduction in credits applicable toward the degree is justified before the student is permitted to proceed with the degree program. The procedures described under “Time Limitation” for M.S. degree candidates also apply here.

A student who is granted a Leave of Absence (see section on “Leave of Absence”) will not be subject to continuing registration, and the leave of absence will not count toward the time limits to complete his/her program of study.



## Atmospheric and Environmental Sciences Ph.D.



### Contact Information

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### Faculty

Professors Davis, Detwiler, Duke, Fontaine, Fox, Kenner, Mott, Price and Stetler; Associate Professors Capehart, Kliche, Riley, Stone, Sundareshwar and French; Instructor Farley; Adjunct Professors Stamm and Bothwell; Adjunct Research Scientist Bunkers; Emeritus Professors Helsdon, Hjelmfelt and Smith.

### Program Description

The Atmospheric and Environmental Sciences program aims to unravel the complex interactions between all the earth's components, such as the biosphere, the atmosphere and oceans, as well as the influence of human activity on the global environment. These interactions occur across many spatio-temporal scales and can profoundly affect the living organisms, the atmosphere around them and the ecosystem. The atmosphere and biosphere are fundamentally coupled on a variety of time-scales and support a complex set of bi-directional interactions. Managing wildfire potential, for example, includes components of atmospheric dynamics, precipitation patterns, vegetation distribution and condition, topographic factors, and more. Similarly, in terrestrial ecosystems, rapid exchange of CO<sub>2</sub>, water and energy between the atmosphere and the land

surface may dominate bi-directional interactions on short time-scales, whereas, on long time-scales, the interactions involve changes in ecosystem structure and composition in response to changes in climate. The key to success lies in training scientists to form interdisciplinary teams that can simultaneously tackle the broad range of processes needed to achieve understanding and prediction of such complex phenomena. Measuring, monitoring, and modeling earth and atmospheric systems increasingly demands an interdisciplinary approach, because problems in earth processes impacting society often cannot be solved by studying the atmosphere, hydrosphere, lithosphere, and/or biosphere in isolation.

The Atmospheric and Environmental Sciences program links expertise in atmospheric science, biogeochemistry, geology, hydrology, water quality and water resources to address regional and local issues that may also be nationally or globally significant. The fundamental objective lies in developing the predictive capability to address linkages between earth system components and land management practices in a way that benefits decision-making at regional and national levels. We use the Black Hills of South Dakota and the surrounding Great Plains as a natural laboratory for the development of methodologies to link fundamental observations of the environment across a range of temporal and spatial scales, and integrate them with state-of-the-art modeling, visualization, and analysis.

Key interrelated research themes drive the research and teaching program, building on ongoing research and disciplinary strengths already present at the School of Mines, including meteorology, biogeochemistry, ecology, geology, climatology, hydrology, remote sensing, and geographic information systems.

### **Specific examples include:**

- Physical meteorology and storm processes, including impacts on hydrology and fire issues.

- *In situ* atmospheric measurements of storms, aerosols, trace gas concentrations, and more using specially adapted storm-penetrating aircraft.
- Wildfire dynamics and associated issues related to fire prevention, suppression, and post-fire mitigation.
- Carbon cycling and the potential effects of local and regional climate change, including the frequency and severity of storms, drought cycles, and wildfire potential.
- Nutrient transformations in aquatic and terrestrial ecosystems, including Black Hills Forests and coastal salt marshes.
- Water quality and quantity as it impacts regional growth and environmental systems.
- A Geographic Information System (GIS) laboratory as well as IBM-compatible computers with modeling and remote sensing analysis software.
- The Museum of Geology, located on campus and housing over 300,000 specimens, serves as a resource for paleontological instruction.

Many School of Mines faculty members who are actively involved in the AES program have externally funded research projects. These projects provide research assistantship opportunities for AES students. In addition to graduate research assistantships, support is also possible through graduate teaching assistantships and various fellowships and scholarships. AES students are strongly encouraged to work with their advisors and faculty colleagues to apply for research funding or fellowships to support their studies.

### **Program Requirements**

Degree candidates in AES are expected to complete an approved multidisciplinary program of coursework and also perform original research in a focused area. A minimum total of 80 credit hours beyond the bachelor's degree is required.

Students entering the AES program with a previous M.S. degree in a relevant discipline are allowed to apply a maximum of 24 course credit hours in an appropriate field toward the course credit requirement and 6 thesis research credits toward the research-credit requirement. There is no language requirement in the AES program. However, all AES students are expected to be proficient in speaking, understanding, and writing the English language. Graduate students who are enrolled full time in the AES program should be able to complete their degree requirements and graduate within three to four years starting with a master's degree, and four to five years starting from a bachelor's degree. The time required to complete the degree will vary depending on the transfer of previously earned credits, coursework recommendations specified by the student's committee, and individual research requirements.

### **The following key learning outcomes will be developed in all students:**

- a. A core of basic and specialized scientific and technical knowledge;
- b. An understanding of the basic scientific tools of measuring, monitoring, and modeling;
- c. The ability to apply these tools to understand atmospheric, hydrologic and land-surface interactions;
- d. The professional skills crucial to research, including obtaining and reviewing research literature, proposing research problems, critically evaluating their own work and the work of others, and communicating in writing and orally with their colleagues;
- e. The understanding and application of professional methods and ethics in their work; and
- f. The ability to form interdisciplinary teams to solve complex problems.

Students entering the program will normally already possess a foundational degree (typically the M.S. degree) in atmospheric sciences, meteorology, geology, hydrology, or environmental sciences/engineering. Students will build on this foundation by pursuing elective courses that prepare them for advanced work in their chosen specialty. The student and his/her

committee are charged to prepare a course of study that will help the student become proficient in a specific research area. Great emphasis is placed on the independent origination of a research problem that will yield a new, original scientific insight.

**Ph.D. in Atmospheric and Environmental Studies** **Credit Hours**

M.S. academic core (24 cr) and research (6 cr)	30
Required academic courses	10
Elective academic courses	13
Research credits	27
<b>Total required for the degree</b>	<b>80</b>

**The required academic courses include:**

**AES 790 Seminar**

This course builds professional communication skills, including writing and oral presentation, while exposing students to examples of disciplinary and interdisciplinary research. (1credit)

**AES 792 Topics (Interdisciplinary Problems)**

This innovative course brings together faculty and students to create a working group that selects a research problem, studies the literature, and develops a research plan that integrates the multiple disciplines of all the participants. Students participate in this course for 1 credit in their first year, and repeat the course in the second year for two credits, taking a correspondingly greater role in the work of the group. This course is modeled after traditional disciplinary research working groups, but is intended to facilitate the emergence of cohesive interdisciplinary teams, and to provide an incubator for new research plans and funding proposals. (3credits)

**AES 808 Fundamental Problems in Engineering and Science**

This course trains students to identify and tackle fundamental research problems; it combines literature review, proposal development, critical thinking, and professional ethics, and leads to an actual proposal in the student's specialty for submission to a funding agency. (3 credits)

**Department Elective in Measuring/Modeling of Earth Systems**

Students must complete at least one course in measuring and/or modeling techniques, to be selected by the student's committee. An array of courses are offered at the School of Mines to fulfill this 3 credit elective course requirement. These courses are offered by the Departments of Civil and Environmental Engineering, Geology and Geological Engineering, Atmospheric Sciences, Chemistry, and Chemical and Biological Engineering, and Mathematics and Computer Sciences, and by other departments on campus as well. Listed below are examples of courses that might be included as electives in an AES program of study. These lists are intended as examples and are not intended to limit a student and committee as they construct an individual program.

**Potential elective courses for AES:**

- ATM 501 Atmospheric Physics
- ATM 506 The Global Environmental Change
- ATM 503 Biogeochemistry
- ATM 505 Air Quality
- ATM 515 Earth Systems Modeling
- ATM 519 Computing Methods in Atmospheric Sciences
- ATM 520 Remote Sensing for Research
- ATM 530 Radar Meteorology
- ATM 540 Atmospheric Electricity
- ATM 555 Synoptic Meteorology II
- ATM 560 Atmospheric Dynamics
- ATM 603 Biosphere-Atmosphere Interactions
- ATM 612 Atmospheric Chemistry
- ATM 625 Scaling in Geosciences
- ATM 643 Precipitation Physics and Cloud Modification
- ATM 644 Numerical Dynamics and Prediction
- ATM 660 Atmospheric Dynamics II
- ATM 670 Boundary Layer Processes
- ATM 673 Mesometeorology
- CEE 634 Surface Water Hydrology
- CEE 521 Environmental Systems Analysis
- CEE 526/526L Environmental Engineering Physical/Chemical Process Design
- CEE 527/527L Environmental Engineering Biological Process Design

CEE 528L Advanced Treatment Plant Design  
 CEE 533 Open Channel Flow  
 CEE 628 Environmental Engineering  
     Measurements  
 CEE/GEOE 692 Topics  
 CEE 739 Techniques of Surface Water  
     Resource and Water Quality  
     Investigations I  
 CEE 784 Modeling and Computation in Civil  
     Engineering  
 CEE 785 Applications of Finite Element  
     Methods in Civil Engineering  
 GEOL 516/L Introduction to GIS  
 GEOL 517 Geospatial Databases  
 GEOL519 Advanced Geospatial Analysis  
 GEOL 633 Sedimentation  
 GEOE 663 Ground-water Geochemistry  
 GEOE 682 Fluvial Processes

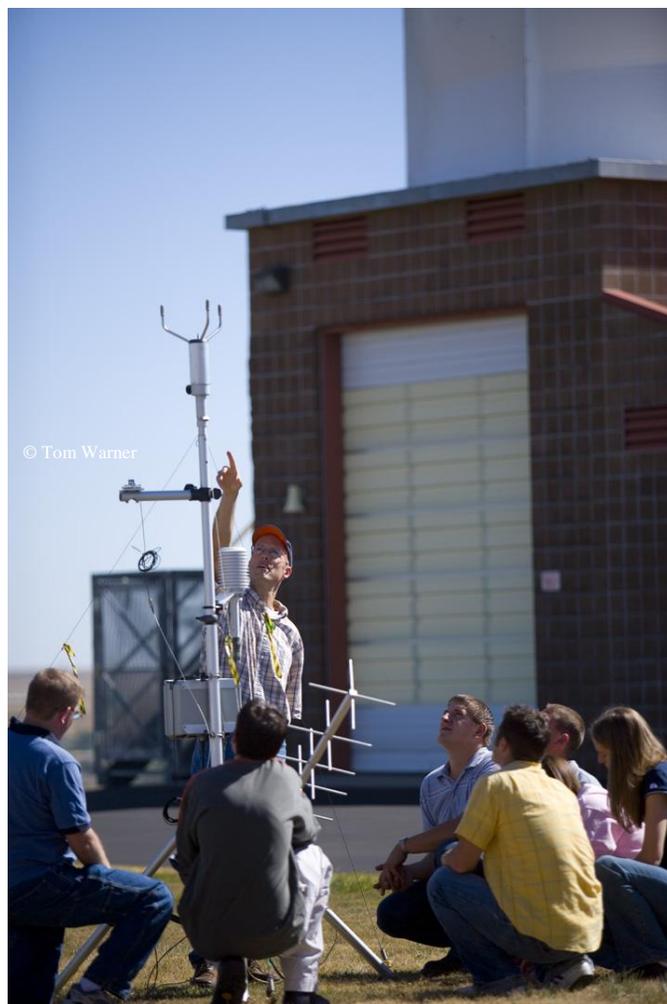
Student progress and mastery will be measured using the usual instruments in a doctoral program. A written or oral qualifying exam is used to assess the student's mastery of the M.S. coursework. A comprehensive examination is given to evaluate the student's ability to formulate a research problem based on substantive literature review, and to test the student's knowledge in the area of specialty. It is given in two parts: 1) a written examination consisting of a review paper in the student's field of study and a research proposal, and 2) an oral examination to evaluate the research proposal and verify the student's understanding of the basic sciences and specialized field of study. The dissertation forms the final test of the student's ability to perform and communicate research. The student must prepare a doctoral dissertation and successfully complete a public defense covering the scientific validity of the work, as well as the student's basic and specialized knowledge in the field of study.

### **Management of the AES Program**

The AES program is managed by the Graduate Office. A program committee composed of 3-5 faculty representing different disciplines oversees the program, including setting policies and reviewing the curriculum. The program committee will also take measures to facilitate interaction by all faculty and students

participating in the program. A program coordinator heads the program committee, and provides oversight of student affairs, including meeting with new and existing students, tracking student progress, and conducting orientations for new students.

The preceding committee is distinct from the graduate student advisory committees that provide guidance to individual AES students during the course of their academic studies. The graduate student's major professor serves as the head of this advisory committee.



## Atmospheric Sciences M.S.



### Contact Information

#### **Dr. Andrew Detwiler (Interim Head)**

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### Faculty

Professor Detwiler; Emeritus Professors Helsdon, Hjelmfelt and Smith; Associate Professors Capehart, Kliche, Sundareshwar and French; Instructors Clabo and Farley; Adjunct Professors Stamm and Bothwell; Adjunct Research Scientist Bunkers.

### Atmospheric Sciences

The Department of Atmospheric Sciences offers advanced undergraduate and graduate courses leading to the master of science degree in atmospheric sciences with specializations in meteorology or earth systems science, and the doctor of philosophy degree in atmospheric and environmental sciences (AES). For more information on the AES program, see page 162. Faculty in the Department of Atmospheric Sciences are members of the Institute of Atmospheric Sciences (IAS), an active research group that conducts research with sponsorship from the State of South Dakota and various

federal agencies.

The primary objective of the atmospheric sciences graduate program is to give students a basic understanding of the factors influencing atmospheric phenomena, including solar and terrestrial radiation, the laws of fluid motion and thermodynamics, microphysical and electrical processes in clouds, ecology, atmospheric chemistry, and biogeochemistry. Instruction is offered in the interpretation of conventional weather, satellite and radar data; observations collected by specially instrumented aircraft; and output from numerical models of atmospheric processes. The graduate student is expected to carry out original research in the atmospheric sciences using some of these tools and resources. In addition, the student must successfully complete the coursework and program requirements enumerated below.

A student applying for admission to the master's degree program in the Department of Atmospheric Sciences should have a baccalaureate degree in meteorology or atmospheric sciences, one of the biological or physical sciences, earth system sciences, mathematics, or engineering. It is desirable for applicants to have received undergraduate credit for mathematics through Calculus 2 (for the earth systems science specialization — see below) or ordinary differential equations (for the meteorology specialization). For the meteorology specialization, undergraduate physics is required, and for the earth systems specialization, undergraduate physics and chemistry are desirable. Experience with computer programming is recommended. Graduate Record Examination (GRE) scores from the General Test are required for all students except School of Mines graduates. TOEFL scores are required of all applicants from colleges outside the U.S.

### Course requirements for the M.S. degree

1. Fifteen credit hours of coursework in atmospheric sciences at the 500-level or above.
2. Nine additional credit hours of non-atmospheric sciences electives at the 400-level or

above (300-level non-atmospheric sciences courses can be accepted if approved by the Graduate Education and Research Council), or atmospheric sciences electives at the 500-level.

3. Thesis research — 6 credit hours. (Please note undergraduate credit limitations given under “Advanced-Degree Grade Requirements” (p. 146) for master of science degrees.)

### **Other program requirements**

The following program requirements apply to all students in atmospheric sciences:

- At least one course at the 500/600-levels must be taken in each of the following core areas: meteorology, earth system science, and techniques. Course descriptions in the catalog describe the area to which each ATM course belongs.
- Satisfactory performance on a general coursework exam covering each of the core courses as well as selected elective coursework.
- Registration in ATM 700 Graduate Research (thesis) each semester the student is receiving an assistantship.
- Registration in ATM 690 Graduate Seminar each spring semester.
- Completion of a master’s thesis. The thesis must adhere to the format and content guidelines as set forth by the graduate school, and be approved by the student’s graduate advisory committee and the Dean of Graduate Education.

In addition, there are requirements specific to the two ATM M.S. specializations. Each student will choose one of these specializations. The requirements are:

### **Meteorology Specialization**

Students entering the program with a bachelor’s degree in fields outside of atmospheric sciences or meteorology must take the following courses: ATM 450 – Synoptic Meteorology I (not for graduate credit), ATM 501 – Atmospheric Physics, ATM 555 – Synoptic Meteorology II, and ATM 560 – Atmospheric Dynamics I. Any additional coursework can be determined by student’s graduate committee.

Students entering the program with a bachelor’s degree in atmospheric sciences or meteorology, and having taken the equivalent of AATM 450, ATM 4/555 and ATM 560, are required only to take ATM 501 (Atmospheric Physics). Students having taken ATM 401/501 at SDSM&T for their undergraduate program of study are not required to take ATM 501 for their graduate program. The course equivalencies to ATM 450, ATM 4/555 and ATM 560, and/or additional requirements will be assessed by the student’s graduate committee.

### **Earth System Science Specialization**

All students will be required to take the following course: ATM 603 - Atmosphere-Biosphere Interactions. They also must complete at least one remote sensing course.

### **Program of Study**

A specific plan of study will be determined on an individual basis with concurrence from the student’s advisor and graduate advisory committee members. In either specialization, exceptions to these departmental requirements may be granted by the student’s committee for good cause.

Elective courses offered by other departments are encouraged as long as the 15 hours of coursework in atmospheric sciences at the 500-level or above are completed as outlined in course requirements for M.S. degree. Graduate students may take electives in the fields of physics, mathematics, computer science, chemistry, engineering, engineering management, social sciences, or the humanities to further integrate their coursework in the atmospheric sciences with knowledge in other technical fields and with the general concerns of society.

A student may choose the meteorology specialization with the intent to qualify for employment in the federal civil service as a meteorologist. Specific course distribution requirements for these requirements are listed on page 62 earlier in this catalog within the general description of the Department of Atmospheric Sciences. Students in either specialization may pursue an M.S. degree in atmospheric sciences without satisfying these requirements and be qualified for careers in many non-federal and/or non-meteorological careers. Examples of such career options include research in and applications of remote sensing techniques; work in air quality either for non-federal government agencies, or for industry or the consulting firms industries often employ; research and applications in the environmental sciences with an emphasis on atmospheric issues, and further graduate work in atmospheric or environmental sciences.

Undergraduate students at School of Mines may decrease the time required to obtain a master of science degree in atmospheric sciences by taking as electives the preparatory undergraduate and entry-level graduate courses available to them or by completing the bachelor of science in interdisciplinary sciences program with an emphasis on atmospheric sciences. They may then enter the graduate program with the necessary background for graduate study in atmospheric sciences as above.

### **Facilities and Resources**

Students typically work directly with faculty on externally-funded research projects. Graduate research assistantships associated with these projects are available that provide part-time employment for students during the academic months and possible full-time employment during the summer. Facilities and resources of the IAS are utilized in these research efforts. These facilities comprise various meteorological instrument platforms and packages including several automated surface weather stations and a laser optical distrometer. Sophisticated computer facilities are available on campus, including a state-of-the-art 3-D computer visualization facility and a high-performance multiple-node computer

cluster, with additional access to the larger computer complexes elsewhere.

### **Faculty Research**

Current research projects include field investigations of thunderstorms; applications of weather radar data to rainfall measurements and remote inference of cloud microphysical characteristics; numerical modeling of clouds ranging in size from small cumulus to severe storms including storm electrification, lightning, and lightning-influenced atmospheric chemistry; analysis of field observations and numerical simulations of complex surface ecosystems; land-surface hydrology; satellite remote sensing; land-surface/atmosphere exchange processes; fire weather prediction and modeling; biogeochemical cycling; and carbon sequestration and ecological modeling. In addition, IAS scientists are currently involved in activities to disseminate scientific knowledge to wider audiences and improve and enhance scientific literacy and educational opportunities for the people of South Dakota.

## Biomedical Engineering M.S. and Ph.D.



### Contact Information

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### Advisory Council

Professors Bang, Buck, Kalanovic, Kerk, Kjerengtroen, Korde, Langerman and Weiss, Associate Professors Medlin and Muci; Assistant Professors Fong, Yoon and AML lab-Sears.

### Biomedical Engineering

Offered jointly with University of South Dakota (USD).

Biomedical engineering (BME) is concerned with the application of engineering and science methodologies to the analysis of biological and physiological problems and to the delivery of health care.

The biomedical engineer serves as an interface between traditional engineering disciplines and living systems and may work in either direction, applying the patterns of living organisms to engineering design or engineering new approaches to human health.

Both the master of science and doctor of philosophy degrees are cross-disciplinary degrees. The objective of the M.S. program is to prepare a

student for research and development careers in biomedical industry and further research at the doctoral level. The Ph.D. program will prepare a student for a career as a researcher who advances the frontiers of biomedical science and engineering with attention to generating new ideas for commercialization.

Current focus areas of faculty activity within the program are (1) cardiovascular mechanics, pathology, and devices (heart valves, stents, etc.), (2) biomaterials (nanomaterials, bioadhesives, tissue engineering, etc.), (3) computational biomedical engineering (biomechanics, imaging, advanced modeling/simulations, etc.), and (4) assistive technology/rehabilitation engineering (advanced prosthetics, control, biomimetics, etc.). Students in the programs will be associated with one or more of several existing and newly formed research centers and laboratories, e.g., the Cardiovascular Research Institute, the Center for Accelerated Applications at the Nanoscale, the Center for Development of Light Activated Materials, the Computational Mechanics Laboratory, or the Direct Write Technology Laboratory.

The program is administered by the Dean of Graduate Education with input from the program coordinator, who is advised by the program advisory council. The program advisory council is comprised of faculty from the mechanical, materials science and metallurgical engineering, electrical and computer engineering, chemistry, and mathematics and computer science departments.

Admission to the programs will be based on the established graduate admission standards at the South Dakota School of Mines and Technology. The Graduate Record Examination (GRE), three letters of recommendation, and a GPA of 3.00 or better are expected of all applicants for the Ph.D. program. The TOEFL exam is required for students whose native language is not English. Students seeking exceptions warranted by special circumstances are requested to contact the biomedical engineering graduate program coordinator.

Students completing their M.S. degrees will graduate with a high level of competence in

- understanding of cardiovascular systems and devices;
- the application and characterization of various forms of biomaterials;
- the acquisition and processing of medical signals and images;
- the computation and simulation of phenomena in biomechanical systems; and
- transferring their understanding of biomaterials, biomechanics, and signal processing to the creation of new applications.

Students completing their Ph.D. degrees will graduate with a higher level of expertise in transferring their understanding of one of the program focus areas—cardiovascular mechanics/pathology/devices, biomaterials, computational biomedical engineering, or rehabilitation engineering/assistive technology to the creation of new knowledge and applications.

In addition, doctoral students will possess a high level of expertise in their specialized area of research. This competency will be developed through focused research objectives which culminate in the doctoral dissertation. Graduates of the programs will also demonstrate

- the ability to communicate effectively in written and oral presentations,
- intellectual honesty when working with data and ideas, and
- the ability to make an original contribution to their fields.

Courses are offered at both School of Mines and USD campuses, and students may elect either campus as their campus of residence. Courses offered at School of Mines are relayed to students resident at USD by video, and vice versa.

Students entering with baccalaureate degrees in biomedical engineering are required to take the courses listed in the table (Group A) below.

**Group A** (Required Courses for students entering with a B.S. in BME)

Course #	Course Title	Credits
BME 603	Molecular Biology for Engineers	3

BME 673 <sup>1</sup>	Engineering Analysis I	3
BME 773 <sup>2</sup>	Engineering Analysis II	3
BME 790	Seminar	1
BME 798	Thesis (M.S. students)	6
BME 896	Field Experience (Ph.D. students)	1
BME 898	Dissertation (Ph.D. students)	30

Students entering with baccalaureate degrees in engineering disciplines other than biomedical engineering are required to take the courses listed in the table below (Group B). Depending on the student's background, the student's advisory committee may recommend that one or more of the required courses below be substituted by course(s) listed in the elective courses category.

**Group B** (Required courses for students entering with a B.S. in a non-BME engineering discipline)

Course #	Course Title	Credits
BME 601	Biomaterials	3
BME 602	Anatomy and Physiology for Engineers	3
BME 603	Molecular Biology for Engineers	3
BME 604	Sensing and Signal Processing	3

**One of the following two:**

BME 606	Occupational Biomechanics	3
BME 607	Biomechanics 3	
BME 673 <sup>1</sup>	Engineering Analysis I	3
BME 773 <sup>2</sup>	Engineering Analysis II	3
BME 790	Seminar	1
BME 798	Thesis (M.S. students)	6
BME 896	Field Experience (Ph.D. students)	1
BME 898	Dissertation (Ph.D. students)	30

Elective courses in the area of the student's intended research are to be selected in consultation with the student's advisory committee. These courses are listed in the Group C table below. The number of Group C elective courses required will depend on the student's background and educational goals, as summarized below.

## Elective Course Requirements

M.S.: Five Group C courses for those entering with a B.S. in biomedical engineering; one Group C course for those entering with a B.S. in a non-biomedical engineering program.

Ph.D.: Six Group C courses including one Special Topics course, and seven additional engineering or Group C courses; for those entering with a B.S. in biomedical engineering. Nine Group C courses including one Special Topics course for those entering with a B.S. in a non-biomedical engineering program.

Minimum of six Group C courses along with additional Group B and C courses for those entering with an M.S. degree. An additional 21 credits of prior graduate level coursework may be applied toward the Ph.D. program at the discretion of the student's advisory committee.

### Group C (Elective Courses)

Course #	Course Title	Credits
<b>Biomaterials Area</b>		
BME 721 <sup>3</sup>	Tissue Engineering	3
BME 724	Biopolymers	3
BME 725	Biocomposites	3
BME 726	Bio/MEMS and Nano Systems	3
BME 730	Vascular Mechanics/Pathology	3
BME 751	Drug Delivery	3
BME 761	Bioadhesives	3
BME 792	Topics	4
BME 792	Topics	3
<b>Computational Biomedical Engineering</b>		
BME 730	Vascular Mechanics/Pathology	3
BME 731	Advanced Biomechanics	3
BME 732	Medical Imaging	3
BME 733	Cardiovascular Fluid Dynamics	3
BME 734	Transport Phenomena in Biomedical Engr.	3
BME 735	CAD/CAM in Medicine and Surgery	3
BME 737	Advanced Signal Processing and Imaging	3
BME 761	Bioadhesives	3
BME 738	Information Technology	3

	in Medicine	3
BME 792	Topics	4

### Rehabilitation Engineering /Assistive Technology Area

Course #	Course Title	Credits
BME 732	Medical Imaging	3
BME 745	Molecular Machines	3
BME 737	Advanced Signal Processing and Imaging	3
BME 738	Information Technology in Medicine	3
BME 735	CAD/CAM in Medicine and Surgery	3
BME 761	Bioadhesives	3
BME 792	Topics	4

Graduate courses from another university or from a related engineering discipline 21 credits (max)

### Curriculum Notes

<sup>1</sup>May substitute: ME 673.

<sup>2</sup>May substitute: ME 773.

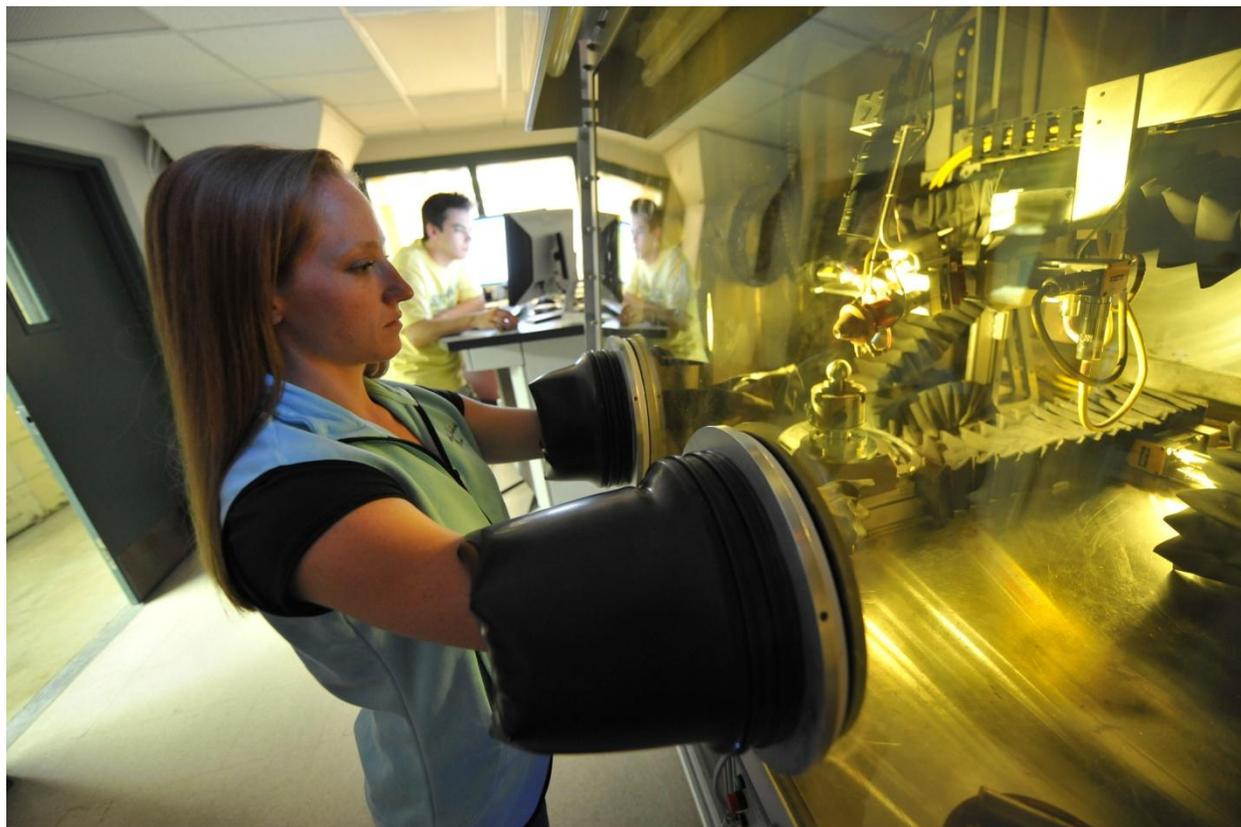
<sup>3</sup>Offered by USD.

The details of individual tracks can be discussed with the program director. An assessment of the student's qualifications will be undertaken early in his or her program. The assessment comprises preliminary and qualifying examinations. Additional information is available in the Handbook of Biomedical Engineering.

Each student is also required to pass a comprehensive examination. There is no language requirement for the BME Ph.D. program.

For program supervision purposes, the BME graduate program coordinator is the graduate advisor until the major professor is appointed. The major professor is the person responsible for the student's dissertation research. The graduate office representative on the student's dissertation committee must be selected from outside of the department with which the major professor is affiliated, and also is to be a member of the BME advisory council. Each program of study must be approved by the BME advisory council. It is not necessary that the student be associated with the department of his or her major professor.

Detailed information on examination policy, admission to candidacy, and defense of dissertation is included in the South Dakota School of Mines Biomedical Engineering M.S./Ph.D. Handbook.



## Chemical and Biological Engineering Ph.D.



### Contact Information

#### **Dr. David J. Dixon**

Department of Chemical and Biological  
Engineering  
Chemistry/Chemical Engineering Bldg C222  
(605) 394-1235 Fax: (605) 394-1232  
Dept: (605) 394-2421  
E-mail: [David.Dixon@sdsmt.edu](mailto:David.Dixon@sdsmt.edu)  
<http://cbe.sdsmt.edu>

### Faculty

Professors Bang, Dixon, Puszynski, Salem and Winter; Associate Professors Christopher, Gilcrease and Menkhaus; Assistant Professors Benjamin, Hower, Sani and Shende.

### Program Advisory Council

Professors Bang, Dixon, Puszynski (Program Coordinator) and Winter; Associate Professor Gilcrease; Assistant Professor Benjamin.

### Chemical and Biological Engineering

The Department of Chemical and Biological Engineering (CBE) offers, in addition to B.S. and M.S. degrees in chemical engineering, a Ph.D. degree in chemical and biological engineering. The Ph.D. program provides the chemical and biological engineering Ph.D. graduate a core educational experience in transport phenomena, chemical kinetics, biochemical engineering,

chemical thermodynamics, and biotechnology. This knowledge base, along with key electives, provides graduate students the training to participate in biochemical and petrochemical processing, bio-based energy technologies, including biomass and biofuels; catalysis; bio-based and bio-compatible materials; bioremediation; emerging energy technologies; synthesis and functionalization of nanomaterials, and processing of polymers and composite materials. These areas are aligned with the expertise of our faculty members. The current research interest of the faculty can be found on the departmental website <http://cbe.sdsmt.edu>.

The State of South Dakota is recognized as a leader and major producer of ethanol from starch in the United States. Hence the State of South Dakota is well positioned to play an important role in development of new bio-based technologies and value-added agricultural products. This Ph.D. program directly supports the recently established **National Science Foundation Industry/University Cooperative Research Center (NSF I/UCRC) for BioEnergy Research and Development (CBeRD)**. This unique national center focused on bio-based energy and chemical feedstocks, is comprised of five universities, including the SDSM&T, North Carolina State University, Kansas State University, State University of New York - Stony Brook, University of Hawaii, and more than 30 industries and state and federal laboratories. Students participating in CBeRD I/UCRC Center research will be working on projects of current and immediate interest to the industrial sponsors. Students also have the opportunity to participate in more fundamental research being pursued through the **2010 Center for Bioprocessing Research and Development (CBRD)** at the South Dakota School of Mines and Technology and the South Dakota State University. The CBRD center focus is to develop the fundamental understanding and technologies to convert lignocellulose to fuels and key building block chemicals. The research foci of the of these two research centers — pretreatment, conversion, extremophiles, separations, and process simulation and economic analysis — relies on the fundamental underpinnings taught in the

Chemical and Biological Engineering Ph.D. program.

The Ph.D. program is also a strong supporter of State-focused areas in advanced materials, polymers, composites, and nanotechnology. The **Composites and Polymer Engineering Laboratory (CAPE)** is a key resource utilized by our students <http://cape.sdsmt.edu/>. Opportunities exist for CBE Ph.D. students to participate in cutting-edge research funded by the National Science Foundation, the Department of Energy, the Department of Defense, and industrial collaborators.

The Ph.D. Program in chemical and biological engineering is administered by a graduate Program Coordinator and Program Advisory Council consisting of appointed faculty members actively involved in the program. The Program Advisory Council is responsible for the curriculum and program policies.

## Curriculum

The current curriculum is designed to provide the CBE Ph.D. graduate with the depth and breadth of engineering knowledge to become a leader in their chosen focus area. To facilitate this, each student is asked to complete a program of study plan that will provide the framework for the student's coursework and research. This should be filed with the Program Coordinator before the midterm of the second semester in residence. The CBE Ph.D. Advisory Council must approve all programs of study. Detailed information on examination policy, admission to candidacy, and defense of dissertation are included in the Chemical and Biological Engineering Ph.D. Program Handbook.

Students entering the program with B.S. or M.S. degrees from disciplines other than Chemical or Biochemical Engineering will be required to take several selected courses in Chemical Engineering at the undergraduate level, to provide a firm understanding of engineering principles.

The Graduate Record Examination (GRE), three letters of recommendation, and a GPA of 3.00 or better are required of all applicants for the

Ph.D. program. The TOEFL exam is required for students whose native language is not English.

All CBE Ph.D. candidates are required to successfully complete the required minimum credits and earn a grade of "C" or better, except for a final grade of "S" in CBE 898. However a 3.00 GPA must be maintained to receive graduate research assistantships (GRA).

Below is the summary of the basic required courses:

Category	Credits
Required courses <sup>1</sup> (minimum 6 credits from Chemical Engineering and 6 credits from Biological Engineering focus areas)	24
Required seminar	2
Minimum required research credits	30
Minimum electives <sup>1,2</sup>	12
<b>TOTAL</b>	<b>80</b>

<sup>1</sup> Students entering with a M.S. degree in Chemical Engineering or a closely related discipline may apply a maximum of twenty-four (24) course credit hours toward the required and elective course requirements subject to approval of the Chemical and Biological Engineering Ph.D. Program Advisory Council.

<sup>2</sup> Elective courses can be selected from other SDSM&T courses as a part of a student's program of study, subject to approval of his/her major professor and graduate committee.

### Required courses (focus area — Chemical Engineering)

CBE 544	Reactor Design	3
<b>OR</b>		
CBE 728	Heterogeneous Kinetics	3
CBE 550	System Analysis Applied to Chemical Engineering	3
CBE 612	Transport Phenomena: Momentum	3
CBE 613	Transport Phenomena: Heat	3
CBE 621	Advanced Chemical Engineering Thermodynamics I	3
CBE 616	Computations in Transport Phenomena	3
CBE 714	Transport Phenomena: Mass	3

**Required courses (focus area — Biological Engineering)**

CBE 584	Fund. of Biochemical Eng.	3
CBE 584L	Biochemical Engineering Lab	3
CBE 735	Bioseparations	3
CBE 792	Topics	3

**Required courses (Seminar and Research)**

CBE 890	Graduate Seminar	1
CBE 898D	Dissertation	1-9

**Example elective courses**

CBE 791	Independent Study	1-3
CBE 792	Topics	1-3
CBE 890	Graduate Seminar	1
CBE 894	Adv. Tech Internship	1-6
CBE 574L	Experimental Polymer Tech.	1
CBE 574	Polymer Technology	3
CHEM 560	Biochemistry	3
CHEM 582	Environmental Chemistry	3
MES 712	Interfacial Phenomena	3
NANO 701	Nano Materials	3
ENGM 631	Optimization Techniques	3
ENGM 720	Statistical Process Control	3

## Chemical Engineering M.S.



### Contact Information

#### **Dr. David Dixon**

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Chemistry/Chemical Engineering Bldg. C222

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E-mail: [David.Dixon@sdsmt.edu](mailto:David.Dixon@sdsmt.edu)

<http://cbe.sdsmt.edu>

### Faculty

Professors Bang, Dixon (Program Coordinator),  
Puszynski, Salem and Winter; Associate  
Professors Christopher, Gilcrease and Menkhaus;  
Assistant Professors Benjamin, Hower, Sani and  
Shende.

### Chemical Engineering

The Department of Chemical and Biological Engineering offers programs of study leading to the master degree in chemical engineering (ChE). Students may consider either a thesis or non-thesis executive program option. A student who elects the thesis option will be required to present a thesis based upon an original investigation for which 6 credits must be earned toward a total requirement of 30 credits in an approved program of study. For the non-thesis executive program option, a student must earn 32 credits in an approved program of study and complete a special project. In the non-thesis executive program, which is oriented primarily toward industrial needs, students take at least one course in

technology management as part of their required courses for the M.S. in chemical engineering.

Chemical engineers with a M.S. degree obtain graduate education that provides them with an in-depth understanding of the chemistry, mathematics, and physical laws describing systems at both molecular and macroscopic levels. With this knowledge, the chemical engineer can participate in interdisciplinary research, development, and implementation of new and improved technologies in areas such as: biotechnology, catalysis, nanotechnology, chemical technology, energy, environmental processes, as well as manufacturing of high-performance materials for electronic and structural applications. A student who does not have a bachelor's degree in chemical engineering will be expected to take several additional undergraduate chemical engineering courses to provide a solid ChE foundation. The current research interest of the faculty can be found on the departmental website at: <http://cbe.sdsmt.edu>.

A core curriculum for all M.S. candidates in chemical engineering includes the following courses or approved substitutions:

CBE 550	Systems Analysis Applied to Chemical Engineering	3
CBE 612	Transport Phenomena: Momentum	3
CBE 613	Transport Phenomena: Heat	3
CBE 621	Advanced Chemical Engineering Thermodynamics I	3
	Kinetics Elective <sup>1</sup>	3
	Applied Computation Elective <sup>2</sup>	3
CBE 790	Seminar	1

<sup>1</sup>Kinetics Elective: CBE 544 or MES 728

<sup>2</sup>Applied Computation Elective: CBE/ME 616, MATH 432, IENG 486, and ATM 519/519L

In addition to the core curriculum, students pursuing the non-thesis option must complete a minimum of 2 credits of non-thesis research, CBE 788, 3 credits in engineering management, and 8 credits of chemical engineering approved electives. Students pursuing the thesis option are required to complete, in addition to the core

curriculum, a minimum 6 credits of thesis research, CBE 798, and 5 credits of chemical engineering approved electives.

An oral thesis defense for the thesis degree or oral project examination for the non-thesis degree, as well as final examination in the field of chemical engineering, are required prior to the completion of the graduate study.



*Mines Matters:* The new Chemical and Biological Engineering and Chemistry Building incorporates state-of-the art graduate and undergraduate research space. This new facility will foster the growth of rapidly-emerging technologies, such as ethanol, fuel production, food and agricultural processing, and environmentally-friendly plastics and coatings.

## Graduate Studies in Chemistry

### Contact Information

**Dr. Michael Gunn (Interim Head)**  
Department of Chemistry  
Chemistry/Chemical Engineering 220  
(605) 394-1241  
E-mail: [Michael.Gunn@sdsmt.edu](mailto:Michael.Gunn@sdsmt.edu)

### Faculty

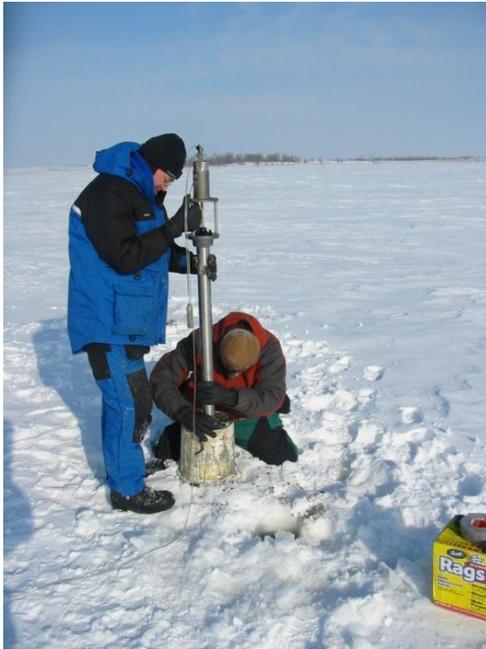
Professor Boyles; Associate Professors Fong and Heglund; Assistant Professors Meyer, Smirnova and Zhu; Instructors Christofferson, Filipova and Marshall.

## Chemistry

Students interested in pursuing graduate studies in chemistry should consider the following programs in which the faculty of the Department of Chemistry participate: M.S. and Ph.D. in Biomedical Engineering, and Ph.D. in Nanoscience and Nanoengineering.



## Civil Engineering M.S.



### Contact Information

#### **Dr. Scott Amos, Graduate Coordinator**

Department of Civil and Environmental  
Engineering, Civil/Mechanical 118  
(605) 394-1694  
E-mail: Scott.Amos@sdsmt.edu

### Faculty

Professors Amos, Bang, Fontaine, Gribb, Hansen, Kenner and Mott; Associate Professors Stone and Surovek; Assistant Professors Arneson-Meyer, Benning, Fick, Nam and Robinson; Distinguished Professor Emeritus Ramakrishnan; Professors Emeritus Hovey, Iyer and Preber; Associate Professor Emeritus Klasi.

### Civil Engineering

The Department of Civil and Environmental Engineering offers graduate coursework and research opportunities leading to the Master of Science degree in civil engineering in the following emphasis areas: advanced materials, construction management, environmental, geotechnical, water resources, and structural engineering. Students may specialize or take courses from several areas.

2011-2012 Catalog

### **Background Requirements**

A GPA of 3.00 or better is required of all applicants for the MSCE program. The Graduate Record Examination (GRE) is required of all applicants except School of Mines graduates. The TOEFL exam is required for students whose native language is not English.

All incoming students are expected to present a full year each of college-level calculus, physics, and chemistry as part of their undergraduate record. Deficiencies in these areas must be remedied by taking the necessary coursework prior to, or in the first year of enrollment in the graduate program.

All incoming students, including those without a BS degree in civil engineering, are also expected to have completed courses in, or to develop proficiency in, the appropriate background courses for their intended emphasis area. Additional subjects may be required by the students' graduate committee depending on the student's area of concentration. The student and the graduate committee will arrange in writing how these requirements can best be met. These requirements will be a formal component of a student's program of study.

### **Curriculum**

All rules and regulations of the graduate office, included elsewhere, apply to candidates for the degree of Master of Science in civil engineering. Both thesis and non-thesis options are available. All MSCE students are required to attend the CEE graduate student seminar series.

### **Thesis Option**

The MSCE thesis degree option consists of program of graduate coursework and thesis research. Candidacy for the MSCE degree with thesis is contingent upon an aptitude to do research. Students are accepted into the MSCE thesis option on the recommendation of a major professor. A written thesis proposal and public presentation is required.

The requirements for the MSCE thesis degree are as follows:

1. A program of at least 30 credit hours of coursework and research.
2. At least 15 credit hours of approved graduate coursework (500 level courses and above) to include Research Methods (CEE 500). Independent study (CEE 691) and Non-thesis Research (CEE 788) are not applicable toward the thesis option.
3. At least 6 credit hours of thesis research. No more than 6 credit hours of thesis research will count toward degree requirements.
4. A satisfactory thesis based upon individual research.
5. Meeting or exceeding prescribed academic standards.
6. Passing an oral examination on general knowledge and successfully defending the thesis.

- Life cycle assessment to prepare agricultural processes for a carbon-constrained and sustainability-aware marketplace.
- Developing self-healing concrete.
- Developing pervious concrete to reduce runoff to streams and rivers.
- Analyzing river systems to characterize fisheries habitat.
- Determining the fate and transport of mercury within airsheds and water bodies.
- Characterizing arsenic transport in mining-impacted waterways.

Students are encouraged to contact individual faculty members to discuss potential thesis topics and availability of research assistantships.

### **Non-thesis Option**

The non-thesis MSCE degree consists of a program of graduate coursework. A project is not required. The requirements for the MSCE non-thesis degree are as follows:

1. A program of at least 32 credit hours of coursework, of which no more than 3 credits may be from CEE or CM 691, 788, 790, 791, 798, or CP 697.
2. At least 20 credit hours of approved graduate coursework (500 level courses and above).
3. Meeting or exceeding prescribed academic standards.
4. Passing a written examination on general knowledge in the field (CEE 788).

### **Research**

Our faculty have established reputations of excellence and provide you with exciting opportunities for making your own contribution to cutting-edge research projects such as:

- Predicting the response of structures to fire, blast, and other extreme loads.
- Developing stronger, lighter, and more corrosion resistant components for aircraft systems.
- Developing geo-biological dust control techniques for construction or waste sites.

## **Graduate Studies in Computer Engineering**



### **Contact Information**

#### **Dr. Kazem Sohraby**

Department of Electrical and Computer Engineering

Electrical Engineering/Physics 311

(605) 394-1219

E-mail: [Kazem.Sohraby@sdsmt.edu](mailto:Kazem.Sohraby@sdsmt.edu)

### **Computer Engineering**

Students interested in pursuing graduate studies in communications and applied electromagnetics; digital computers, embedded systems and VLSI, and power and control systems, please see electrical engineering.

Students interested in pursuing graduate studies in robotics please see Robotics and Intelligent Autonomous Systems page 213.

## Graduate Studies in Computer Science

### Contact Information

**Dr. Kyle Riley** Department of Mathematics  
and Computer Science  
McLaury 308  
(605) 394-2471  
E-mail: [Kyle.Riley@sdsmt.edu](mailto:Kyle.Riley@sdsmt.edu)

### Faculty

Professors Corwin, Logar and Weiss; Associate Professor McGough; Assistant Professor Qiao; Instructor Schrader; Emeritus Professors Carda, Opp and Weger.

### Computer Science

Students interested in pursuing graduate studies involving artificial intelligence, computer vision, pattern recognition and robotics, please see the masters of science program in Robotics and Intelligence Autonomous Systems page 209.



## Construction Management M.S. Construction Management Certificate



### Contact Information

#### **Dr. Scott Amos**

Department of Civil and Environmental  
Engineering

C/M 118

(605) 394-1694

E-mail: [Scott.Amos@sdsmt.edu](mailto:Scott.Amos@sdsmt.edu)

### Construction Management

The Master of Science in Construction Management (MSCM) degree and Construction Management Certificate are designed to provide programs of advanced study for candidates anticipating a managerial career in the construction industry. In addition to course delivery in a hybrid distance mode, flexibility is built into the program to provide an optimum educational experience to students.

#### **Background Requirements**

The construction management coursework is geared towards the working professional, although many students also enter the program immediately after completing an appropriate undergraduate degree. The successful applicant will have a background in business, science, engineering, technology or a related field. Most applicants to the program will have academic backgrounds in the traditional disciplines of civil, electrical, mechanical, architectural, or industrial

engineering. At least one semester of calculus and a course in probability and statistics are highly recommended.

Practicing engineers or students seeking to enhance their marketability for upper-level management positions in various construction related industries may be initially interested in the certificate in Construction Management. Further studies will lead to the Master of Science (MS) degree in Construction Management.

#### **Curriculum**

The 32 hour non-thesis MSCM degree consists of a program of graduate work culminating in a final exam to demonstrate readiness for professional practice. The interdisciplinary curriculum includes an 18-hour core of construction management oriented courses, up to 12 hours of technical electives, and two hours for research or preparation for the professional practice exam allowing a candidate's program of study to reflect both individual interests and career goals. A project is not required and normally is not encouraged for the MSCM non-thesis degree.

The requirements for the MSCM degree are as follows:

1. A program of at least 32 credit hours of coursework, of which no more than 3 credits may be CM 691, 791, or CP 697.
2. At least 20 credit hours of approved graduate-level coursework (500 level courses and above).
3. Meeting or exceeding prescribed academic standards.
4. Passing a professional practice examination on general knowledge in the field (CM 788).
5. All rules and regulations of the graduate office, including elsewhere, apply to candidates for the degree of master of science in construction management.

## Required Core Courses

CM 506 Sustainable Construction\*  
CM 508 Construction Procurement Systems\*  
CM 610 Construction Project Management\*  
CM 615 Regulatory Environment of Construction  
CM 619 Construction Company Management\*  
CM 665 Construction Equipment Management\*  
CM 788 Professional Practice Project

\* *Denotes certificate courses*

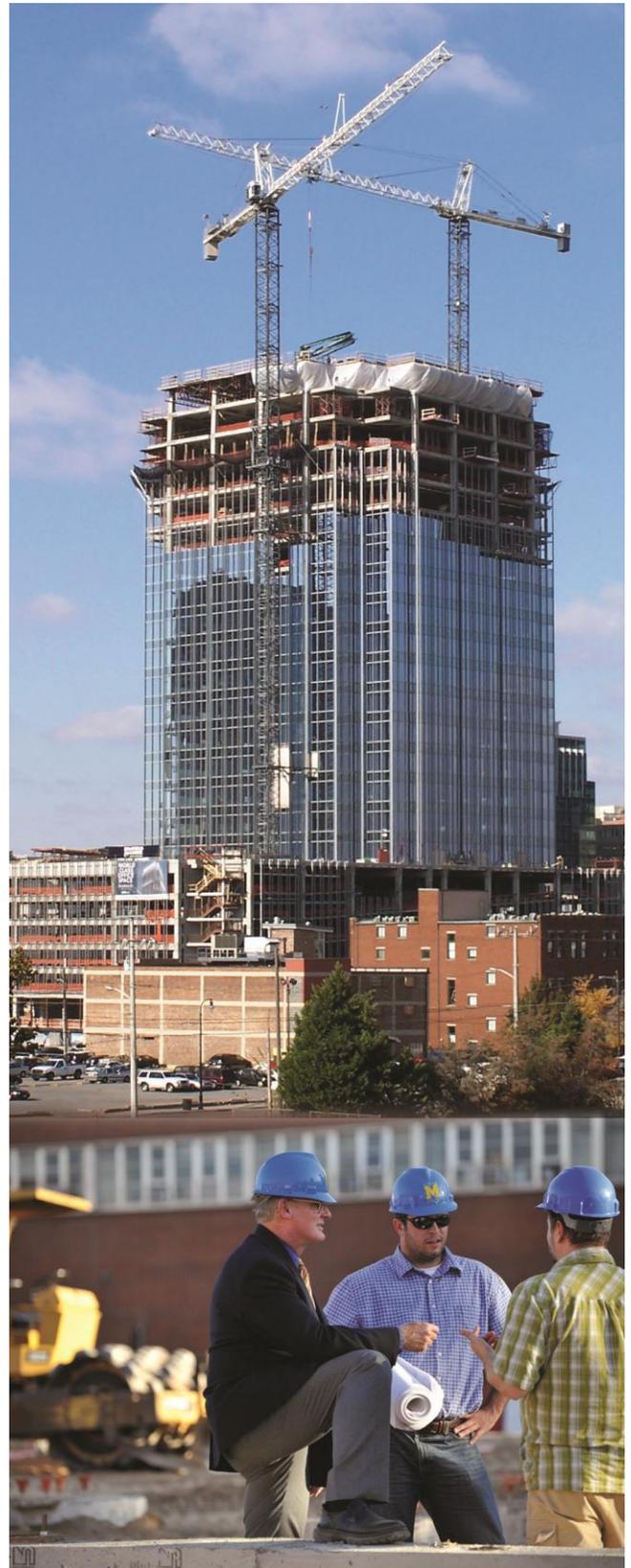
## Recommended Elective Courses

Students may use approved graduate-level School of Mines or transfer courses for up to 12 hours of elective credit provided they are included in the approved Program of Study.

The ENGM courses available in distance learning mode are listed below.

ENGM 620 Quality Management  
ENGM 625 Innovation and Commercialization  
ENGM 640 Business Strategy  
ENGM 650 Safety Management  
ENGM 661 Engineering Economics for Managers  
ENGM 655 Ergonomics for Managers  
ENGM 675 Legal and Ethical Issues in Engineering Management  
ENGM 742 Engineering Management & Labor Relations  
IENG 531 Industrial Hygiene  
  
IENG 531 Industrial Hygiene  
IENG 566 Project Planning and Control

Students may use any graduate School of Mines course or transfer course for up to 6 hours of elective credit provided it is approved by their advisor. A maximum of 12 hours may be transferred from other programs or institutions if approved by advisor.



## Electrical Engineering M.S.



### Contact Information

#### **Dr. Kazem Sohraby**

Department of Electrical and Computer Engineering

Electrical Engineering/Physics 311

(605) 394-1219

E-mail: [Kazem.Sohraby@sdsmt.edu](mailto:Kazem.Sohraby@sdsmt.edu)

### Faculty

Steven P. Miller Endowed Chair and Professor Whites; Professor Sohraby; Associate Professors Montoya and Tolle; Assistant Professors Anagnostou and Hoover; Instructor Linde.

### Electrical Engineering

The mission of the electrical and computer engineering graduate program is to provide

quality student learning at an advanced level and to disseminate new knowledge in electrical engineering, while at the same time working to increase resources in support of these objectives.

The graduate program in electrical engineering consists of research and study leading to the master of science degree in electrical engineering (M.S. EE) and multidisciplinary Ph.D. degrees in materials engineering and science, nanoscience and nanoengineering, and biomedical engineering. In special cases, with the consent of the graduate committee of the electrical and computer engineering department, students may elect to do research in association with another engineering or science department.

The prospective student should have completed a baccalaureate degree in electrical engineering or computer engineering. Applicants from universities that are not accredited by the Accreditation Board for Engineering and Technology (ABET) are generally required to submit Graduate Record Exam (GRE) scores from the General Test with their application.

Depending on the student's undergraduate background, and at the discretion of the electrical and computer engineering graduate committee, graduates of other institutions may also be required to take one or more courses of preparatory undergraduate work in addition to their graduate program of study.

The M.S. EE degree is available with thesis and non-thesis tracks. The course requirements for these tracks are as follows:

### **Thesis option**

The thesis M.S. EE degree consists of a program of graduate coursework and thesis research. Candidature for the M.S. EE degree with Thesis is contingent on an aptitude to do research. A limited number of students are accepted into the M.S. EE Thesis option, on the recommendation of a major professor. The requirements for the M.S. EE Thesis degree are as follows:

1. A program of at least 30 credit hours of coursework and research.

2. At least 15 credit hours of graduate coursework (500 level courses and above).
3. At least 6 credit hours of thesis research. (No more than 9 credit hours of thesis research will count toward degree requirements.)
4. A satisfactory thesis based upon individual research.
5. Meeting or exceeding prescribed academic standards.
6. Passing an examination on general knowledge and successfully defending the thesis.

### **Non-Thesis option**

The non-thesis MSEE degree consists of a program of graduate coursework. A project is not required and normally is not encouraged for the M.S. EE non-thesis option. The requirements for the M.S. EE non-thesis degree are as follows:

1. A program of at least 32 credit hours of coursework.
2. At least 20 credit hours of graduate coursework (500 level courses and above).
3. Meeting or exceeding prescribed academic standards.
4. Passing an examination on general knowledge in the field.

### **Language Requirements**

1. Students whose native language is not English are generally required to take the Test of English as a Foreign Language Test (TOEFL).
2. Graduate students with a TOEFL score below 560 are required to attend a remedial course in English.
3. Meeting or exceeding prescribed academic standards.

4. Passing an examination on general knowledge in the field.

### **Graduate Credit Taken as an Undergraduate**

Undergraduate students taking 600 level graduate courses and petitioning these courses for graduate credit should realize that application of these credits to the program of study is subject to the approval of the student's graduate committee. A student's graduate program will come under the control of the graduate committee at the time the student is accepted into the graduate program.

### **Graduate Committee and Program of Study**

The ECE Graduate Committee is the graduate committee for all M.S. EE non-thesis degree students, with the ECE Graduate Coordinator serving as the advisor. M.S. EE thesis students form a graduate committee with a major professor who has agreed to supervise the research of the student. In both cases, the student must arrange to have a faculty member external to the Department of Electrical and Computer Engineering on his or her committee.

Each student must submit a program of study to the candidate's graduate committee by the end of the first semester of study. Approval of the program of study is necessary in order to register for the second and subsequent semesters.

The student's graduate committee has the right to disallow any course proposed in the student's program of study that they feel is not appropriate for the graduate degree in electrical engineering. A student accepted into the Ph.D. program in materials engineering and science, nanoscience and nanoengineering, or biomedical engineering must have his or her program approved by the graduate committee responsible for that respective program.

### **Research Areas and Resources**

The M.S. EE degree offers emphases in the areas of communications and applied electromagnetics, and embedded systems and control systems. In addition to the more discipline-specific equipment listed below, the ECE department has well-equipped laboratories of networked PCs, general purpose test and measurement equipment such as high-speed

oscilloscopes, arbitrary function generators, logic analyzers, and printed circuit board prototyping machines and software.

Research activities in the communications and applied electromagnetics area include: compact and reconfigurable antennas, electromagnetic propulsion of space sailcraft, engineered electromagnetic materials using active and passive circuit particles, and ultra-wideband and ground penetrating radar. Resources in support of this program include a number of vector network analyzers, impedance analyzers, Agilent Advanced Design System, Microwave Studio, and IE3D. In addition, the Steven P. Miller Endowed Chair in electrical engineering was established in 2001 to support telecommunications in the ECE department.

Research activities in the embedded systems and signal processing area include: neural network and fuzzy logic chips, computationally intelligent systems, FPGA- and CPLD-based embedded system design, fault tolerant computer systems, residue and pseudo-floating point number architectures, pattern recognition, system identification, wavelet signal processing and adaptive signal processing. Resources in support of this program include logic analyzers, a variety of microcontroller and microprocessor development systems, FPGA and CPLD prototyping boards, VHDL and Verilog compilers, Analog Devices DSP development tools, Mentor Graphics Computer Aided Design Toolset, a variety of microchip fabrication equipment, and printed circuit board manufacturing equipment.

Research activities in the area of control systems include: robotics, machine control, fuzzy logic control, nonlinear and adaptive control, modeling of power systems, power systems stability, generator dynamics, fault analysis, and wind power. In addition, a number of robotics projects are performed in association with the School of Mines Center of Excellence in Advanced Manufacturing and Production (CAMP).

### **M.S. EE Course Offerings**

Courses that students would take for each of the focus areas would typically include, but would

not be limited to, those listed below:

### **Communication and Applied**

#### **Electromagnetics:**

- EE 621 Information and Coding Theory
- EE 622 Statistical Communication Systems
- EE 623 Random Signals and Noise
- EE 692 Topics

Regular topics (EE 692) offerings include:

- Advanced Engineering Electromagnetics
- Guided Waves and Material Measurements
- Advanced Antennas
- Computational Electromagnetics

#### **Embedded Systems and Signal Processing:**

- EE 612 High-Speed Digital Design
- EE 624 Advanced Digital Signal Processing
- EE 641 Digital Systems Design
- EE 643 Advanced Digital Systems
- EE 644 Fault Tolerant Computing
- EE 647 HDL Design
- EE 648 Advanced VLSI Design

#### **Control and Power Systems:**

- EE 552 Robotic Control System
- EE 618 Sensors and Signal Processing
- EE 633 Power System Analysis I
- EE 634 Power System Analysis II
- EE 651 Digital Control Systems
- EE 652 Nonlinear and Optimal Control System

## Engineering Management M.S.



### Contact Information

#### **Dr. Stuart D. Kellogg**

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Civil Mechanical 320  
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### School of Mines Faculty

Ervin Pietz Professor Kellogg; Professor Kerk;  
Associate Professors Matejckik, Karlin and Jensen;  
Assistant Professor Piper.

### **Engineering Management**

The M.S. degree in Engineering Management (MSEM) is designed to provide a program of advanced study in technically oriented disciplines for candidates anticipating a managerial career. It is a multi-disciplinary applications-oriented degree, which draws from the fields of

engineering, management, business, operations research and management science.

The intent of the program is to provide an interface between training received in engineering and scientific disciplines with the management of resources and personnel in a technical environment. In addition to being available in distance mode, flexibility is built into the program in order to provide an optimum educational experience to students. Graduates of the EM program are likely to find an initial position as a mid level supervisor within a broad range of applications requiring the use of quantitative models to integrate human and material resources necessary to perform an integrated function. Program specific information and resources may be found at the department of industrial engineering website:

<http://ie.sdsmt.edu>.

Application should be made through the graduate office at School of Mines

<http://graded.sdsmt.edu/prospective/apply>

All candidates for this degree must possess a bachelor's degree from a four-year accredited institution, in which satisfactory performance has been demonstrated. In addition to these requirements, the following minimum bachelor's level credits shall have been completed:

1. Mathematics one year minimum, to include algebra and basic calculus (Equivalent to School of Mines MATH 123).
2. Six semester hours of natural and physical science (fields of geology, astronomy, biology, meteorology, chemistry, and physics) and which must include at least 3 credit hours of chemistry or physics.
3. Three semester hours of probability and statistics. (Students may complete prerequisite requirements in probability and statistics through an Internet-based study option. Students desiring this option should contact the program coordinator.)

In addition, individual elective courses may have additional prerequisite requirements. A maximum of 12 semester hours of credit may be

transferred into the candidate's program from another institution. This must be from a regionally accredited institution. Application materials will be evaluated by an admission committee composed of the program director and such other faculty as deemed appropriate for the review. Recommendations from this committee will be made to the Dean of Graduate Education and research at the School of Mines.

Requirements for the degree include the completion of a minimum of 24 credits of coursework and 6 credits of research for the thesis option, or 32 credits of coursework for the non-thesis option. A cumulative GPA of 3.0 must be obtained by the end of the program of study and other general and master's level grade requirements must be maintained as specified in this catalog. The probation policy outlined in this catalog applies to all credits taken.

The continuing registration requirement must be satisfied at the School of Mines campus. Students utilizing transfer credits should plan accordingly and ensure that they are officially enrolled in a minimum of the two credits from the School of Mines the semester in which they graduate.

In the early stages of the candidate's program, a student advisor will be appointed by the program director of School of Mines. The advisor will meet with the student to prepare a program along the direction of the specific emphasis desired. The advisor and student will then organize a advisory committee, and file their committee program of study with the School of Mines graduate office according to the directions specified under "Supervision of the Master's Program" of the Master of Science Programs section of this catalog.

### **Certificate Program**

The graduate level Occupational Safety Certificate is designed to respond to a business need across all sectors (including general industry,

### **Core Course Requirements**

A minimum of 3 semester hours of required coursework must be completed in each of four discipline areas. Discipline areas and allowable

courses are shown below.

#### **Business/Finance**

ENGM 661	Engineering Economics for Managers
ENGM 640	Business Strategy

#### **Management**

ENGM 742	Engineering Management and Labor Relations
IENG 566	Project Planning and Control

#### **Quantitative Methods**

ENGM 631	Optimization Techniques
ENGM 732	Stochastic Models in Operations Research
ENGM 745	Forecasting for Business and Technology

#### **Operations Management**

ENGM 663	Operations Planning
ENGM 620	Quality Management

Students wishing to utilize transfer courses to satisfy core requirements should contact their advisor or the program coordinator for suitability of transfer credits. In some cases, agreements with other state institutions are already available.

### **Recommended Elective Courses**

Any core course not used to satisfy core requirements may be used as an elective. Students may use any graduate School of Mines course provided it is approved by their committee. ENGM courses are available in distance learning mode and are listed below.

#### **School of Mines Courses**

ENGM 625	Innovation and Commercialization	3
ENGM 640	Business Strategies	3
ENGM 650	Safety Management	3
ENGM 655	Ergonomics for Managers	3
ENGM 675	Legal and Ethical Issues in Engineering Management	3
ENGM 720	Statistical Process Control	3

ENGM 732	Stochastic Models in Operations Research	3
ENGM 745	Forecasting for Business and Technology	3
ENGM 792	Advanced Topics in Technology Management	3
IENG 351	Industrial Engineering	3

**Approved USD Elective and Core Courses**

BADM 611	Investments	3
BADM 701	Readings and Business Problems	3
BADM 720	Quantitative Methods	3
BADM 722	Advanced Information Systems	3
BADM 726	Decision Support Systems	3
BADM 727	Database Management Administration	3
BADM 728	Microcomputers and Small Business Management Systems	3
BADM 761	Organizational Theory and Behavior	3
BADM 762	Business and its Environment	3
BADM 770	Marketing Administration	3
BADM 780	Administrative Policy	3
BADM 781	Managerial Accounting	3
BADM 794	Research Problems	3

The following are sample programs for the project option for a student with a mining engineering degree (Student A), and a non-thesis option for a student contemplating a career as a laboratory manager in a government laboratory (Student B).

**Student A**

ENGM 661	Engineering Economics for Managers	3
ENGM 742	Engineering Management and Labor Relations	3
IENG 566	Project Planning and Control	3
ENGM 663	Operations Planning	3
ENGM 631	Optimization Techniques	3
ECON 782	Managerial Economics	3
ENGM 620	Quality Management	3
ENGM 732	Stochastic Models in Operations Research	3
ENGM 650	Safety Management	3
ENGM 745	Forecasting for Business and	

ENGM 788	Technology	3
	Master Research Problems/Project	2
<b>Total</b>		<b>32</b>

**Student B**

ENGM 661	Engineering Economics for Managers	4
ENGM 742	Engineering Management and Labor Relations	3
IENG 566	Project Planning and Control	3
ENGM 663	Operations Planning	3
ENGM 631	Optimization Techniques	3
ECON 782	Managerial Economics	3
ENGM 732	Stochastic Models in Operations Research	3
ENGM 720	Statistical Process Control	3
<b>Total</b>		<b>3</b>

## **Geology and Geological Engineering M.S. and Ph.D.**



### **Contact Information**

#### **Dr. Laurie Anderson**

Department of Geology and Geological  
Engineering

Mineral Industries 307

(605) 394-2461

E-mail: Laurie.Anderson@sdsmt.edu

#### **Geology Faculty**

Professors Duke, Paterson and Price; Associate  
Professor Uzunlar; Assistant Professor Terry;  
Professors Emeritus Fox, Lisenbee and Redden.

#### **Geological Engineering Faculty**

Professors Davis and Stetler; Assistant Professors  
Sawyer and Katzenstein; Professor Emeritus Rahn

### **Geology and Geological Engineering**

The Department of Geology and Geological Engineering offers advanced study leading to an M.S. degree in geology and geological engineering or a Ph.D. degree in geology and geological engineering. Students must elect to pursue either a Geology Specialization or a Geological Engineering Specialization, each of which has different background requirements and program requirements. The available coursework and current faculty expertise support the following areas of concentration. Students take a

core of required courses supplemented by electives determined by the student's committee based on the intended field of study:

1. Energy and Mineral Resources
2. Environmental/Exploration Geophysics
3. Ground Water / Environmental Studies
4. Mineral Deposits/Mineralogy/Petrology
5. Sedimentation/Stratigraphy
6. Paleontology\*
7. Structural Geology/Tectonics
8. Geomechanics/Engineering geology

\* Ph.D. only. Students concentrating in Paleontology at the Master's level should apply for the separate M.S. in Paleontology.

### **Background Requirements for M.S. and Ph.D.**

The Graduate Record Examination (GRE) is required of all applicants except School of Mines graduates. The TOEFL exam is required for students whose native language is not English.

### **Geology Specialization**

1. All incoming students are expected to present a full year each of college-level Calculus, Physics, and Chemistry as part of their undergraduate record. Deficiencies in these areas must be remedied by taking the necessary coursework prior to or in the first year of enrollment in the graduate program.
2. All incoming students are expected to have completed courses in, or to develop proficiency in, the following areas. Additional subjects may be required by the student's graduate committee depending on the student's area of concentration. The student and the graduate committee will arrange in writing how these requirements can best be met.

- Physical Geology
- Mineralogy
- Stratigraphy and Sedimentation
- Petrology
- Structural Geology
- Field Geology

## Geological Engineering Specialization

1. All incoming students are expected to present three semesters of Calculus and one semester of Differential Equations, as well as two semesters each of Physics and Chemistry, as part of their undergraduate record. Deficiencies in these areas must be remedied by taking the necessary coursework prior to or in the first year of enrollment in the graduate program.

2. All incoming students are expected to have completed courses in, or to develop proficiency in, the following areas. Additional subjects may be required by the student's graduate committee depending on the student's area of concentration. The student and the graduate committee will arrange in writing how these requirements can best be met.

- Physical Geology or Geology for Engineers
- Mineralogy
- Stratigraphy and Sedimentation
- Structural Geology
- Statics
- Mechanics of Materials
- Fluid Mechanics

### Master's Program

The M.S. degree program consists of research and study in various fields depending on the student's interests. The M.S. thesis option requires 32 credits, including six to eight (6-8) credits of thesis research and twenty-four to twenty-six (24-26) credits of coursework. The non-thesis option includes 32 credits of coursework and is available to students at the discretion of the department head. Candidates for the M.S. degree must fulfill all degree requirements of the graduate office and also the program requirements. Each student must elect a specialization in Geology or in Geological Engineering.

### **Geology Specialization Requirements**

Core Courses:

GEOL 604    Advanced Field Geology  
GEOL 633    Sedimentation

One course from:

GEOL 517    Geospatial Databases  
GEOL 519    Advanced Geospatial Analysis  
GEOE 766    Digital Modeling of Ground-Water  
MEM 533    Comp Apps in Geoscience  
                 Modeling

One course from:

GEOL 621    Advanced Structural Geology  
GEOL 622    Geotectonics

One course from:

GEOE 552    Geochemical Exploration  
GEOE 641    Geochemistry  
GEOE 664    Advanced Ground Water

### **Geological Engineering Specialization Requirements**

Core Courses:

GEOL 633    Sedimentation  
GEOE 766    Digital Modeling of Ground Water

Geological Engineering students focus on one of three areas. Typical coursework recommended for each focus is shown below.

Ground Water and Environmental Focus

GEOE 641    Geochemistry  
GEOE 664    Advanced Ground Water  
CEE 634    Surface Water Hydrology  
GEOE 682    Fluvial Processes

Geomechanics Focus

GEOE 668    Eng. Geology of Surficial Deposits  
CEE 643    Advanced Soil Mechanics I  
CEE 646    Stability of Soil and Rock Slopes  
CEE 647    Earth Structures  
MEM 533    Comp Apps in Geoscience  
                 Modeling

Energy and Mineral Resources Focus

GEOE 552    Geochemical Exploration  
GEOE 525    Engineering Geophysics II  
GEOE 641    Geochemistry  
GEOE 661    Petroleum Geology  
GEOL 652    Problems in Ore Deposits

### Doctor of Philosophy Program

Admission to the Ph.D. program in Geology and Geological Engineering is normally limited to qualified students who have already earned an M.S. degree in geology, geological engineering, paleontology, or a related field. Students holding an M.S. but with extensive undergraduate deficiencies may be placed into the M.S. program in Geology and Geological Engineering until these deficiencies are remedied. Students with a B.S. degree who apply to the Ph.D. program will be admitted to the M.S. program in Geology and Geological Engineering until they have accumulated sufficient course credits for an M.S. degree. Students placed into the M.S. under one of these two circumstances will be admitted to the Ph.D. program after passing the qualifying exam.

### Qualifying Exam

All Ph.D. students are expected to take a qualifying exam to demonstrate their potential for independent research. Students entering with a B.S. degree will take the examination in the semester immediately following the completion of 24 credits of graduate coursework. Students placed in the M.S. due to undergraduate deficiencies must take it in the semester immediately following the completion of the deficiencies. Students entering with a completed M.S. degree will take it before the end of their second semester in residence.

To pass the qualifying exam, the student must 1) complete all undergraduate deficiency requirements, 2) submit a valid Ph.D. Program of Study to the department chair; 3) complete a literature search and paper on a topic related to the student's area of concentration; and 4) present and defend the paper in an oral examination by the department faculty. The paper should reflect a sustained effort during the student's first year and culminate in an analysis of potential significant research problems. The identified problems need not match the eventual dissertation topic.

### Curriculum

A minimum of eighty (80) credit hours are required beyond the B.S. degree. At least fifty (50) of these credits must be for coursework. Up to twenty-four (24) course credits and six (6) research credits from the M.S. degree can be

applied toward the total required credits if the student's committee agrees.

The student's committee will work with the student to devise a program of courses appropriate to the student's area of study. It is recommended that at least ten (10) credits are related to the student's research specialty and that six (6) to twelve (12) hours of coursework be taken outside the department. Students must choose between the Geology Specialization and the Geological Engineering Specialization.

### Geology Specialization

#### Core Courses:

GEOL 633	Sedimentation
GEOL 604	Advanced Field Geology
GEOL 808	Fundamental Problems in Geol/GeoE

#### One course from:

GEOL 517	Geospatial Databases
GEOL 519	Advanced Geospatial Analysis
GEOE 766	Digital Modeling of Ground Water
MEM 533	Computer Applications in Geoscience Modeling

#### One course from:

GEOL 621	Advanced Structural Geology
GEOL 622	Geotectonics

#### One course from:

GEOE 641	Geochemistry
GEOE 664	Advanced Ground Water
GEOL 652	Problems in Ore Deposits

### Geological Engineering Specialization

All Ph.D. students in the Geological Engineering specialization are expected to focus in one of the three areas of groundwater/environmental, geomechanics, or energy/mineral resources. Recommended courses for each focus are listed below.

#### Required of all GEOE students:

GEOE 766	Digital Modeling of Ground Water
GEOL 633	Sedimentation
GEOL 808	Fundamental Problems in Geol/GeoE

**Ground Water and Environmental Focus:**

GEOE 664	Advanced Ground Water
GEOE 641	Geochemistry
GEOE 663	Ground-Water Geochemistry
CEE 634	Surface Water Hydrology
CEE 521	Environmental Systems Analysis
GEOL 517	Geospatial Databases
GEOL 519	Advanced Geospatial Analysis
CEE 730	Statistical Methods in Water Resources
CEE 731	Topics in Water Quality Assessment
CEE 526	Environmental Engineering Physical/Chemical Process Design
CEE 621	Env. Contaminant Fate and Transport

**Geomechanics Focus:**

GEOE 668	Eng. Geology of Surficial Deposits
CEE 647	Earth Structures
CEE 646	Stability of Soil and Rock Slopes
CEE 643	Advanced Soil Mechanics I
MEM 550	Rock Slope Engineering
MEM 512	Rock Mechanics III
GEOE 664	Advanced Ground Water
CEE 645	Advanced Foundations
CEE 647	Earth and Earth Retaining Structures
CEE 784	Modeling and Comp in Civil Engr

**Energy and Mineral Resources Focus:**

GEOE 525	Engineering Geophysics II
GEOE 552	Geochemical Exploration
GEOE 661	Petroleum Geology
GEOL 652	Problems in Ore Deposits <sup>4</sup>
GEOE 641	Geochemistry
MEM 533	Comp App in Geoscience Modeling
GEOE 663	Ground-Water Geochemistry
CEE 627	Treatment, Disposal, and Management of Hazardous Waste
GEOL 650	Seminar in Ore Deposits
CEE 784	Modeling and Comp in Civil Engr

**Dissertation Proposal Defense**

The dissertation proposal is part of the comprehensive examination. All Ph.D. students are required to prepare a research proposal for the

work to be accomplished for the dissertation. The proposal is due one month prior to the comprehensive examination, so that the candidate's committee may review the proposal to assure that it is defensible. If not, then the student will have an opportunity to resubmit, although this may alter the final date of the comprehensive examination.

**Comprehensive Examination: Summary of Rules and Organizations**

When the student's program of coursework has been substantially completed and dissertation proposal prepared, he/she will undertake the comprehensive examination for admission to candidacy. This examination should normally occur after the student has spent four semesters in the Ph.D. program, but must take place at least four months prior to the final defense. The comprehensive examination will consist of written and oral examinations covering the student's field of study and related subjects. It will be prepared by the student's advisory committee, with potential suggestions from any faculty member from whom the student has taken a graduate course. The oral examination is open to any faculty member, but must include the candidate's full committee.

If the student has not completed all requirements for the Ph.D. degree by the fifth year following the comprehensive examination, his/her active status will be automatically terminated and the comprehensive examination must be repeated.

1. No later than two (2) months prior to the examination date the student must make a request to the student's committee to take the Comprehensive Examination. The dissertation research proposal must be submitted at least one month prior to the examination date.
2. The examination will consist of four parts, all of which must be completed within one working week. The examination may be scheduled for spring and fall semesters only, but not during the week of final examinations or the last week of classes.

3. The written examinations will be graded prior to the oral examination.
4. The oral examination will last three hours. It will begin with an oral presentation of the dissertation proposal by the student, who will then undergo an oral examination by the committee that may include questions concerning the proposal, the written exam topics, and any relevant subject area related to the student's research.
5. The written examination will consist of three parts: one general, and two specific topics. Each part of the written examination will be three (3) hours in length.

General (written)	25%
Specific Topic (written)	25%
Specific Topic (written)	25%
Oral Examination	25%

**Geology Specialization:**

The General part will include General Geology. Specific topics will be chosen from the following list:

- Structural geology
- Sedimentation/stratigraphy
- Paleontology

- Igneous/metamorphic petrology
- Economic geology/mineral exploration
- Crystal chemistry/mineralogy
- Geomorphology
- Geophysics
- Glacial and Pleistocene Geology

**Geological Engineering Specialization:**

The General part will include Geological Engineering, General Geology, and Fundamentals of Engineering. Specific topics will be chosen from the following list:

- Ground Water
- Engineering Geology
- Petroleum Engineering
- Minerals
- Hydrology and Hydraulic Engineering
- Geophysical Exploration
- Geochemistry
- Geomorphology
- Rock Mechanics
- Geotechnical Engineering

A student may substitute successful completion of the Fundamentals of Engineering (F.E.) examination for one of these three (3) parts. A student also may propose hybrid fields with other disciplines if approved by his or her graduate committee.

## Materials Engineering and Science M.S.



### Contact Information

#### **Dr. Jon J. Kellar**

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### Steering Committee

Steering Committee members are from the Departments of Materials and Metallurgical Engineering, Physics, and Chemistry.

### Faculty

Douglas W. Furstenau Professor Kellar; Professors Boyles, Foygel, Howard, Petukhov and Salem; Associate Professors Corey, Cross, Heglund and Sobolev; Assistant Professors Fong, Meyer, West, Widener and Zhu; Emeritus Professor Stone, Distinguished Professor Emeritus Han; Adjunct Professor Medlin.

### Master of Science in Materials Engineering and Science

This interdisciplinary degree program works in concert with other colleges and the Ph.D. in materials engineering and science (Ph.D./MES).

The M.S./MES degree offers an education in the broad area of materials. Students pursuing this degree will expand their knowledge and

understanding of the science and technology of materials synthesis, behavior, and production. Graduates of the program formulate solutions to materials problems through the use of multi-disciplinary approaches made possible with a broad background in basic materials science and engineering coupled with an area of specialization.

Two options are available in this degree program: one option involves a thesis component and the other option involves coursework only. In the thesis option, 24 hours of coursework and a minimum 6 credit hours of thesis research are required. With the second option, 32 hours of coursework must be taken. In the latter option however, the students are required to undertake a project under the supervision of a faculty member. Because students graduating with this degree are expected to have a broad-based fundamental knowledge in both materials engineering and materials science, every student is required to take the following core courses.

MES 601 Fundamentals of Materials Engineering (4 cr.)

MES 603 Condensed Matter Physics (4 cr.)

MES 604 Chemistry of Materials (4 cr.)

In addition MES 790 Seminar (1 cr.), is a required course.

Areas of research currently carried out include inorganic, organic, and biological behavior/synthesis/treatments of materials, polymer chemistry, solid state physics, interfacial chemistry/physics, thermal, magnetic and transport properties of semiconductors, superconductors, metals and alloys, dielectric and composite materials, recovery and processing of minerals/materials/scrap, process simulation and optimization, thermodynamics of various materials, corrosion and corrosion inhibition, strengthening mechanisms, deformation induced transformation plasticity, artificial intelligence, and behavior/properties/synthesis of composites.

## **Undergraduate Degrees That Prepare Students for the M.S. MES Program**

The breadth of the field of materials engineering and science is such that graduates from any of the following disciplines should be prepared for graduate study in the M.S. MES program: chemistry, physics, metallurgical engineering, chemical engineering, materials engineering, mechanical engineering, civil engineering, and electrical engineering. Students with baccalaureate degrees in other disciplines may gain admission to the program but may require remedial undergraduate work prior to beginning their graduate coursework.



*Mines Matters:* The South Dakota School of Mines and Technology Career Center assists students with sharpening interview skills, finding internships, and by hosting a Career Fair in fall and spring of each year.

## Materials Engineering and Science Ph.D.



### Contact Information

#### **Dr. Jon J. Kellar**

Department of Materials and Metallurgical  
Engineering  
Mineral Industries 112  
(605) 394-2343  
E-mail: [Jon.Kellar@sdsmt.edu](mailto:Jon.Kellar@sdsmt.edu)

### Advisory Council

Advisory Council members are from the Departments of Civil and Environmental Engineering, Mechanical Engineering, Materials and Metallurgical Engineering, Physics, and Chemistry.

### Materials Engineering and Science

The doctor of philosophy program in materials engineering and science (MES) offers a student the opportunity to expand his/her knowledge and understanding of the science and technology of materials production, behavior, and applications. The student will undertake multidisciplinary approaches, combining the basic elements of both engineering and science, to the solution of materials-related problems. Because such problems are found in every science and engineering discipline, the degree applicant has considerable flexibility in the selection of the department in which to pursue dissertation research, within the confines of the applicant's academic preparation and interests. Candidates will study either a science or engineering emphasis within the MES Ph.D. program. For example, research emphasis may be placed on

improving processes for the production of metallic, polymeric, ceramic, or other structural or electronic materials. Alternatively, the degree candidate may investigate mechanisms for improving material properties, which in turn, could lead to new or better applications. Classroom and individualized instruction will provide the necessary theory to complement such creative activities.

Example areas of specialization include but are not limited to

- Activities of Multicomponent Systems
- Computational Modeling
- Polymer Synthesis
- Concrete Technology
- Corrosion Inhibition
- Development of Multiphase Materials
- Fiber Reinforced Composites
- Geotechnology
- Magnetic Nanocomposites
- Nanoscale Electronic Materials
- Polymer Matrix Composites
- Reaction Kinetics
- Semiconductor Materials and Devices
- Strengthening Mechanisms
- Surface Chemistry of Flotation
- Thermophysical Properties
- Thin Films

The program is administered directly by the Dean of Graduate Education and sponsored programs, with the head of the MES Ph.D. advisory council serving as program coordinator. The advisory council currently comprises faculty members from the Departments of Civil and Environmental, Mechanical, Materials and Metallurgical Engineering, and the Departments of Physics, and Chemistry.

The Graduate Record Examination (GRE), three letters of recommendation, and a GPA of 3.00 or better are required of all applicants for the MES Ph.D. program. The TOEFL exam is required for students whose native language is not English.

All candidates for the MES Ph.D. program are required to successfully complete the following minimum credits and earn a grade of "C" or better, except for a final grade of "S" in MES 800:

Category	Credits
Analytical Mathematics	3
Numerical Mathematics	3
Program Major Emphasis (Engineering or Science)	44-54
Dissertation Research	20-30
Total beyond the B.S. degree	80

### General Program Requirements

(Minimum program requirements: 80 credits)

#### M.S. Degree (24 credits)

Programs-major courses may be used to satisfy coursework hour requirements for analytical mathematics, numeral mathematics, or fundamental science courses taken in the M.S. program of study (subject to approval).

#### Analytical Mathematics (3 credits)

ME 673 (3-0) Applied Engineering Analysis I

PHYS 581 (3-0) Mathematical Physics

#### Numerical Mathematics (3 credits)

CEE 784 (3-0) Modeling and Computation in Civil Engineering

CEE 785 (3-0) Applications of Finite Element Methods in Civil Engineering

MATH 547 (3-0) Design and of Experiments

ME 773 (3-0) Applied Engineering Analysis II

MET 614 (3-0) Advanced Metallurgical Simulation Techniques

MEM 533 (3-1) Computer Applications in Geoscience Modeling

#### Program Emphasis (30 credits)

Two program emphasis areas are available: materials science and materials engineering. See sections below.

Research (20 credits)

MES 898 (19) Dissertation

MES 890 (1-0) Seminar

A maximum of 10 additional research credits may be included within the hours specified for the program major, subject to approval by the student's advisory committee. The courses listed

in Sections II and III below are suggested courses for the science of engineering emphasis, but students are not limited to this selection. Students may take courses out of each emphasis when developing their programs of study.

### Science Emphasis Requirements

(Minimum program requirements: 30 credits)

#### Thermodynamics of Solids (3 credits)

MES 712 (3-0) Interfacial Phenomena

PHYS 743 (3-0) Statistical Mechanics

CBE 613 (3-0) Transport Phenomena: Heat

CBE 714 (3-0) Transport Phenomena: Mass

MES 728 (3-0) Heterogeneous Kinetics

#### Crystal Structure/Chemistry of Solids

(3 credits)

MES 603 (4-0) Condensed Matter Physics

MES 604 (4-0) Chemistry of Materials

PHYS 771 (3-0) Quantum Mechanics I

#### Bulk or Surface Analysis (3 credits)

NANO 703/L (3-1) Instrumentation and Characterization of Nano-Materials

#### Fundamental Engineering Mechanics

(6 credits)

Courses from the engineering emphasis section can also be used to fulfill this requirement.

ME 425 (3-0) Probabilistic Mechanical Design

MET 450 (3-0) Forensic Engineering

MET 440/540 (3-0) Mechanical Metallurgy

ME/MET 443(3-0) Composite Materials

MET 625 (3-0) Strengthening Mechanisms in Materials

Dissertation Related Topics (12 credits)

## **Engineering Emphasis Requirements**

(minimum program requirements: 30 credits)

### **Analytical Mechanics**

- ME 623 (3-0) Advanced Mechanical Vibrations  
ME 613 (3-0) Transport Phenomena: Heat  
MES 713 (3-0) Adv Solid Mechanics I  
MES 770 (3-0) Continuum Mechanics

### **Elasticity/Plasticity**

- CEE 643 (3-0) Advanced Soil Mechanics I  
CEE 644 (3-0) Advanced Soil Mechanics II  
CEE 646 (3-0) Stability of Soil and Rock Slopes  
MES 713 (3-0) Advanced Solid Mechanics I  
MEM 450/550 (3-0) Rock Slope Engineering

### **Failure Analysis Fracture Mechanics**

- ME 715 (3-0) Advanced Composite Materials  
Fundamental Materials Science (6 credits)

Courses from the science emphasis section can also be used to fulfill this requirement.

- CHEM 420 (3-0) Organic Chemistry III  
CHEM 452/552 (3-0) Inorganic Chemistry  
CHEM 426/526 (3-0) Polymer Chemistry  
MES 603 (4-0) Chemistry of Materials  
MES 601 (4-0) Fundamentals of Materials Engineering  
MES 604 (4-0) Chemistry of Materials  
CBE 474/574 (2 to 3) Polymer Technology  
PHYS 439 (4-0) Solid State Physics  
MET 445/545 (3-0) Oxidation and Corrosion of Metals

An assessment of the student's qualifications will be undertaken early in their program. The assessment is comprised of performance in pre-determined courses and a dissertation proposal. Further information is available in the School of Mines materials engineering and science Ph.D. Handbook.

Each student is also required to pass a comprehensive examination. There is no

language requirement for the MES doctoral program.

For program supervision purposes, the MES Ph.D. program coordinator is the graduate advisor until the major professor is appointed. The major professor is the person responsible for the student's dissertation research. The graduate office representative on the student's dissertation committee must be selected from outside of the department with which the major professor is affiliated, and should also be a member of the MES Ph.D. Advisory Council. The MES Ph.D. Advisory Council must approve all programs of study. It is not necessary that the student be associated with the department of affiliation of his or her major professor. The detailed information on examination policy, admission to candidacy, and defense of dissertation are included in the School of Mines Materials Engineering and Science Ph.D. Handbook.

## Mechanical Engineering M.S. and Ph.D.



### Contact Information

#### **Dr. Michael Langerman**

Head, Department of Mechanical Engineering  
Civil Mechanical 172  
(605) 394-2408  
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#### **Lisa Carlson, MBA**

Ph.D. Coordinator  
Civil Mechanical 131  
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### Faculty

Professors Langerman, Abata, Dolan, Kalanovic, Kjerengtroen, Korde, and Muci-Kuchler; Associate Professors Bedillion and Widener; Assistant Professors Ellingsen, Shahbazi, and Simmons; Professors Emeritus Pendleton and Gnirk.

### Mechanical Engineering

The Department of Mechanical Engineering offers two graduate degrees the master of science and the doctor of philosophy degree. The primary goals of the graduate program are to develop the scholastic ability, independent creativity, and professional competence of an individual to a higher level than is possible in an undergraduate program.

The graduate program offers opportunities for higher education and research in manufacturing, solid mechanics, transport phenomena, computational mechanics, vibrations, controls and robotics, experimental mechanics, fracture mechanics, composite materials, and advanced materials processing. The graduate program features courses in continuum mechanics, computational methods in transport phenomena, advanced heat transfer, advanced fluid mechanics, engineering analysis, advanced solid mechanics, integrated manufacturing systems, applied intelligent control, theory of materials behavior, and advanced mechanical system control.

The mechanical engineering department is one of the largest programs on campus and has well-equipped laboratories. Several faculty members within the department are associated with the Computational Mechanics Laboratory (CML), where high-end workstations are available for pursuing research and design in modeling. Several faculty members are associated with the Center for Advanced Manufacturing and Production (CAMP), where research in advanced manufacturing, advanced composites, and advanced design methodologies is conducted. The department has a strong collaborative relationship with the Arbogast Advanced Materials Processing (AAMP) center and the Additive Manufacturing Laboratory (AML).

Other labs include the Fluid Mechanics and Heat Transfer Lab, which houses a Mach 3 supersonic wind tunnel, Vibrations Lab, Neural Networks and Controls Lab, Micromechanics Lab, Advanced Dynamics Lab, and a small Ballistics Lab. The campus fosters interdisciplinary research, and state-of-the-art equipment such as an electron microscope, atomic force microscope, x-ray diffractometer, Raman spectrometer, laser Vibration Pattern Imager, FADAL VMC40 Vertical Machining Center, Bridgeport Romi CNC lathe, Coordinate Measuring Machine, Injection Molding Machine, IBM 7540 Industrial Robot, and Universal Testing Machines are available in the department or on campus. Graduate research laboratories also include equipment for modern digital controls and

machine vision, thermal image analysis, high-speed imaging and experimental mechanics.

### **Master's Program**

The master of science degree program in mechanical engineering can be pursued using either of two (2) equal options. They are:

#### 1. **Non-Thesis:**

Total credit hours required	32
Project ME 788	4
Remaining 28 hours are taken (maximum) at the 400/500 level (minimum) at the 600/700 level	9 19

#### 2. **Thesis:**

Total credit hours required	30
Thesis ME 798	6
Remaining 24 hours are taken (maximum) at the 400/500 level (minimum) at the 600/700 level	9 15

### **Curriculum Notes**

1. 300 level acceptable if outside department and on approved blanket waiver list.

2. Students may enroll in 300/400 level courses only if 500/600 level courses within the major are not being offered or by written permission of the student's major professor and the department head.

Within the first semester in residence, each student is requested to carefully evaluate their preference of study after discussion with the mechanical engineering faculty, and a decision must be made shortly after the beginning of the second semester in residence. In either case the student must by then choose a major professor, and with the major professor's assistance develop a plan of study. The plan is due by the end of the first full calendar month of the student's second semester (end of September or end of January) in residence. The plan will be submitted to:

1. Graduate office
2. The department head
3. Major professor
4. Copy to the student

Each master's degree candidate must select an advisory committee. In addition to the candidate's major professor, the committee must consist of at least one other mechanical engineering professor and a graduate office representative. The graduate office representative, whose appointment must be approved by the graduate dean, must be selected from outside of the mechanical engineering department. The student and his/her supervising professor will nominate the out-of-department committee member after the student has received the nominee's consent.

### **The core curriculum required of all M.S. students includes:**

- ME 673 Applied Engineering Analysis I
- ME 773 Applied Engineering Analysis II

In addition, students should select one course from each of the three areas listed below (or approved substitutions) for a total of five core courses.

### **Thermal Sciences**

- ME 612 Transport Phenomena: Momentum
- ME 613 Transport Phenomena: Heat
- ME 616 Computations in Transport Phenomena
- ME 618 Conduction Heat Transfer
- ME619 Convection Heat Transfer
- ME 620 Radiation Heat Transfer

### **Mechanical Systems**

- ME 623 Advanced Mechanical Vibrations
- ME 680 Advanced Strength of Materials
- MES 713 Advanced Solid Mechanics I
- ME/MES 770 Continuum Mechanics

### **Manufacturing and Controls**

- ME 683 Advanced Mechanical System Control
- ME 781 Robotics

The details of the actual course selections must be developed by the student, the student's academic advisor, and the student's committee.

Entering students usually have a bachelor's degree in mechanical engineering. Qualifying examinations may be required of entering students. A minimum GPA of 3.00 is expected for regular (non-probationary) admission. Applicants who are graduates of institutions that are not accredited by the Accreditation Board of Engineering and Technology (ABET) are required to sit for the Graduate Record Exam and have their scores submitted prior to consideration for admission.

### **Final Examination (MS Thesis Program)**

Upon completion of the thesis, mechanical engineering graduate students electing this option will be examined orally over the written thesis and coursework as prescribed in the Graduate section. A mechanical engineering graduate student with an accumulated GPA of 3.4 or better in those courses in their graduate program will have their coursework exam combined with the thesis defense. For students having an accumulated GPA of less than 3.4 in courses in their graduate program, a separate focused coursework oral examination will be administered by the student's graduate committee. The GPA will be computed using midterm grades for the semester in which the student is currently enrolled. The coursework examination will examine primarily concepts and fundamentals of those courses selected, rather than the mechanics of problem solution and will, in general, attempt to establish the student's in-depth knowledge of the course content. The student's graduate committee will select specific courses from the student's graduate program in which the student has indicated possible deficiencies. The major professor will inform the student no less than three weeks prior to the examination what courses have been selected. However, it is the student's responsibility to secure this information from the major professor.

### **Final Examination (MS Non-Thesis Option)**

Mechanical engineering MS graduate students selecting a non-thesis option will be required to

pursue a special investigation under the direction of a faculty member. The report on this study will be written and formal although not of thesis quality nor extent. Upon the completion of the special investigation and with the approval of the directing faculty member, the student will be given a formal oral examination over the investigation. Rules concerning an oral examination over coursework taken by the student in their graduate program will be identical to the rules stipulated above for those students taking the thesis option.

### **Doctoral Program**

The following discussion assumes students are entering the program with a Bachelor's of Science degree. Students entering with a Master of Science degree will design their program of study in accordance with their graduate committee input.

Students entering the PhD program will be required to submit a plan of study and choose an advisor by the mid-term of the second semester of coursework. The degree requirements include a minimum of 80 credit hours beyond the Bachelor of Science degree. The 80 credit hours include 50 credit hours of coursework (see below) and 30 credit hours of research (ME 898). The program of study allows the student to obtain a minor by taking 12 credit hours in a program outside the mechanical engineering department (see below).

In addition to the successful completion of the curriculum, the program of study requires passing a qualifying exam, submitting a research topic proposal, passing a comprehensive exam, and successfully defending the dissertation.

### **Curriculum**

#### **Required Core Courses**

ME 673	Applied Engr Analysis I	3
ME 773	Applied Engr Analysis II	3
TOTAL		6

#### **Coursework: Choose 32 credits from below (or equivalent courses):**

ME 612	Transport Phenomena: Momentum	3
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ME 613	Transport Phenomena: Heat	3
ME 616	Computations in Transport Phenomena	3
ME 618	Conductions Heat Transfer	3
ME 619	Convection Heat Transfer	3
ME 620	Radiation Heat Transfer	3
ME 623	Adv Mechanical Vibrations	3
ME 625	Smart Structures	3
ME 680	Adv Strength of Materials	3
ME 683	Adv Mechanical Systems Control	3
ME 691	Independent Study	3
ME 692	Special Topics	3
ME 713	Adv Solid Mechanics I	3
ME 715	Adv Composite Materials	3
ME/MES 770	Continuum Mechanics	3
ME 781	Robotics	3
ME 896	Field Experience(TBD)	2
TOTAL		32

Minor:

MATH/PHYS/EE/CEE/ChE/MES/BME/NANO:

12 Credits

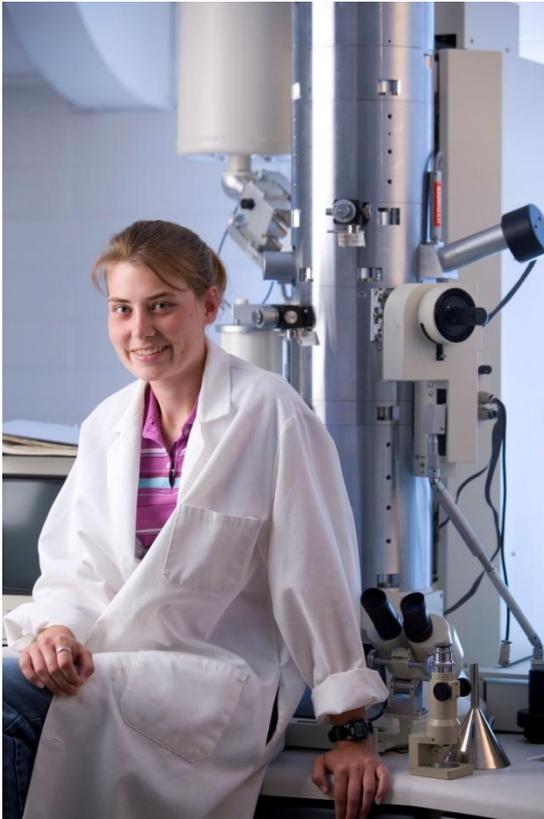
TOTAL	12
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Dissertation

ME 898D	Dissertation	30
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TOTAL	30
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## **Graduate Study in Metallurgical Engineering**



### **Contact Information**

#### **Dr. Jon J. Kellar**

Department of Materials and Metallurgical Engineering  
Mineral Industries 112  
(605) 394-2343  
E-mail: [Jon.Kellar@sdsmt.edu](mailto:Jon.Kellar@sdsmt.edu)

### **Faculty**

Douglas W. Fuerstenau Professor Kellar;  
Professor Howard; Associate Professor Cross;  
Assistant Professor West; Research Scientist  
Hong; Adjunct Professors Jhasti, Kim, Sears and  
Medlin; Distinguished Professor Emeritus Han;  
Professor Emeritus Stone.

## **Metallurgical Engineering**

Students interested in pursuing graduate studies focusing on materials engineering and science, please see master of science in materials engineering and science. Other relevant graduate programs include those in nanoscience and nanoengineering and biomedical engineering.

## Nanoscience and Nanoengineering Ph.D.



### Contact Information

#### **Dr. Steve Smith**

Nanoscience and Engineering  
(605) 394-5268

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<http://nano.sdsmt.edu>

### Advisory Council

Professors Boyles, Kjerengtroen, Petukhov and Smith; Miller Professor Whites; Associate Professors Fong and Yang; Assistant Professors Ahrenkiel, Anagnostou, West and Zhu; Research Scientists Hong and Sears.

### Nanoscience and Nanoengineering

The Nano Science and Engineering Ph.D. (Nano SE Ph.D.) Program at the South Dakota School of Mines and Technology is an interdisciplinary Ph.D. program focusing on the science and engineering of nanomaterials. The goal of nanoscience and nanotechnology is to manipulate matter at the atomic and “nano” length scales (dimensions from a few to 100’s of atomic radii), e.g. the molecular to mesoscopic levels, where new materials and phenomena have been discovered. The ability to engineer systems at these length scales will require professionals with a broad understanding of fundamental principles and the ability to cross-over into other fields. The nano program provides the training to allow scientists and engineers to address these challenges, and the opportunity for students to

engage in such research at the School of Mines while pursuing the Ph.D.

The Nano SE Ph.D. program offers a research-intensive degree focused on nanoscience and nanotechnology, with an emphasis on nano-scale materials. A multi-disciplinary core curriculum is taken by students from diverse science and engineering backgrounds. These “core” courses are intended to introduce students to contemporary topics in nanoscience and nanotechnology, and to initiate a cross-disciplinary approach to research and learning. These courses can usually be completed in one, or at most two years. In addition to this core, students entering with an M.S. degree are required to take at least two electives outside the student’s traditional area of training. Students entering at the B.S. level will be expected to pursue, or take coursework equivalent to, an M.S. degree, in addition to the nano core curriculum.

Students from traditional science and engineering backgrounds enter the program with well-defined research interests and affiliate themselves with a research group and a faculty mentor. Current nano program participants draw from the Departments of Chemistry and Physics, and Chemical, Electrical, Materials and Metallurgical, and Mechanical Engineering. Students with traditional training in these areas participate in cross-disciplinary research with a nano focus. Examples of active research areas are: synthesis and characterization of nanocomposite materials, photo-activated nano-inks for direct write applications, nano-energetic materials, polymer chemistry, theory of spintronic devices, and structural and optical characterization of nano-materials for solar energy, bio-fuels and other forms of renewable energy.

The Nano SE Ph.D. program builds on traditional science and engineering disciplines, and offers a “core” curriculum which introduces students from varying science and engineering backgrounds to contemporary topics in nanoscience and nanotechnology. Students are expected to obtain graduate level training in a traditional discipline, designated as the “program major emphasis”, and take a minimum of 6 elective credits outside their own area. Students

entering the program with an M.S. may apply up to 24 transfer credits toward fulfilling the program major emphasis requirements. More information is available in the Nano SE Ph.D. Program Handbook.

Students with an M.S. degree in science or engineering are eligible for admission. However, students with a B.S. degree only will also be considered for admission when the student has proven to possess exceptional qualifications. The Graduate Record Examination (GRE), three letters of recommendation, and a GPA of 3.00 or better are required of all applicants for the Ph.D. program. The TOEFL exam is required for students whose native language is not English.

All candidates for the Ph.D. program are required to successfully complete the following minimum credits and earn a grade of "C" or better, except for a final grade of "S" in NANO 898:

The program of study must be filed with the graduate office, and approved by the Nano SE Ph.D. program director before midterm of the second semester of residence, and again before the qualifying exam. Below is the summary of the required course of study.

<b>Category</b>	<b>Credits</b>	
NANO 701	Nano Materials	3
NANO 702	Theory and Applications of Nanoscale Material Systems	3
NANO 703	Instrumentation & Characterization of Nano Materials	4
NANO 890	Seminar	1
	Program Major Emphasis	26-36
	Dissertation Research	30-40
<b>TOTAL</b>		<b>80</b>

### General Program Requirements

(Minimum program requirements: (80 credits))

M.S. Degree (24 credits)

Students entering the Ph.D. program with a previous M.S. degree in a relevant discipline are allowed to apply a maximum of 24 semester course credit hours toward the course credit requirements subject to approval of the Dean of

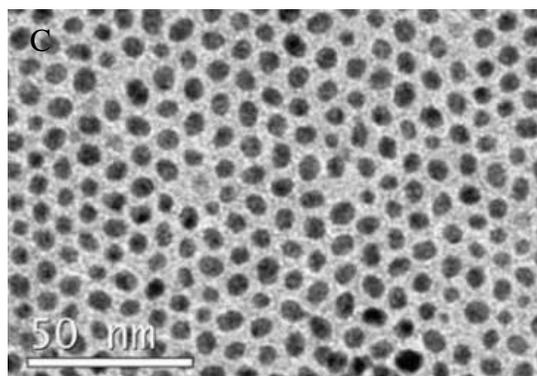
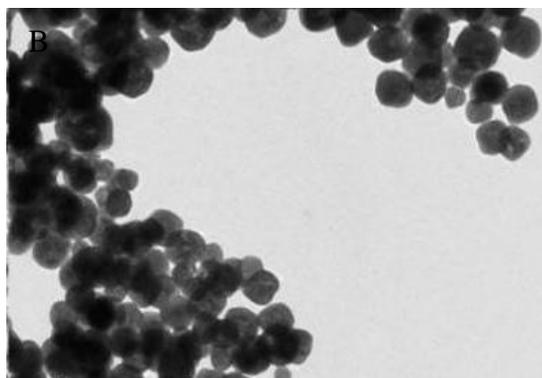
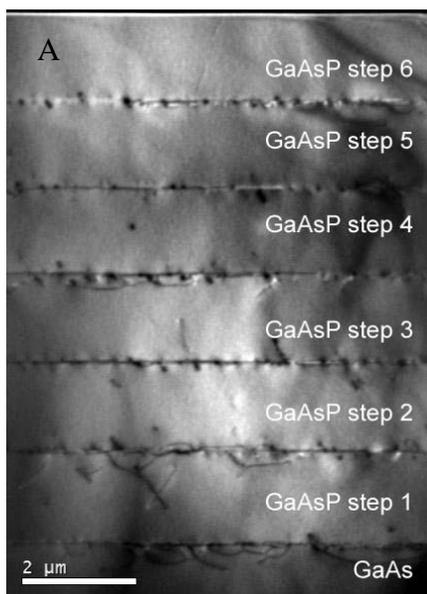
Graduate Education.

The following is a list of electives for each focus area of the program. Graduate level courses which serve the needs of our other graduate programs are also available as electives.

<b>Category Credits</b>		
NANO 445/545	Introduction to Nanomaterials	(3-0)
NANO 504	Nanophotonics	3
NANO 604	Nanophotonic Materials	3
NANO 677	Printed Electronics	3
NANO 704	Crystallography and Structure of Nanomaterials	3
NANO 705	Nanoelectronics	3
NANO 706	Diffraction Methods for Nanomaterials Research	3
NANO 707	Defects in Nanoscaled Materials	3
NANO 708	Nanomaterials for Photovoltaics	3
NANO 712	Electromagnetic Properties of Heterogeneous Materials	3
NANO 715	Polymeric Nanomaterials	3
NANO 717	Nano Chemistry	3
NANO 791	Independent Study	1 to 3
NANO 792	Topics	1 to 3
MES 601	Fundamentals of Materials Engineering	4
MES 603	Condensed Matter Physics	4
MES 604	Chemistry of Materials	4
ME/CBE 612	Transport Phenomena – Momentum	3
ME/CBE 613	Transport Phenomena – Heat	3
CBE 714	Transport Phenomena – Mass	3
PHYS 721	Adv Electricity and Magnetism	3
PHYS 743	Statistical Mechanics	3
PHYS 771	Quantum Mechanics I	3
PHYS 773	Quantum Mechanics II	3
MES 712	Interfacial Phenomena	3
MES 713	Advanced Solid Mechanics	3
MES 728	Heterogeneous Kinetics	3
MES 770	Continuum Mechanics	3

For program supervision purposes, the nano SE Ph.D. program director is the graduate advisor until the major professor is appointed. The major professor is responsible for the student's dissertation research. The graduate office

representative on the student's dissertation committee must be selected from outside of the department with which the major professor is affiliated, and should also be a member of the Nano Ph.D. Advisory Council. It is not necessary that the student be associated with the department of affiliation of his or her major professor. Detailed information on examination policy, admission to candidacy, and defense of dissertation are included in the School of Mines nano science and engineering Ph.D. Program Handbook.



Examples of Nanomaterials synthesized and characterized at School of Mines: A: III-V hetero-junctions for advanced solar cells, B: Upconverting nano-particle phosphors for solar cells, C: Gold Nano-particles used in nano-composite materials.

## Paleontology M.S.



### Contact Information

#### **Dr. Laurie Anderson**

Department of Geology and Geological  
Engineering

Mineral Industries 307

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### Faculty

Professors Anderson and Price; Assistant  
Professor Pagnac; Collections Manager Shelton;  
Haslem Post-doctoral Fellow Wood; Adjunct  
Professors Benton and Martin; Professor Emeritus  
Fox.

### Supporting Faculty

Assistant Professors Terry and Sawyer.

### Paleontology

The master's program in paleontology emphasizes the opportunity for combining field work in western South Dakota with study of the extensive collections of the Museum of Geology. Fossiliferous deposits range from the Jurassic through the Holocene. A student may enter this program with an undergraduate degree in geology, anthropology, one of the biological sciences, or other science disciplines, but for the latter majors,

deficiencies must be completed as listed below. Students with more than 2-3 deficiencies should plan to complete them prior to applying for admission.

Candidates for the M. S. degree must fulfill all degree requirements of the graduate office. The thesis option is the only option for the M.S. in paleontology.

1. All incoming students are expected to present one semester of college-level Physics and two semesters each of college-level Calculus and Chemistry as part of their undergraduate record. Deficiencies in these areas must be remedied by taking the necessary coursework prior to or in the first year of enrollment in the graduate program.
2. All incoming students are expected to have completed courses in, or to develop proficiency in, the following areas. Additional subjects may be required by the student's graduate committee depending on the student's area of interest. The student and the graduate committee will arrange how these requirements can best be met.

- Statistics
- Mineralogy
- Historical Geology
- Invertebrate Paleontology
- Petrology
- Structural Geology
- Stratigraphy and Sedimentation
- Field Geology

No graduate credit will be granted for making up undergraduate-level deficiencies.

The GRE exam is required of all applicants except School of Mines graduates. The TOEFL exam is required for students whose native language is not English.

### Degree Requirements

Thirty-two (32) semester credits are required for the M.S. degree. The following courses must be taken as part of the graduate program of study:

GEOL 632	Rocky Mountain Stratigraphy
GEOL 633	Sedimentation
PALE 671	Advanced Field Paleontology
PALE 673	Comparative Osteology

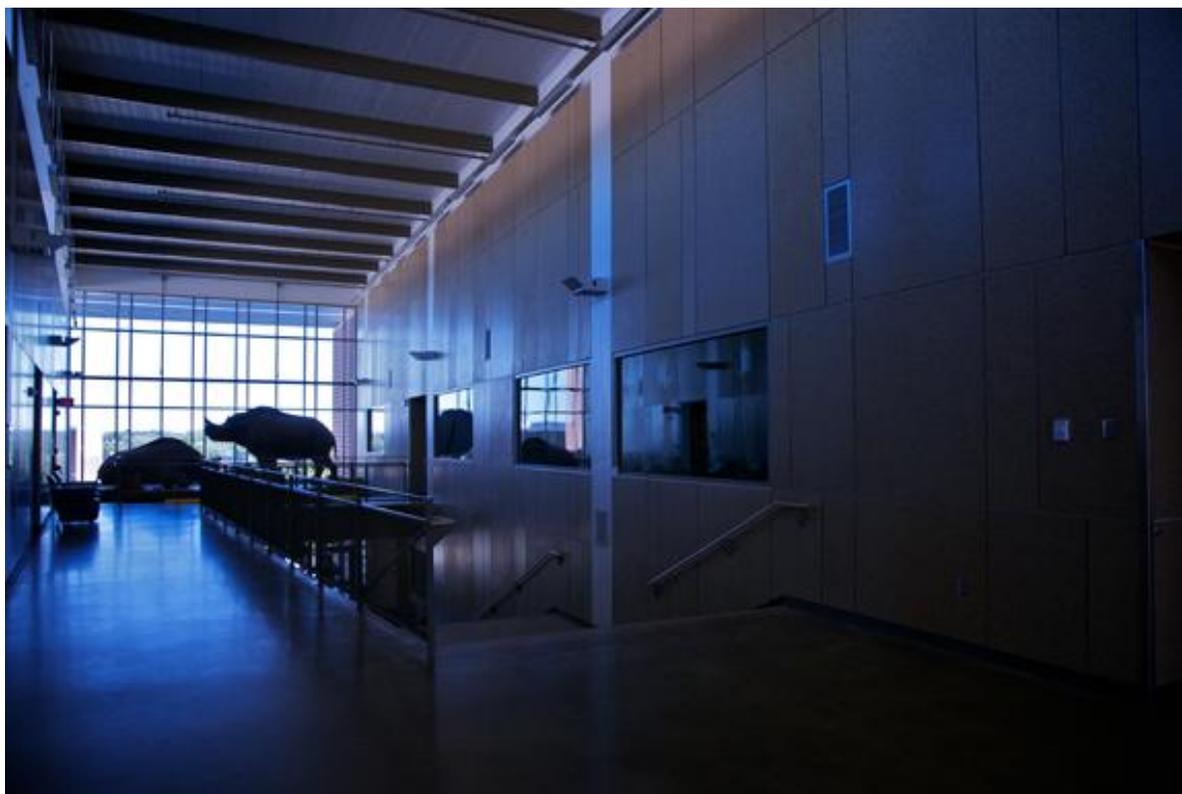
- PALE 676 Vertebrate Paleontology
- PALE 678 Vertebrate Biostratigraphy
- PALE 798 Master's Thesis  
(a minimum of six (6) credits)
- PALE 790 Seminar or approved substitution

The following courses are recommended:

- GEOL 572 Museum Conservation and Curation
- GEOL 573 Museum Preparation Techniques and Exhibit Design
- GEOL 517 Geospatial Databases
- GEOL 519 Advanced Geospatial Analysis
- PALE 672 Micropaleontology
- GEOL 604 Advanced Field Geology or other appropriate courses in geology.

The candidate will pass a reading examination in one of the following languages: French, German, Spanish, or Russian. The examination will consist of translating a paleontology abstract or similar-length passage of technical writing into acceptable English. The student will have two hours to complete the translation and is permitted the use of a bound (not electronic) standard foreign language dictionary.

All thesis samples, specimens, and their documentation collected while at School of Mines must be curated into the systematic collections of the Museum of Geology for future students, scientists, and technologies.



## Physics M.S.



### Contact Information

#### **Dr. Andre G. Petukhov**

Department of Physics

Electrical Engineering/Physics 223

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### Faculty

Professors Foygel, Petukhov, Sobolev; Associate Professor Corey; Assistant Professor Bai.

### Physics

The mission of physics graduate program is to provide students with quality graduate instruction and research experience suitable in many physics-related careers. Required coursework in physics along with elective courses selected from other disciplines such as mathematics, computer science, chemistry and engineering support a number of career options in industry, education and applied research. Graduates with this degree may also pursue a Ph.D. degree in physics. Areas of research concentration include astrophysics, condensed matter, materials science, nuclear and elementary particle physics, and theoretical physics.

#### **Available Options for Degrees**

A (thesis) and B (non-thesis). Option A requires a thesis based on research, while Option B substitutes additional coursework and a research

paper/project for the thesis requirement. The non-thesis options are deemed appropriate for students who do not require Ph.D. preparation in physics in order to be successful in their careers. Examples of career tracks not requiring study in physics beyond the master's level include medical physics, science education at the k-12 and "community college" level as well as various industrial applications. While deemed less appropriate for students advancing to doctoral study in physics, the non-thesis options are a viable and even preferred course of study for some students.

Students should expect that completion of an M.S. degree take two academic years of full-time study.

### **Degree requirements**

**M.S. Physics Option A** requires 19 credit hours of required core courses, 6 credit hours of electives, and 7 credit hours for thesis which leads to total of 32 credit hours.

**M.S. Physics Option B** requires 19 credit hours of required core courses, 11 credit hours of electives, and 2 credit hours for research/design paper which leads to total of 32 credit hours.

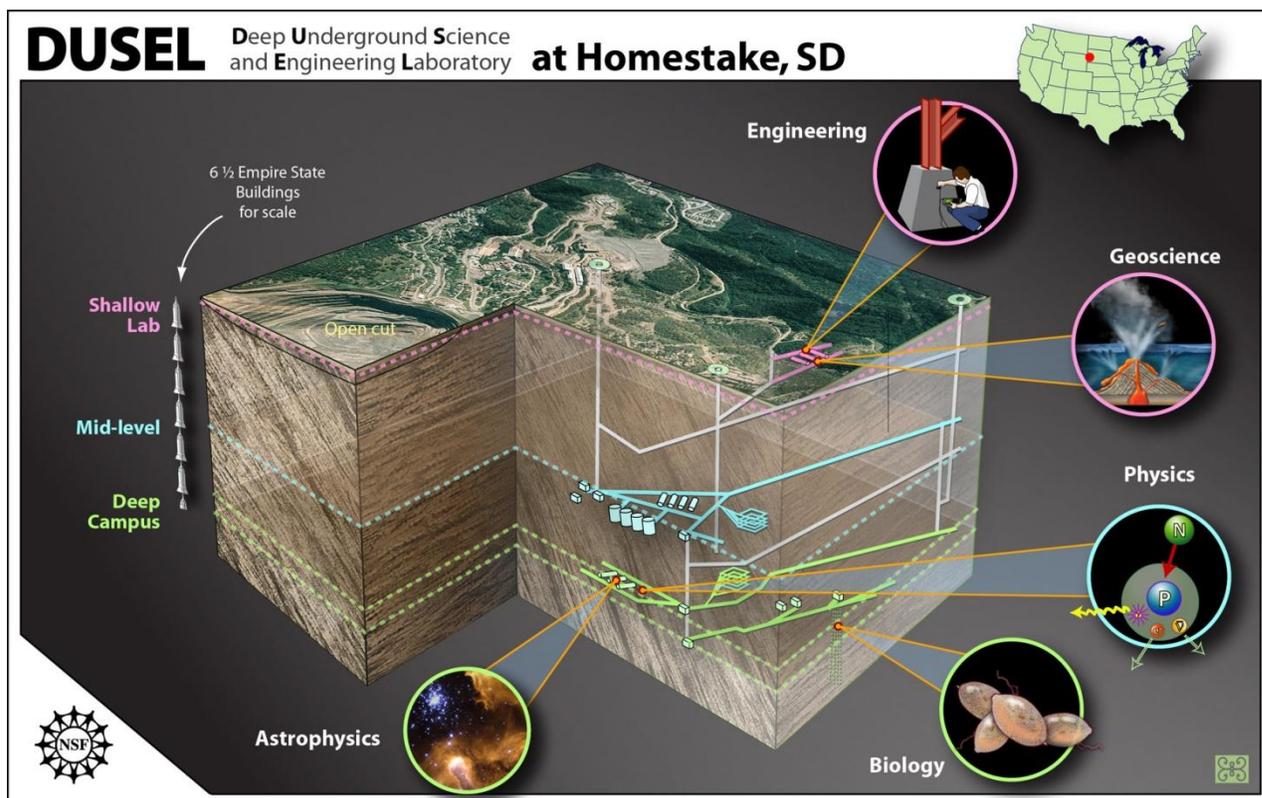
### **Required Core Courses**

PHYS 721 Electrodynamics I	3
PHYS 723 Electrodynamics II	3
PHYS 743 Statistical Mechanics	3
PHYS 751 Classical Mechanics	3
PHYS 771 Quantum Mechanics I	3
PHYS 773 Quantum Mechanics II	3
PHYS 590 Graduate Seminar	1
<b>Subtotals</b>	<b>19</b>

### **Electives**

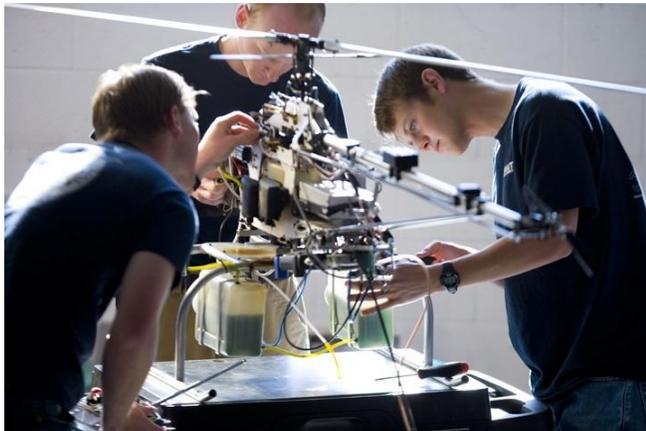
PHYS 533 Nuclear and Particle Physics	3
PHYS 539 Solid State Physics I	4
PHYS 581 Mathematical Physics I	4
MES 603 Condensed Matter Physics	4
PHYS 683 Mathematical Physics II	3
PHYS 691 Independent Study	1-3
PHYS 692 Special Topics	1-3

PHYS 739 Condensed Matter Physics I	3	PHYS 791 Independent Studies	1-4
PHYS 749 Condensed Matter Physics II	3	PHYS 792 Topics	1-4
PHYS 775 General Relativity	3	PHYS 798 Thesis	1-12
PHYS 779 Group Theory	3	<b>Subtotal</b>	<b>29-58</b>
PHYS 781 Nuclear and Particle Physics	3		
PHYS 783 Quantum Field Theory	3	*Offered by SDSU	
PHYS 785 Astrophysics and Cosmology	3	**Offered by SDSU/USD	
PHYS 787 Research*	1-9		
PHYS 788 Master's Research Problems/ Projects**	1-5		



*Mines Matters:* The National Science Foundation selected the former Homestake gold mine as the site for a multipurpose Deep Underground Science and Engineering Laboratory (DUSEL). To learn more about the history of Homestake and DUSEL visit <http://www.lbl.gov/nsd/homestake>.

## **Robotics and Intelligent Autonomous Systems M.S.**



### **Contact Information**

#### **Dr. Jeff McGough**

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<http://rias.sdsmt.edu>

### **Faculty**

Professors Batchelder, Corwin, Dolan, Kalanovic, Korde, Logar, Penaloza and Weiss; Associate Professors Bedillion, Braman, McGough and Tolle; Assistant Professors Hoover and Qiao; Instructors Kanth, Linde and Schrader.

### **Robotics and Intelligent Autonomous Systems**

The Master of Science in Robotics and Intelligent Autonomous Systems (RIAS) is an interdisciplinary, research-oriented degree in an emerging technical area. Students in the program will be required to take courses in computer science, computer engineering, electrical engineering or mechanical engineering. The primary objective of the RIAS program is to give students a basic understanding of the mechanical, electrical and computing systems required to

participate in advanced mobile intelligent robotics applications.

The program covers the essentials of robotics, artificial intelligence, control, communications, sensors and signal processing. Students have the opportunity to gain advanced knowledge in focus areas such as pattern recognition, computer vision, nonlinear control, digital signal processing, and communications. Graduates of this program should have a variety of career options in industrial applications, defense, homeland security, space exploration, or they can pursue study of a more advanced degree. The design and development of intelligent autonomous systems capable of interacting with the environment to complete complex tasks is a rare skill and the discipline is an emerging field.

### **General Background**

Ideally, the entering student will normally have completed a four year degree (B.S.) in either computer engineering, computer science, electrical engineering or mechanical engineering or a closely related field of study. However, any capable and highly motivated student interested in this program is encouraged to apply regardless of academic background. This masters degree is a multidisciplinary degree and it is not expected that students will have the background in all the disciplines that are involved in the program. Leveling courses are offered to help the student gain skills to be successful in the academic areas outside their undergraduate training. Credit by examination is available. In the case of deficits in background, the student may be admitted on a probationary status while they make up missing coursework.

### **Mathematics Background**

- Year of Calculus (Calculus I and II)
- One semester of Multivariate Calculus (Calculus III)
- One semester of Differential Equations
- One semester of probability and statistics is suggested but not required.

## Physics Background

- Two semesters of calculus based physics are suggested but not required

## Programming Background

- Introductory programming course

## Exams

- TOEFL – required for international students
- GRE – recommended but not required

The candidate who qualifies for the degree must satisfy the following requirements:

1. A minimum of 30 credits is required.
2. A minimum of 6 credits of CSC 798 (Master's Thesis) and 24 credits of coursework is required.
3. The twenty four credits coursework is divided into core and elective courses.
  - a. Completion of the 6 credits of core courses: Robotics, Autonomous Systems.
  - b. A minimum of 18 credits of elective courses. Three credits of technical elective selected by the student and advisor may be taken leaving a minimum of 15 credits from the RIAS elective list below.
4. A satisfactory thesis based on individual research. The student must present a formal defense of his or her thesis research.

Additional information can be found in the Graduate Handbook which can be accessed through the RIAS website (<http://rias.sdsmt.edu/>) by clicking on Graduate Handbook.

## Language Requirements

1. Students whose native language is not English are generally required to take the Test Of English as a Foreign Language (TOEFL). Graduate students with a TOEFL score below the Graduate School cutoffs are required to attend a remedial course in English. See Graduate School website for details.

2. There is no foreign language requirement for the M.S. in RIAS degree.

## Curriculum Leveling

Incoming students are not expected to have multiple undergraduate degrees. To address missing pre-requisites for core courses, two "leveling" courses are offered to help prepare students and act as prerequisites for the core classes. These courses do not count toward the 30 required credits. The two leveling courses are EE 505 (Survey of Circuits and Systems) and CSC 505 (Survey of Data Structures and Algorithms.)

Students will get individual assistance to develop their program of study that will meet their academic and professional goals.

### Core Curriculum (Total of 6 credits):

CSC/CENG 515	Robotics
CSC 516	Introduction to Autonomous Systems

### Electives (Total of 15 credits):

#### **Computer Science Courses**

CSC 564	Image Processing/Computer Vision
CSC 549	Pattern Recognition
CSC 533	Graphics
CSC 521	Graphical User Interfaces
CSC 510	Parallel Computing

#### **Computer Engineering Courses**

CENG 420	Digital Signal Processing
CENG 544	Computer Networks
CENG 547	Embedded and Real Time Computer Systems

#### **Electrical Engineering Courses**

EE 624	Advanced Digital Signal Processing
EE 643	Advanced Digital Systems
EE 651	Digital Control System
EE 652	Non-linear Controls

### ***Mechanical Engineering Courses***

ME 623	Advanced Mechanical Vibrations
ME 683	Advanced Mechanical System Control
ME 781	Robotics

**Note:** There is room in the current course rotation for two leveling or background courses without having to extend the time of the degree or overload in hours.

### **Research Areas and Resources**

Currently active research areas include: Autonomy, Computer Vision, Controls, Localization, Mapping, Motion Planning, Navigation.

Some of the active research projects include: Unmanned Aerial Vehicle, Autonomous Underwater Vehicle, Unmanned Ground Vehicle, and Intelligent Controls.

The RIAS program does have two dedicated development labs, but the research and project teams utilize a variety of resources from around campus. Please see the RIAS website for additional information, <http://rias.sdsmt.edu/>



## DEFINITIONS OF ABBREVIATIONS USED IN COURSE DESCRIPTIONS

### Abbreviation Definition

AES	Atmospheric and Environmental Sciences
ANTH	Anthropology
ART	Art
ARTH	Art History
ATM	Atmospheric Sciences
BIOL	Biology
BME	Biomedical Engineering
CBE	Chemical and Biological Engineering
CEE	Civil and Environmental Engineering
CENG	Computer Engineering
CHEM	Chemistry
CHIN	Chinese
CM	Construction Management
CP	Career Planning
CSC	Computer Science
EE	Electrical Engineering
EM	Engineering Mechanics
ENGL	English
ENGM	Engineering Management
ENVE	Environmental Engineering
EXCH	Student Exchange - International
GE	General Engineering
GEOE	Geological Engineering
GEOG	Geography
GEOL	Geology
GER	German
GES	General Engineering and Science
GS	General Studies
HIST	History
HUM	Humanities
IENG	Industrial Engineering
IS	Interdisciplinary Sciences
MATH	Mathematics
ME	Mechanical Engineering
MEM	Mining Engineering and Management
MES	Materials Engineering and Science
MET	Metallurgical Engineering
MSL	Military Science
MUAP	Applied Music

MUEN	Music Ensemble
MUS	Music
NANO	Nanoscience and Nanoengineering
PALE	Paleontology
PE	Physical Education
PHIL	Philosophy
PHYS	Physics
POLS	Political Science
PSYC	Psychology
SOC	Sociology
SPAN	Spanish
SPCM	Speech

Courses above 400 level are normally reserved for graduate studies; however, in some cases, undergraduate students may take graduate level courses.

Students must receive a passing grade of “D” or better for any prerequisite course unless specifically stated.

Black Hills State University offers courses in accounting, business administration, economics, entrepreneurship, and religion.

## **COURSES**

### **AES 790 SEMINAR**

(1-0) 1 credit. Not to exceed 1 credit toward fulfillment of Ph.D. degree requirements. A highly-focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, or research. Seminars may be conducted over electronic media such as Internet and are at the upper division or graduate levels.

### **AES 791 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study that include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

### **AES 792 TOPICS**

1 to 3 credits. Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **AES 808 FUNDAMENTAL PROBLEMS IN ENGINEERING AND SCIENCE**

(3-0) 3 credits. The course, available only for doctoral candidates, involves description, analysis, and proposed methods of attack of long-standing, fundamental problems in science and engineering. Independent work is emphasized with goals of understanding these basic questions and proposing practical designs and experiments for the solution. This course is cross-listed with GEOL 808.

### **AES 898 DISSERTATION**

Credit to be arranged; not to exceed 12 credits toward fulfillment of Ph.D. degree requirements. Open only to doctoral candidates. A formal

treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee. Oral defense of dissertation and research findings is required.

### **ANTH 210 CULTURAL ANTHROPOLOGY**

(3-0) 3 credits. Introduces the nature of human culture as an adaptive ecological and evolutionary system, emphasizing basic anthropological concepts, principles, and problems. Draws data from both traditional and industrial cultures to cover such concepts as values and beliefs, social organization, economic and political order, science, technology, and aesthetic expression.

### **ART 111/111A DRAWING I**

(3-0) 3 credits. Introduces various drawing concepts, media, and processes developing perceptual and technical skills related to accurate observing and drawing.

### **ART 112/112A DRAWING II**

(3-0) 3 credits. Prerequisites: ART 111/111A. Emphasizes the continuing development of essential drawing skills and perceptual abilities as drawing concepts, compositional complexity, and creativity gain importance.

### **ART 491 INDEPENDENT STUDY**

1 to 12 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study that include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **ARTH 211 HISTORY OF WORLD ART I**

(3-0) 3 credits. Art and architecture in the historical and contextual development of the role of visual arts, including crafts, drawing, painting,

sculpture, and architecture, in the historical and cultural development of world civilization from prehistory through the 14th century.

### **ARTH 321 MODERN AND CONTEMPORARY ART**

(3-0) 3 credits. An exploration of technological and cultural influences on materials and content of art from the late 1800s to the present.

### **ARTH 491 INDEPENDENT STUDY**

1 to 9 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study that include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **ARTH 492 TOPICS**

1 to 6 credits. Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A maximum of 6 credits of special topics will be allowed for degree credit.

### **ATM 301 INTRODUCTION TO ATMOSPHERIC SCIENCES**

(3-0) 3 credits. Prerequisites: PHYS 111 or PHYS 113 or equivalent. Basic physical principles are applied to the study of atmospheric phenomena. Topics covered include the structure of the atmosphere, radiative processes, atmospheric motions, meteorological processes, air masses, fronts, weather map analysis, weather forecasting, and severe storms including thunderstorms, hail, tornadoes, hurricanes, and blizzards.

### **ATM 391 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete

individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. May be repeated to a total of 6 credit hours.

### **ATM 392 TOPICS**

1 to 3 credits. Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest experts may serve as instructors. May be repeated to a total of 6 credit hours.

### **ATM 401/501 ATMOSPHERIC PHYSICS**

(3-0) 3 credits. Prerequisites: PHYS 213, MATH 321 or equivalent. An introduction to physical processes that govern the behavior of the atmosphere. Topics will include atmospheric thermodynamics; absorption, scattering and radiative transfer; convective motion, tropospheric chemistry, and cloud and precipitation development; and atmospheric electricity. Satisfies the meteorology distribution requirement for the ATM M.S. program. Students enrolled in ATM 501 will be held to a higher standard than those enrolled in ATM 401.

### **ATM 403/503 BIOGEOCHEMISTRY**

(3-0) 3 credits. Prerequisites: Permission of instructor. The earth system is tightly connected through biogeochemical interactions. This course will present a multi-disciplinary array of intermediate and advanced topics in terrestrial, aquatic, and atmospheric biogeochemistry. Instantaneous to decadal time-scale interactions of carbon, water, and multiple nutrient cycles will be discussed, and a critical survey of the state-of-the-art field modeling, and remote sensing methods for studying biogeochemical cycles will be presented. ATM 503 satisfies the Earth Systems distribution requirement for the ATM M.S. program. Students enrolled in ATM 503 will be held to a higher standard than those enrolled in ATM 403.

### **ATM 404/504 ATMOSPHERIC THERMODYNAMICS**

2 or 3 credits. Prerequisites: PHYS 211 and MATH 225 or permission of instructor. This course will cover topics related to the thermodynamics of the atmosphere, particularly as they apply to a parcel of air. It will include the history of gas laws leading to the ideal gas law, the first and second laws of thermodynamics, adiabatic transformations and the introduction of entropy, the thermodynamic properties of water in its three phases, and the effects of water vapor on the thermodynamics of atmospheric processes. The final third of the course will introduce vertical stability and atmospheric thermodynamic diagrams. Students enrolled in ATM 504 will be held to a higher standard than those enrolled in ATM 404.

### **ATM 405/505 AIR QUALITY**

(3-0) 3 credits. Prerequisites: MATH 125 or equivalent and one semester of college chemistry. Up-to-date problems and trends in urban air quality, global effects of environmental pollution, effects of air pollutants on weather processes, the technology of pollutant production, and pollutant dispersal. A treatment of the chemistry and physics of reactions involving primary air pollutants is included. Satisfies the Earth Systems distribution requirement for the ATM M.S. program. Students enrolled in ATM 505 will be held to a higher standard than those enrolled in ATM 405.

### **ATM 406/506 GLOBAL ENVIRONMENTAL CHANGE**

(3-0) 3 credits. Prerequisites: CHEM 112 or equivalent, PHYS 111 or PHYS 113, BIOL 311 or permission of instructor. Major global environmental changes will be addressed using an interdisciplinary approach. Topics will include basic processes and principles of ecosystems, biogeochemical cycles, major climate controls, and atmospheric chemistry and feedbacks between climate and various earth system processes. Students enrolled in ATM 506 will be held to a higher standard than those enrolled in ATM 406. This course is cross-listed with BIOL 406/506.

**ATM 430/530 RADAR METEOROLOGY**  
(3-0) 3 credits. Prerequisites: MATH 125 and PHYS 213. Fundamentals of radar, scattering of electromagnetic waves by water drops and other hydrometeors, radar equations and the quantitative study of precipitation echoes, hydrometeor size distributions, Doppler weather radars, and applications of radar in meteorology. Satisfies the Techniques distribution requirement for the ATM M.S. program. Students enrolled in ATM 530 will be held to a higher standard than those enrolled in ATM 430.

### **ATM 450/450L SYNOPTIC METEOROLOGY I**

(2-1) 3 credits. Prerequisites: ATM 301. Analysis of surface synoptic weather, upper air, and vertical temperature-moisture soundings; the structure of extratropical storms, synoptic-scale processes responsible for development of precipitation and severe weather phenomena.

### **ATM 455/455L/555/555L SYNOPTIC METEOROLOGY II**

(2-1) 3 credits. Prerequisites: ATM 450/450L and concurrent enrollment in corresponding laboratory module, or permission of instructor. Study and application of modern techniques for forecasting the development and movement of weather systems and for forecasting various weather phenomena. Includes discussion of numerical weather prediction and suite of forecasting models run daily by the National Centers for Environmental Prediction; use of current software packages such as McIDAS and GEMPAK for analyzing observed data and model output; interpreting weather phenomena in terms of dynamical theories; forecasting of convective weather phenomena; and understanding the use of Model Output Statistics (MOS). Satisfies the meteorology distribution requirement for the ATM M.S. program. Students enrolled in ATM 555/555L will be held to a higher standard than those enrolled in ATM 455/455L.

**ATM 460/560 ATMOSPHERIC DYNAMICS**  
(3-0) 3 credits. Prerequisites: MATH 321 and PHYS 211. Equations of motion, kinematics of

fluid flow, continuity equation, vertical motion, theorems of circulation and vorticity, quasi-geostrophic systems, and wave motions in the atmosphere. Satisfies the meteorology distribution requirement for the ATM M.S. program. Students enrolled in ATM 560 will be held to a higher standard than those enrolled in ATM 460.

#### **ATM 491 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. May be repeated to a total of 3 credit hours.

#### **ATM 492 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest experts may serve as instructors. May be repeated to a total of 5 credit hours.

#### **ATM 515/515L EARTH SYSTEMS MODELING**

(2-1) 3 credits. Prerequisites: MATH 125 or equivalent. This course provides the background for earth systems and climate modeling, with student projects on 0-D, 1-D, and 2-D models. The course will cover: radiation balance, climate feedback mechanisms, greenhouse gases, biogeochemical coupling, land and ocean surface processes, ecosystems, ocean circulations, and sea ice. Course will include familiarization of systems modeling using the STELLA modeling package. Students will also collaborate to develop components of a larger modeling project. Satisfies the Techniques distribution requirement for the ATM M.S. program.

#### **ATM 519/519L COMPUTING METHODS IN ATMOSPHERIC SCIENCES**

(2-1) 3 credits. Prerequisites: CSC 150/150L or equivalent. Introduction to the Linux operating system from the user's perspective. Fundamentals of the Fortran 90/95 programming languages. Introduction to scientific data formats commonly used in the meteorology community (netCDF, GRIB, Climate and Forecast Metadata Conventions). Additional material may include shell scripts, and visualization of meteorological data using community based software (IDV, NCAR Command Language). Satisfies the Techniques distribution requirement for the ATM M.S. program.

#### **ATM 520/520L REMOTE SENSING FOR RESEARCH**

(2-1) 3 credits. Prerequisites: MATH 125 or equivalent, CSC 150/150L or equivalent, or permission of instructor. Radiative transfer with respect to satellite remote sensing. Basic IDL programming. Image processing. Image enhancement. Image classification and interpretation. Satellite operations. Overview of operational and research satellite platforms and select applications. The remote sensing of surface and atmospheric features. Labs and student projects. Satisfies the Techniques distribution requirement for the ATM M.S. program.

#### **ATM 540 ATMOSPHERIC ELECTRICITY**

(3-0) 3 credits. Prerequisites: PHYS 213 or equivalent or permission of instructor. This course will cover topics in fair weather electricity including ions, conductivity, currents, and fields making up the global circuit. In addition, topics in thunderstorm electricity including charge separation theories and the microphysical and dynamic interactions responsible for charging, current balances, and the lightning discharge will be introduced. Satisfies the meteorology distribution requirement for the ATM M.S. program.

**ATM 570 WILDFIRE METEOROLOGY**

(3-0) 3 credits. Prerequisites: ATM 301 or equivalent. In this course students will learn about basic physical processes related to fire behavior and fire weather. Topics include combustion and heat, forest fuels, fire danger, fire behavior and spread, fire spread models, smoke management, prescribed fire, and case studies of significant large wildfires in recent history. Some outdoor field instruction is included.

**ATM 591 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

**ATM 592 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

**ATM 603 BIOSPHERE-ATMOSPHERE INTERACTIONS**

(3-0) 3 credits. Prerequisites: Permission of instructor. The biosphere and the atmosphere are intimately connected. In this course, the biogeochemical sources and sinks of a wide range of gases affecting atmospheric chemistry, climate, and ecosystem health are examined in detail. Microbial, plant, and animal processes relating to nitrogen, sulfur, and carbon trace gas production and consumption will be covered in detail. Relevant biophysical phenomena occurring in vegetation canopies, soils, wetlands, and oceans will be discussed. The role of humans in altering these natural processes will be revisited throughout the course, and overviews of trace gas measurement techniques will be presented. Satisfies the Earth Systems distribution requirement for the ATM M.S. program.

**ATM 612 ATMOSPHERIC CHEMISTRY**

(3-0) 3 credits. Prerequisites: One year of college chemistry. Radiative, chemical, and biological processes associated with formation of stratospheric ozone, tropospheric ozone, biogenic emissions and human-caused emissions, "greenhouse" effects, and aqueous-phase equilibria in clouds. The approach will include aspects of classical chemistry, nucleation, instrumentation, and modeling of effects of chemical pollutants on cloud microphysics. Interactions of biological and human-caused emission of trace gases with radiation and oxidant balance of the earth's atmosphere. Topics to be addressed include: stratospheric ozone formation and the "ozone hole," Tropospheric ozone formation, field techniques to measure chemical fluxes, and photochemistry of the remote troposphere. Satisfies the Earth Systems distribution requirement for the ATM M.S. program.

**ATM 625/625L SCALING IN EOSCIENCES**

(2-1) 3 credits. Prerequisites: MATH 125, CSC 150/150L, or equivalent; MATH 442 or equivalent. Issues regarding the scaling of geophysical processes across various problem domains in the geosciences will be presented and explored through lectures, labs and course projects. Topics include Fourier Analysis, Taylor/Moment Expansion, Fractals, Power Laws, and Upscaling/Downscaling Techniques. Applications include Climate, Turbulence, Weather and Climate Prediction, Remote Sensing and GIS, Ecosystem Studies, Geology, and Hydrology. Satisfies the Techniques distribution requirement for the ATM M.S. program.

**ATM 643 PRECIPITATION PHYSICS AND CLOUD MODIFICATION**

(3-0) 3 credits. Prerequisites: ATM 501 or equivalent. Aerosols, condensational drop growth, growth of ice particles by deposition of vapor, accretion, and cloud modification techniques. Emphasis on problem solving with aid of computers. Satisfies the meteorology distribution requirement for the ATM M.S. program.

**ATM 644/644L NUMERICAL DYNAMICS AND PREDICTION**

(2-1) 3 credits. Prerequisites: ATM 560. Basic governing equations, wave motions, baroclinic instability, numerical methods, numerical prediction models; boundary layer, moisture and radiation parameterization, and data assimilation. Satisfies the Techniques distribution requirement for the ATM M.S. program.

**ATM 651/651L MEASUREMENT AND INSTRUMENTATION**

(2-1) 3 credits. Prerequisites: Permission of instructor. An overview of the principles of measurement will be covered, in combination with detailed investigations into instruments designed to measure some of the following phenomena: radiation, temperature, humidity, wind, precipitation, photosynthesis, surface reflectance, and concentrations and fluxes of trace gases. Multiple scale measurement techniques will be addressed. Students will learn to collect, log, and download field data using both manual and automatic methods. An integral part of the course will be a field-based measurement project. The topics covered in this course will vary depending on the research interests of students enrolled and the contributing professors. Satisfies the Techniques distribution requirement for the ATM M.S. program.

**ATM 660 ATMOSPHERIC DYNAMICS II**

(3-0) 3 credits. Prerequisites: ATM 560. Derivation, solution, and physical interpretation of the fundamental hydrothermodynamic equations as applied to atmospheric waves, mesoscale motions, atmospheric energetics, general circulation, tropical and stratospheric flows. Introduction to numerical prediction. Satisfies the meteorology distribution requirement for the ATM M.S. program.

**ATM 670 BOUNDARY LAYER PROCESSES**

(3-0) 3 credits. Prerequisites: ATM 501, ATM 560, or permission of instructor. Atmospheric structure and processes near the ground. Turbulence and the closure problem, buoyancy and stress-driven mixed layers, mixed layer

growth, heat, moisture, and momentum transfer, surface balance of radiation, heat and moisture, parameterization, and modeling of the boundary layer. Satisfies the meteorology distribution requirement for the ATM M.S. program.

**ATM 673 MESOMETEOROLOGY**

(3-0) 3 credits. Prerequisites: ATM 560 or permission of instructor. Observations and analysis of basic meteorological fields on the mesoscale. Dynamics, phenomenology, and forecasting of mesoscale weather phenomena: Internally generated circulations, mesoscale convective systems, externally forced circulations. Mesoscale modeling and nowcasting. Satisfies the meteorology distribution requirement for the ATM M.S. program.

**ATM 690 SEMINAR**

(1-0) 1 credit. Not to exceed 1 credit toward fulfillment of M.S. degree requirements. A highly-focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, or research. Seminars may be conducted over electronic media such as Internet and are at the upper division or graduate levels. Enrollment required of all graduate students in residence each spring semester.

**ATM 691 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

**ATM 692 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

**ATM 798 THESIS**

Credit to be arranged. Not to exceed 6 credits toward fulfillment of M.S. degree requirements. Open only to students admitted to the ATM M.S. program. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

**BIOL 121 BASIC ANATOMY**

(3-0) 3 credits. Anatomy of the human body to include basic biological principles and medical nomenclature. This course is specifically designed for students in the pre-nursing curriculum.

**BIOL 121L BASIC ANATOMY LAB**

(0-1) 1 credit. Pre- or Co-requisites: BIOL 121. Laboratory experience that accompanies BIOL 121. Exercises to complement material in BIOL 121 with special emphasis on the anatomy of the cat.

**BIOL 123 BASIC PHYSIOLOGY**

(3-0) 3 credits. The physiology of the human body. This course is specifically designed for students in a pre-nursing curriculum.

**BIOL 123L BASIC PHYSIOLOGY LAB**

(0-1) 1 credit. Pre- or Co-requisites: BIOL 123. Laboratory exercises to accompany BIOL 123 including non-invasive experimentation and computer demonstration materials.

**BIOL 151 GENERAL BIOLOGY I**

(3-0) 3 credits. The introductory course for those majoring in biology and microbiology. Presents the concepts of cell biology, evolution, heredity, molecular genetics, and ecology.

**BIOL 151L GENERAL BIOLOGY I LAB**

(0-1) 1 credit. Pre- or Co-requisites: BIOL 151. Laboratory experience that accompanies BIOL 151. Laboratory exercises designed to reinforce

subject material covered in BIOL 151 lectures.

**BIOL 153 GENERAL BIOLOGY II**

(3-0) 3 credits. Prerequisites: BIOL 151. A continuation of BIOL 151, the introductory course for those majoring in biology and microbiology. Presents the concepts of animal and plant structure and function, energetics, and reproduction.

**BIOL 153L GENERAL BIOLOGY II LAB**

(0-1) 1 credit. Pre- or Co-requisites: BIOL 153. Laboratory experience that accompanies BIOL 153. Laboratory exercises designed to reinforce subject material covered in BIOL 153 lectures.

**BIOL 231 GENERAL MICROBIOLOGY**

(3-0) 3 credits. Prerequisites: CHEM 106 or CHEM 112. Principles of basic and applied microbiology. Topics covered are bacteriology, virology, microbial genetics, immunology, and disinfection.

**BIOL 231L GENERAL MICROBIOLOGY LAB**

(0-1) 1 credit. Prerequisites: CHEM 106L or CHEM 112L. Pre-or Co-requisites: BIOL 231. Laboratory experience that accompanies BIOL 231. Basic laboratory skills necessary for general microbiology. Emphases are made on techniques of aseptic bacterial transfer, serial dilutions in bacterial cell counts, bacterial staining, and serology.

**BIOL 298 UNDERGRADUATE RESEARCH**

1 to 3 credits. Prerequisites: Permission of instructor. Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses that are theoretical.

**BIOL 311 PRINCIPLES OF ECOLOGY**

(3-0) 3 credits. Basic principles of ecology including the sub disciplines of physiological ecology, population ecology, community ecology, evolutionary ecology, and ecosystems ecology

from both a theoretical and applied aspect.

### **BIOL 341 MICROBIAL PROCESSES IN ENGINEERING AND NATURAL SCIENCES**

(3-0) 3 credits. Prerequisites: CHEM 112. This course introduces and develops important fundamental topics including: microbial structure and chemistry; cellular metabolism; and intercellular processes and extracellular conditions that control microbial behavior, leading to applications such as biocatalysis, biofuels production, environmental bioremediation, food processing, microbial ecology, pharmaceuticals production, environmental microbiology, and wastewater renovation.

### **BIOL 371 GENETICS**

(3-0) 3 credits. Principles governing the nature, transmission and function of hereditary material with application to plants, animals, humans, and microorganisms.

### **BIOL 406/506 GLOBAL ENVIRONMENTAL CHANGE**

(3-0) 3 credits. Prerequisites: CHEM 112 or equivalent, PHYS 111 or PHYS 113, BIOL 311, or permission of instructor. Major global environmental changes will be addressed using an interdisciplinary approach. Topics will include basic processes and principles of ecosystems, biogeochemical cycles, major climate controls, atmospheric chemistry, and feedbacks between climate and various earth system processes. Students enrolled in BIOL 506 will be held to a higher standard than those enrolled in BIOL 406. This course is cross-listed with ATM 406/506.

### **BIOL 423 PATHOGENESIS**

(3-0) 3 credits. Prerequisites: BIOL 231 and CHEM 112. Lecture/discussion course on principles of medical microbiology including the molecular basis of pathogenesis, host-parasite relationship, and pathology of animal and human diseases. Emphasis on current literature in pathogenesis.

### **BIOL 423L PATHOGENESIS LAB**

(0-1) 1 credit. Prerequisites: BIOL 231L or

equivalent; Pre- or Co-requisites: BIOL 423. Basic laboratory skills necessary for pathogenic microbiology. Emphasis is on bacteriological, biochemical and serological tests of medically important pathogens.

### **BIOL 431 INDUSTRIAL MICROBIOLOGY**

(3-0) 3 credits. Prerequisites: BIOL 231 or equivalent. The roles of microbes in nature, industry, and public health are considered. Application of microbiology to engineering is emphasized. Concurrent registration in BIOL 431L recommended but not required.

### **BIOL 431L INDUSTRIAL MICROBIOLOGY LABORATORY**

(0-1) 1 credit. Prerequisites: BIOL 231L or equivalent; Pre- or Co-requisite: BIOL 431. Basic laboratory skills necessary for applied environmental microbiology. Emphasis is on sampling of environmental microorganisms, bacterial growth curve, analysis of water quality, isolation of coliphages, and Ames test for chemical mutagens.

### **BIOL 491 INDEPENDENT STUDY**

1 to 4 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **BIOL 492 TOPICS**

1 to 5 credits. Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **BIOL 691 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and

special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

### **BIOL 692 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **BME 528/528L APPLIED FINITE ELEMENT ANALYSIS**

(2-1) 3 credits. Basic mathematical concepts of finite element analysis will be covered. The students will learn finite element modeling using state of the art software, including solid modeling. Modeling techniques for beams, frames, two and three-dimensional solids, and thin walled structures will be covered in the course. This course is cross-listed with ME 428/428L.

### **BME 601 BIOMATERIALS**

(3-0) 3 credits. This course will provide students with an overview of the field of biomaterials with the knowledge necessary to conduct biomedical product development and/or biomaterials research. The first portion of the course will provide an introduction to the major classes of materials used in medical devices including metals, polymers, ceramics, composites, and natural materials. Topics covered will include material properties, material processing, testing, corrosion, biocompatibility, tissue responses, etc. The second portion of the course will cover specific biomaterial applications such as dental, orthopedic, cardiovascular, drug delivery, and tissue engineering. The topics of implant cleanliness and sterilization methods will also be discussed. In addition, the topic of national and international governmental regulations and requirements will be reviewed including examples of investigative devices exemptions and 510k submissions. This course is cross-listed with

MET 601.

### **BME 602 ANATOMY AND PHYSIOLOGY FOR ENGINEERS**

(3-0) 3 credits. Introduces biomedical engineering students to fundamentals of human anatomy and physiology. Topics include engineering anthropometry, the skeletal system, skeletal muscle, the neuromuscular control system, the respiratory system, the circulatory system, the metabolic system, the thermoregulatory system, body rhythms, and an introduction to reengineering the human body.

### **BME 603 MOLECULAR BIOLOGY FOR ENGINEERS**

(3-0) 3 credits. This course is designed to provide a basic knowledge on molecular biology and bioinformatics that is directly applicable to engineering and related science fields. Up-to-date techniques in genetic engineering biotechnology, and bioinformatics will be introduced for the understanding of biological problems using engineering concepts or engineering/mechanical problems through biological tools. This course is cross-listed with CBE 603

### **BME 604 SENSING AND SIGNAL PROCESSING**

(3-0) 3 credits. Presentation of principles, characteristics, and applications of instrumentation systems including, sensors, filters, instrumentation amplifiers, analog-to-digital and digital-to-analog conversions, and noise. This course will be useful to graduate students beginning their laboratory thesis research. It is available to students from other departments with permission of instructor.

### **BME 606 OCCUPATIONAL BIOMECHANICS**

(3-0) 3 credits. Anatomical and physiological concepts are introduced to understand and predict human motor capabilities, with particular emphasis on the evaluation and design of manual activities in various occupations. Quantitative models are developed to explain muscle strength performance; cumulative and acute musculoskeletal injury; physical fatigue; and

human motion control.

### **BME 607 BIOMECHANICS**

(3-0) 3 credits. This course presents an introduction to biomechanics from a continuum mechanics perspective. It covers fundamental concepts of solid and fluid mechanics with applications to living systems. Topics in biosolid mechanics include stress, strain, constitutive relations, equilibrium, response to basic loading modes (extension, bending, and torsion), and buckling. Topics in biofluid mechanics include motion of a continuum, constitutive relations, fundamental balance relations, control volume and semi-empirical methods.

### **BME 608 BIOMEDICAL ENGINEERING**

(3-0) 3 credits. This course provides basic concepts in Biomedical Engineering. Topics covered include materials for biomedical engineering, cellular and molecular processes for biomedical engineering, biological sensing, and experimental design.

### **BME 610 EXPERIMENTAL DESIGN AND DATA ANALYSIS IN BIOLOGICAL ENGINEERING**

(3-0) 3 credits. This course is intended to introduce students to basic concepts and tools of experimental design and statistical analysis in the biomedical research. We will discuss how to design and execute an experiment and how to use various statistical tools to estimate data parameters and test hypotheses. It is expected that students will be able to formulate a rational hypothesis from biological theory, design an experiment to test the hypothesis, and use an appropriate statistical analysis to examine the hypothesis and interpret the results upon completion of this course. The primary objective of this course is to help students understand the methodological and practical principles needed to undertake biological research and evaluate others' research as published in the biomedical literature.

### **BME 673 APPLIED ENGINEERING ANALYSIS I**

(3-0) 3 credits. Advanced topics in engineering analysis. Special mathematical concepts will be

applied to mechanical engineering problems. Topics will be selected from the following: Fourier series and boundary value problems applied to heat conduction and convection, Laplace transforms and complex variable analysis applied to vibrations and dynamic system analysis, series solutions of differential equations, partial differential equations, general matrix applications to a variety of large systems of equations in engineering, calculus of variation, and Ritz method for various engineering problems. This course is cross-listed with ME 673.

### **BME 724 BIOPOLYMERS**

(3-0) 3 credits. This course is to survey the structure, function, properties and use of biopolymers. The course has three fifty minute lectures per week on Monday, Wednesday and Friday. Supporting reading materials will be assigned from the textbook and supplementary reading materials (see the list above). Please note that the textbook is meant to supplement the lectures, not to substitute for them; you will ONLY be responsible for the materials presented in the lectures.

### **BME 725 BIOCOSITES**

(3-0) 3 credits. This course focuses on composite materials applied to bioengineering. First part of the course introduces biocomposites for medical applications and biocompatibility. Second part focuses on mechanical design and manufacturing aspects of various fibrous polymer matrix composites in terms of: i) material selection, fabrication, and characterization, ii) mechanics of composite materials, iii) design with composite materials. Third part deals with ceramic or nano composites and their applications in biomedical engineering. Final part introduces various case studies such as dental, orthopedics, prosthetic socket, and external fixator applications.

### **BME 726 BIOCOSITES BIO/MEMS AND NANO SYSTEMS**

(3-0) 3 credits. Application of microelectromechanical systems (MEMS) and nano-systems to biological systems, interaction of living cells and tissues with MEMS substrates and nano-engineered materials, microfluidics,

engineering of inputs and outputs.

### **BME 730 VASCULAR MECHANICS AND PATHOLOGY**

(3-0) 3 credits. The course focuses on the artery and arterial diseases including the genesis of heart disease. Since the artery serves as both a conduit of blood flow and a container of blood pressure, the course covers both the general principles and the occurrence of stress concentration in the pressure vessel. The topics included are atherosclerosis, structure and mechanics of artery, pressure vessel principles, stress concentration in the artery, endothelial cells and low density lipoproteins, smooth muscle cells and stretch, stress reduction and atherosclerosis reduction, the vein graft, intracranial aneurysms, and aortic aneurysms.

### **BME 731 ADVANCED BIOMECHANICS**

(3-0) 3 credits. The course presents the fundamentals of continuum mechanics and nonlinear theory of elasticity with applications to the mechanical behavior of soft biological tissues.

### **BME 732 MEDICAL IMAGING**

(3-0) 3 credits. This course covers the physics of the major modalities commonly used in medical imaging. Also covered are the various principles and methods of constructing an image from the physical interactions of energy with living tissue, and the influence on image quality of the different modalities. Medical imaging systems to be analyzed include conventional X-ray, computed tomography (CT), magnetic resonance imaging (MRI), nuclear medicine (PET and SPECT), and ultrasound. Each of these modalities will be introduced from basic physical principles to the process of image formation. The primary focus is on the physical principles, instrumentation methods, and imaging algorithms; however, the medical interpretation of images, and clinical, research and ethical issues are also included where possible to give students a deeper understanding of the medical imaging field.

### **BME 733 CARDIOVASCULAR FLUID DYNAMICS**

(3-0) 3 credits. Mechanics of blood circulation,

fluid mechanics of the heart, blood flow in arteries, unsteady flow in veins, current concepts in circulatory assist devices, biofluidics, and other selected topics. Review of cardiovascular physiology; introduction to fluid mechanics; models of blood flow and arterial wall dynamics; fluid mechanics and arterial disease; heart valve fluid dynamics; ventricular assist devices.

### **BME 734 TRANSPORT PHENOMENA IN BIOMEDICAL ENGINEERING**

(3-0) 3 credits. The study of transport phenomena in biomedical systems including analysis of engineering and physiological systems and incorporation of these principles into the design of such systems. The objective of this course is for students to learn to think about, understand and model the dynamic behavior of complex biological systems. The scope of the systems to be studied is restricted to an analysis of biotransport phenomena in the human body.

### **BME 735 CAD/CAM IN MEDICINE AND SURGERY**

(3-0) 3 credits. Introduction to computer aided design and modeling of prosthetic devices, and their subsequent manufacture using computer aided manufacturing techniques. Applications in orthopedic implant design and fabrication, dental implant design and fabrication, as well as other types of prosthetics. An advanced level review of current computer modeling and manufacturing technology for medical applications.

### **BME 736 ADVANCED FINITE ELEMENT METHODS**

(3-0) 3 credits. Variational and weighted residual approach to finite element equations. Emphasis on two- and three-dimensional problems in solid mechanics. Isoparametric element formulations, higher order elements, numerical integration, imposition of constraints, convergence, and other more advanced topics. Introduction to geometric and material nonlinearities. Introduction to the solution of dynamic problems and time integration. Use of finite element computer programs. This course is cross-listed with ME 736.

### **BME 737 ADVANCED SIGNAL PROCESSING AND IMAGING**

(3-0) 3 credits. This course develops the theory essential to understanding the algorithms that are increasingly found in modern signal processing applications, such as speech, image processing, digital radio and audio, statistical and adaptive systems. Topics include: analysis of non-stationary signals, transform techniques, Wiener filters, Kalman filters, multirate systems and filter banks, hardware implementation and simulation of filters, and applications of multirate signal processing. Matlab will be used extensively.

### **BME 738 INFORMATION TECHNOLOGY IN MEDICINE**

(3-0) 3 credits. Software techniques used in medical treatment and diagnosis, including transform techniques. Medical reference software engineering. Data mining. Hardware and connectivity issues. Bioinformatics.

### **BME 740 BIOMATERIALS SURFACE SCIENCE AND ENGINEERING**

(3-0) 3 credits. This course focuses on the surface properties of biomaterials and their influence on biological and clinical outcomes. Specifically, the general surface properties of biomaterials such as surface chemistry, surface morphology, surface roughness, and surface charges will be explained. The course will cover the different instrumentation that is currently available to characterize biomaterial surfaces. Also, a variety of surface modification technologies available to engineer biomaterial surfaces will be covered as well. Example cases will be provided regularly to emphasize the biological and clinical significance of biomaterial surfaces.

### **BME 745 MOLECULAR MACHINES**

(3-0) 3 credits. This course studies forces that determine molecular structure, transport, and diffusion, macromolecular assemblies, protein synthesis, structural biology, molecular genetics, enzymology.

### **BME 746 BIOMIMETICS**

(3-0) 3 credits. This course will survey recent research at the intersection of biology and mechanical/structural engineering, in particular, applications where nature's design philosophies are applied in human-engineered structures. Multi-functional materials, hierarchical design, adaptive materials within closed loop systems, self-healing of natural structures, with a view to self-healing human engineered structures. Applications in aerospace and rehabilitation engineering.

### **BME 751 DRUG DELIVERY**

(3-0) 3 credits. This course focuses on the engineering and biomolecular principles of drug therapy. Students will be introduced to the fundamentals of drug delivery, materials used for drug delivery, and controlled/targeted drug delivery strategies.

### **BME 761 BIOADHESIVES**

(3-0) 3 credits. This course will provide a survey of natural and synthetic biological adhesives that are of importance in biomedicine. Main topics include fundamentals of bioadhesion, methods of evaluating bioadhesive interactions, and concepts and strategies in designing bioadhesive systems for biomedical applications.

### **BME 773 APPLIED ENGINEERING ANALYSIS II**

(3-0) 3 credits. Applications of numerical methods to mechanical engineering problems. Topics will include data processing techniques, curve fitting and interpolation of experimental information, solutions to systems of ordinary differential equations, solutions to partial differential equations, and numerical integration both of known functions and functions described only by experimental data. This course is cross-listed with ME 773.

### **BME 788 MASTER'S RESEARCH PROBLEMS/PROJECT**

1 to 12 credits. Independent research problems/projects that lead to research or design paper, but not to a thesis. The plan of study is negotiated by the faculty member and the

candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

### **BME 790 SEMINAR**

(1-0) 1 credit. May not be repeated for degree credit. A highly-focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as Internet and are at the upper division or graduate levels.

### **BME 792 TOPICS**

1 to 4 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **BME 798 THESIS**

Credit to be arranged; not to exceed 6 credits toward fulfillment of M.S. degree requirements. Open only to students pursuing the M.S. thesis option. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

### **BME 888 DIRECTED RESEARCH IN BME – PHD**

1 to 12 credits. Independent research problems/projects that lead to research or design paper, but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

### **BME 896 FIELD EXPERIENCE**

(0-1) 1 credit. Students will spend a minimum of three hours per week in a hospital or another program-approved health care facility. They will

observe and/or work with the technical and clinical staff in order to develop insights into the health care profession and the role of engineering in medicine as it applies to their focus area of study and research. Required of doctoral students only.

### **BME 898 DISSERTATION**

Credit to be arranged; not to exceed 30 credits toward fulfillment of Ph.D. degree requirements. Open only to doctoral candidates. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

### **CBE 111/111L INTRODUCTION TO CHEMICAL PROCESS MODELING**

(1-1) 2 credits. Pre- or Co-requisites: CHEM 112. The primary objectives of this course are: introduction to mathematical modeling of physical and chemical systems; verification of mathematical models by experiment; introduction to engineering software like Excel; development and interpretation of engineering drawings, process flow diagrams (PFD's), and piping and instrumentation diagrams (P&ID's); use of drawing program, such as Visiotec; and introduction to the process simulator AspenPlus; Oral and written communication of technical content to technical and non-technical audiences; and a focus on professional and academic paths in chemical engineering and related fields. This course is cross-listed with ENVE 111/111L.

### **CBE 117L PROGRAMMING FOR CHEMICAL AND BIOLOGICAL ENGINEERING**

(0-1) 1 credit. Pre- or Co-requisites: MATH 123. An introduction to chemical engineering through the development of computational and laboratory skills. The extended use of spreadsheets, programming, and computational software packages will be covered. Elementary numerical methods will be utilized in process modeling and laboratory experiments. Students will participate

in hands-on programming exercises in a computer laboratory, or in a lab, using a tablet-pc.

**CBE 200 UNDERGRADUATE RESEARCH**

1 to 3 credits. Prerequisites: Permission of instructor and freshman or sophomore standing. Directed research or study of a selected problem culminating in an acceptable written report.

**CBE 217 CHEMICAL ENGINEERING MATERIAL BALANCES**

(3-0) 3 credits. Pre- or Co-requisites: CHEM 114 and MATH 123 or permission of instructor. The first course on the theory and practice of chemical engineering with emphasis on material and energy balances. This course is cross-listed with ENVE 217.

**CBE 218 CHEMICAL ENGINEERING FLUID MECHANICS**

(3-0) 3 credits. Prerequisites: CBE 217, MATH 125. The second course on the theory and practice of chemical engineering with emphasis on momentum transfer.

**CBE 222 CHEMICAL ENGINEERING PROCESS THERMODYNAMICS**

(3-0) 3 credits. Prerequisites: CBE 217 and MATH 125. A study of the principles and applications of thermodynamics with emphasis on the first law, the energy balance.

**CBE 250 COMPUTER APPLICATIONS IN CHEMICAL ENGINEERING**

(2-0) 2 credits. Pre- or Co-requisites: MATH 321, CBE 117L or equivalent. The application of digital computer techniques to the solution of chemical engineering problems.

**CBE 317 CHEMICAL ENGINEERING HEAT TRANSFER**

(3-0) 3 credits. Prerequisites: CBE 218, CBE 250 and MATH 321 or permission of instructor. The third course on the theory and practice of chemical engineering with emphasis on heat transfer. Heat transfer by conduction, convection, and radiation is studied. This course is cross-listed with ENVE 315.

**CBE 318 CHEMICAL ENGINEERING MASS TRANSFER**

(3-0) 3 credits. Prerequisites: CBE 317 or ENVE 315 or permission of instructor. The fourth course on the theory and practice of chemical engineering with emphasis on molecular diffusion, membranes, convective mass transfer, drying, humidification, and continuous gas-liquid separation processes. This course is cross-listed with ENVE 316.

**CBE 321 CHEMICAL ENGINEERING EQUILIBRIUM THERMODYNAMICS**

(3-0) 3 credits. Prerequisites: CBE 222 and MATH 225. A continuation of CBE 222 with emphasis on the second and third laws of thermodynamics. Emphasis on thermodynamic properties of fluids, flow processes, phase and chemical equilibria.

**CBE 333 PROCESS MEASUREMENTS AND CONTROL**

(1-0) 1 credit. Prerequisites: CBE 218 or permission of instructor. A study of the equipment and techniques used in monitoring process measurements and the design of feedback control systems.

**CBE 333L CHEMICAL ENGINEERING PROCESS CONTROL LABORATORY**

(0-1) 1 credit. Pre- or Co-requisites: CBE 333. Laboratory experiments in process measurements, feedback control loops, and industrial data acquisition and control.

**CBE 343 CHEMICAL KINETICS AND REACTOR DESIGN**

(3-0) 3 credits. Prerequisites: CBE 317 and CBE 321 or permission of instructor. A study of chemical kinetics and reactor design, including techniques for analyzing kinetic data, choosing reactor operating parameters, economic optimization of homogeneous reactions, and reactor modeling.

**CBE 361L CHEMICAL ENGINEERING FLUID LABORATORY**

(0-1) 1 credit. Pre- or Co-requisites: CBE 218.

Laboratory experiments in fluid flow, fluid flow measurements, and design of fluid handling systems.

**CBE 362L CHEMICAL ENGINEERING HEAT TRANSFER LABORATORY**

(0-1) 1 credit. Prerequisites: CBE 317. Laboratory experiments on heat transfer.

**CBE 364 CHEMICAL PROCESS DESIGN, ECONOMICS, AND SAFETY**

(0-2) 2 credits. Prerequisites: CBE 218 and CBE 222 or permission of instructor. Chemical process design and economics topics may include time value of money, DCFROR/NPV analysis of projects & investment alternatives, after tax analysis estimation of process operating costs, use of heuristics for equipment sizing, and estimation of process capital equipment costs. Safety topics may include toxicology & industrial hygiene, source models, properties & prevention of fires & explosions, relief design & sizing, and hazards identification.

**CBE 417 CHEMICAL ENGINEERING EQUILIBRIUM SEPARATIONS**

(2-0) 2 credits. Prerequisites: CBE 321. The fifth course on the theory and practice of chemical engineering with emphasis on equilibrium staged separations.

**CBE 424/524 MOLECULAR MODELING AND SIMULATION**

(3-0) 3 credits. Prerequisites: CBE 321 and CHEM 114 or permission of instructor. Course covers topics related to computational quantum chemistry, statistical mechanics, and molecular simulation. Emphasis is on the use of existing methods and programs to determine thermodynamic and transport properties as well as reaction kinetic constants and mechanisms. Applications in biological systems, materials, phase equilibrium, and combustion will be discussed. Discussion of the benefits and limitations of computer simulations will accompany each course topic. Student enrolled in CBE 524 will be held to a higher standard than those enrolled in CBE 424.

**CBE 433 PROCESS CONTROL**

(3-0) 3 credits. Prerequisites: MATH 321 and senior standing. Analysis and design of process control systems for industrial processes, including controller tuning and design of multivariable control schemes. This course is cross-listed with MET 433.

**CBE 434 DESIGN OF SEPARATION PROCESSES**

(1-0) 1 credit. Prerequisites: CBE 318. Separation technology and processes are studied with application to current industrial design problems. Topics and design case studies may include: absorption, adsorption, biological separations, crystallization, distillation, environmental separations, ion exchange, membrane separations, molecular distillation, pervaporation, solid separations, supercritical extraction, thermal stripping, and others.

**CBE 434L DESIGN OF SEPARATION PROCESSES LABORATORY**

(0-1) 1 credit. Pre- or Co-requisites: CBE 434. Laboratory experiments in the design of separation processes, including reverse osmosis, crystallization, ultrafiltration, microfiltration, gas permeation, ion exchange, adsorption, and others.

**CBE 444/544 REACTOR DESIGN**

(3-0) 3 credits. Prerequisites: CBE 343, CBE 250. Applications of chemical engineering principles to reactor design. Emphasis includes: non-isothermal reactor modeling, homogeneous and heterogeneous reactors, economic and performance optimization, catalysis, and computer simulation. Students enrolled in CBE 544 will be held to a higher standard than those enrolled in CBE 444.

**CBE 445/545 OXIDATION AND CORROSION OF METALS**

(3-0) 3 credits. Prerequisites: MET 320, or CBE 222 or ME 211 or permission of instructor. Initially, the thermodynamics of electrochemical processes are covered; use of the Nernst equation and Pourbaix diagram is presented in this material. Fundamentals of electrode kinetics are

then discussed with special emphasis on the derivation of the Butler-Volmer equation and application of the Evan's diagram. Following presentation of these fundamental concepts, phenomena observed in corrosion and oxidation such as uniform attack, pitting, stress corrosion cracking, and corrosion fatigue are discussed. Finally, selection of materials for site specific applications is covered. Students enrolled in CBE 545 will be held to a higher standard than those enrolled in CBE 445. This course is cross-listed with MET 445/545.

### **CBE 450/550 SYSTEMS ANALYSIS APPLIED TO CHEMICAL ENGINEERING**

2 to 3 credits. Pre- or Co-requisites: CBE 417, CBE 433, or permission of instructor. The development of mathematical models for dynamic and steady state chemical engineering systems; simulation of these complex systems using computers and software, such as AspenPlus; estimation of physical and equilibrium properties; and analysis of results. Students enrolled in CBE 550 will be held to a higher standard than those enrolled in CBE 450.

### **CBE 455/555 POLLUTION PHENOMENA AND PROCESS DESIGN**

(3-0) 3 credits. Prerequisites: CBE 218, CBE 317, and CBE 417, or equivalent, or permission of instructor. The study of the industrial sources of and treatment of air, water, and land pollutants. The chemical and physical phenomena operating in pollution control equipment and the design of pollution control equipment will be examined. Waste minimization and pollution prevention strategies will be considered. Students enrolled in CBE 555 will be held to a higher standard than those enrolled in CBE 455.

### **CBE 461L CHEMICAL ENGINEERING MASS TRANSFER AND REACTION ENGINEERING LABORATORY**

(0-1) 1 credit. Prerequisites: CBE 318, CBE 343 and CBE 417. Laboratory experiments on mass transfer.

### **CBE 463 PROCESS DESIGN FOR CHEMICAL ENGINEERING**

(0-2) 2 credits. Prerequisites: CBE 318, CBE 343. Pre- or Co-requisites: CBE 417 or permission of instructor. Topics may include conceptualization of chemical processes and evaluation and selection of process alternatives, inherently safer process design, synthesis of BFDs and PFDs, use of process simulators for synthesis and optimization. Students will work in groups on a common process design project, culminating in a Phase II process design (PFD level design) including process description, evaluation of alternatives, economics, and safety.

### **CBE 465 ADVANCED PROCESS AND EQUIPMENT DESIGN**

(0-2) 2 credits. Prerequisites: CBE 317 or permission of instructor. Course topics featuring design of processes and equipment unit operations, such as: filtration, cyclones/hydrocyclones, sedimentation, centrifuges, vacuum system sizing and leakages, particle sizing analysis via sieves, PSA, SEM, TEM, mixers (HT, MT, etc), dispersion of 2<sup>nd</sup> phase and droplet sizes, S,L, V dispersions, compressors, removal of liquid, size reduction/enlargement, process piping/equipment, and crushers. Coverage may also include the principles of heat exchange networks, heat integration, and process optimization.

### **CBE 466 CAPSTONE DESIGN FOR CHEMICAL ENGINEERING**

(0-2) 2 credits. Prerequisites: CBE 463 or permission of instructor. Students will work in design teams to complete a semester-long capstone design project. The course format is predominantly design project based, featuring weekly meetings with faculty mentors. Projects will be open-ended, and may vary from group to group. Projects may involve troubleshooting/optimization/redesign of an existing process. The final design package should include a comprehensive final report with PFDs, P&IDs, equipment specification sheets, and safety and economic analysis.

**CBE 474/574 POLYMER TECHNOLOGY**  
2 to 3 credits. Prerequisites: Senior standing or permission of instructor. A study of the engineering aspects of polymer synthesis and reactor design, polymer testing, polymer characterization, rheology, macro-properties, and fabrication. Students may enroll for 2 or 3 credits, depending upon the particular level of course matter that matches their interest. Students taking 2 credits will take two-thirds of the course material. The instructor, in conjunction with the department head, will monitor student credit hours. Course is not repeatable for credit. Students enrolled in CBE 574 will be held to a higher standard than students enrolled in CBE 474.

**CBE 474L/574L EXPERIMENTAL POLYMER TECHNOLOGY**  
(0-1) 1 credit. Pre- or Co-requisites: CBE 474 or CBE 574. Laboratory experiments in polymer synthesis, chemical and mechanical property testing, extrusion, and modeling. Students enrolled in CBE 574L will be held to a higher standard than students enrolled in CBE 474L.

**CBE 475/575 ADVANCES IN PROCESSING AND NANOENGINEERING OF POLYMERS**  
(2-0) 2 credits. Prerequisites: CHEM 114 and CHEM 114L or MES 604 or permission of instructor. The course will begin with an overview of the basic principles of polymer rheology and structure formation. It will then review recent examples from the scientific literature in which concepts and theories of rheological behavior and structure formation at multiple length scales have been further developed and/or applied to the processing of polymers and composites with advanced functional and multifunctional properties. Special attention will be paid to research related to processing challenges in the formation of polymer nanocomposites, nanofibers and hierarchical composite structures. As part of this course, students will be expected to develop skills in reviewing and critically assessing the scientific literature, and in developing research strategies based on current state of knowledge. Students

enrolled in CBE 575 will be held to a higher standard than students enrolled in CBE 475. This course is cross-listed with MES 475/575 and NANO 475/575.

**CBE 476/576 ORGANOSILICON POLYMER CHEMISTRY AND TECHNOLOGY**  
(1-0) 1 credit. Prerequisites: Senior standing or permission of instructor. An introduction to the engineering and science aspects of silicone-organic polymer chemistry from an industrial viewpoint. The course covers basic silicone nomenclature, monomer and polymerization reactions, curing, reinforcement, general applications, and hands-on laboratory exercises, which includes making things like elastomeric (bouncy) putty and hi-bouncing balls. The course is held during a one week period. Students enrolled in CBE 576 will be held to a higher standard than students enrolled in CBE 476.

**CBE 484/584 FUNDAMENTALS OF BIOCHEMICAL ENGINEERING**  
(3-0) 3 credits. Prerequisites: CBE 343 and BIOL 231 or BIOL 341. An introduction to the characterization of microorganisms, fermentation pathways, unit processes in fermentation, biochemical kinetics, and batch and continuous fermentation. The basic engineering concepts of fermentation, separation, control, and operations will be discussed. Students enrolled in CBE 584 will be held to a higher standard than those enrolled in CBE 484.

**CBE 484L/584L BIOCHEMICAL ENGINEERING LABORATORY**  
(0-1) 1 credit. Pre- or Co-requisites: CBE 484 or CBE 584. Laboratory experiments in biochemical engineering. May include fermentation, dissolved oxygen mass transfer measurements, bioseparations, and other experiments to correlate with selected lecture topics. Students enrolled in CBE 584L will be held to a higher standard than those enrolled in CBE 484L.

**CBE 487 GLOBAL AND CONTEMPORARY ISSUES IN CHEMICAL ENGINEERING**  
(1-0) 1 credit. Pre-or Co-requisites: CBE 465. A study of contemporary global and societal issues

in the field of chemical engineering.

### **CBE 488/588 APPLIED DESIGN OF EXPERIMENTS FOR THE CHEMICAL INDUSTRY**

(2-0) 2 credits. Prerequisites: Senior standing or permission of instructor. An introduction to the engineering concepts of statistics and design of experiments as applied to chemical and biological engineering problems. Includes set up and experiments for product development or for process trials. Includes critical analysis of results of an experimental design project. The course is held during a time period that will accommodate class members and industrial speakers. Students enrolled in CBE 588 will be held to a higher standard than students enrolled in CBE 488.

### **CBE 489 COMPOSITES MANUFACTURING**

(1-0) 1 credit. A background in the concepts of polymers and polymerization as well as an overview of composites concepts, constituent materials, and manufacturing processes provide the groundwork in the first half of the course. A more detailed study of the Vacuum Assisted Resin Transfer molding (VARTM) processing builds upon this groundwork, including topics such as process materials and parameters, mold design and manufacture, and product design considerations. This course concludes with post-processing topics. In conjunction with the concepts lecture, students spend time in the lab constructing and using a simple mold which will illustrate some of the challenges of molding and finishing a composite product. This course is cross-listed with MET 489.

### **CBE 491 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **CBE 492 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A maximum of 6 credits of special topics will be allowed for degree credit.

### **CBE 498 UNDERGRADUATE RESEARCH/SCHOLARSHIP**

Credit to be arranged. Prerequisites: Permission of instructor. Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical. A maximum of 6 credits of undergraduate research will be allowed for degree credit.

### **CBE 603 MOLECULAR BIOLOGY FOR ENGINEERS**

(3-0) 3 credits. This course is designed to provide a basic knowledge on molecular biology and bioinformatics that is directly applicable to engineering and related science fields. Up-to-date techniques in genetic engineering biotechnology, and bioinformatics will be introduced for the understanding of biological problems using engineering concepts or engineering/mechanical problems through biological tools. This course is cross-listed with BME 603

### **CBE 612 TRANSPORT PHENOMENA: MOMENTUM**

(3-0) 3 credits. Introduction to momentum transport. Equations of continuity and motion. Velocity distributions. Boundary layer theory. Turbulent transport compressible flow. This course is cross-listed with ME 612.

### **CBE 613 TRANSPORT PHENOMENA: HEAT**

(3-0) 3 credits. An in-depth study of the fundamental laws of heat transfer. Major areas considered are: heat conduction, free and forced

convection, and radiative heat transfer. Emphasis is placed on the formulation and solution of engineering problems by analytical and numerical methods. This course is cross-listed with ME 613.

### **CBE 616 COMPUTATIONS IN TRANSPORT PHENOMENA**

(3-0) 3 credits. Various computerized techniques, including finite difference and finite element, will be used to solve transient and steady state heat transfer problems involving conduction and convection. This course is cross-listed with ME 616.

### **CBE 621 ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS I**

(3-0) 3 credits. Prerequisites: CBE 321 or permission of instructor. A mathematical development of fundamental laws of thermodynamics and their application to chemical engineering operations and processes. Equilibrium and thermal effects in homogeneous and heterogeneous systems.

### **CBE 691 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

### **CBE 692 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A maximum of 6 credits of advanced special topics will be allowed for degree credit.

### **CBE 714 TRANSPORT PHENOMENA: MASS**

(3-0) 3 credits. Prerequisites: Permission of instructor. An in-depth study of the fundamental

laws of mass transfer. Emphasis is placed on the formulation and solution of Chemical and Biological Engineering processes and problems by analytical and numerical methods.

### **CBE 728 HETEROGENEOUS KINETICS**

(3-0) 3 credits. Principles of Absolute Rate Theory are combined with thermodynamics to study the mechanisms of homogeneous and heterogeneous reactions in metallurgical systems. This course is cross-listed with MES 728.

### **CBE 735 BIOSEPARATIONS**

3-0) 3 credits. Prerequisites: CBE 318 or permission of instructor. This course introduces students to the principles and techniques used to recover and purify biologically-produced molecules, especially proteins, nucleic acids, and organic acids, from bacterial, mammalian, and agricultural production systems. The course will focus on centrifugation and filtration, membrane processing, two-phase extraction, precipitation and crystallization, adsorption and chromatography, and electrophoresis. Analysis will include micro and macro scale process modeling and simulation.

### **CBE 741 MICROBIAL AND ENZYMATIC PROCESSING**

(3-0) 3 credits. Prerequisites: BIOL 341, BIOL 231 or permission of instructor. Most of the processes used for energy generation including bioconversion of biomass, food processing, pollution control, rely not only on physico-chemical but also on biological reactions. The course introduces various renewable energy resources, processes, and products, emphasizing critical aspects and challenges of biomass conversion into biofuels and value-added bioproducts especially using extremophiles and their enzymes. Students are expected to learn both fundamental and applied aspects of microbial and enzymatic processing through scientific literature and case studies focusing on the current trends in the field.

### **CBE 788 MASTER'S RESEARCH PROB/PROJECTS**

Credit to be arranged; not to exceed 9 credits

toward fulfillment of M.S. degree requirements. Open only to students pursuing the M.S. non-thesis option. Independent research problems/projects that lead to a research or design paper but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research which are theoretical. Oral defense of the report and research findings are required.

### **CBE 790 SEMINAR**

(0.5-0) 0.5 credit. Prerequisites: Permission of instructor. This course may be repeated for credit and is designed to support the M.S. in Chemical Engineering. A highly-focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media, such as Internet, and are at the upper division or graduate levels. This course is cross-listed with CBE 890.

### **CBE 791 INDEPENDENT STUDY**

1 to 4 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

### **CBE 792 TOPICS**

1 to 4 credits. Includes Current Topics, Advanced Topics, and Special Topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **CBE 798 THESIS**

Credit to be arranged; not to exceed 9 credits toward fulfillment of M.S. degree requirements. Prerequisite: Approval of advisor. An original investigation of a chemical engineering subject normally presented as a thesis for the master of science degree in chemical engineering.

A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

### **CBE 890 SEMINAR**

(0.5-0) 0.5 credit. Prerequisites: Permission of instructor. This course may be repeated for credit and is designed to support the Ph.D. in Chemical and Biological Engineering. A highly-focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media, such as Internet, and are at the upper division or graduate levels. This course is cross-listed with CBE 790.

### **CBE 894 ADVANCED TECHNICAL INTERNSHIP**

1 to 6 credits. Prerequisites: Approval of advisor. A single semester work experience in conjunction with an industrial, state, governmental, or national laboratory employer. Each student will be asked to prepare a written report of their work experience.

### **CBE 898D DISSERTATION**

1 to 12 credits. Prerequisites: Approval of advisor. An original investigation of a chemical/biological engineering subject, which culminates in the oral and written presentation of a dissertation for the Ph.D. degree in Chemical and Biological Engineering. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

**CEE 117/117L COMPUTER AIDED DESIGN AND INTERPRETATION IN CIVIL ENGINEERING**

(1-1) 2 credits. Students will learn to construct drawing documents using AutoCAD, the use of engineering and architectural scales, lettering practices, geometric construction (manually and AutoCAD), and the ability to visualize in three dimensions.

**CEE 130/130L INTRODUCTION TO CIVIL ENGINEERING**

(1-1) 2 credits. Prerequisites: MATH 102. This course serves as an introduction to the civil engineering profession. Students will learn how to solve engineering analysis and design problems, develop computational skills, and sharpen communication and teamwork skills.

**CEE 206/206L CIVIL ENGINEERING PRACTICE AND ENGINEERING SURVEYS I**

(2-2) 4 credits. Prerequisites: An acceptable score on the Trigonometry Placement Examination; or trigonometry completed with a grade of "C" or better; or permission of instructor. An orientation to the civil engineering profession including historical development, civil engineering careers, professional practice and ethics, and specialties in the profession. Mensuration with the application of surveying techniques; basic surveying computations and field practice; theory of error propagation and its analysis; fundamental concepts of horizontal, angular, and vertical measurements; control systems related to engineering-construction surveys. Horizontal and vertical curves. Traverse computations.

**CEE 284 APPLIED NUMERICAL METHODS**

(3-0) 3 credits. Prerequisites: MATH 123. A one semester introductory course in programming with a language (Visual Basic) and with a spreadsheet and MathCad. Elementary numerical methods and their application to civil engineering problems will be illustrated by the programming technique.

**CEE 316/316L ENGINEERING AND CONSTRUCTION MATERIALS**

(2-1) 3 credits. Prerequisites: EM 321 and CEE 284. Principles that govern physical and mechanical properties of ferrous and nonferrous metals, plastics, bituminous materials, portland cement, aggregates, concrete, and timber. Laboratory exercises to demonstrate basic principles and standard laboratory tests (ASTM Standards) of structural materials. Computer-aided graphics and word processing are required for lab reports.

**CEE 325 INTRODUCTION TO SUSTAINABLE DESIGN**

(3-0) 3 credits. Prerequisites: Junior standing. Theories and principles employed in sustainable design are introduced and employed in various contexts. Analyses of engineering systems will be performed both analytically and quantitatively. Principles will be employed in problem solving as well as in fundamental design efforts. This course is cross-listed with ENVE 325.

**CEE 326 INTRODUCTORY ENVIRONMENTAL ENGINEERING DESIGN**

(3-0) 3 credits. Prerequisites: CHEM 114. As the first course in the theory and practice of environmental engineering, emphases are on the acquisition of introductory knowledge pertaining to natural and engineered environmental engineering systems, identification and mitigation of societal impacts upon the Earth, and application of environmental engineering principles in the design and analysis of systems for water and wastewater treatment and solid/hazardous waste management. This course is cross-listed with ENVE 326.

**CEE 327 ENVIRONMENTAL ENGINEERING PROCESS ANALYSIS**

(3-0) 3 credits. Prerequisites: CEE 326. Pre- or Co-requisites: CEE 284 and one of the following: EM 328, EM 331, CBE 218 or ME 331. As the second course in the theory and practice of environmental engineering, emphasis is on application of material balance concepts in environmental analysis and design with

consideration of water chemistry, environmental process kinetics, ideal and non-ideal reactors, biological process fundamentals, and inter-phase mass transfer phenomena. These fundamental principles are applied in selected natural and engineered environmental contexts spanning air, water and land systems and the effects of society on environmental systems. This course is cross-listed with ENVE 327.

### **CEE 327L ENVIRONMENTAL ENGINEERING PROCESS ANALYSIS LAB**

(0-1) 1 credit. Co-requisites: CEE 327. A laboratory course to accompany CEE 327, in which students will perform hands on laboratory experiments; collect, analyze and interpret data; and document findings in scholarly written reports. The course is cross-listed with ENVE 327L.

### **CEE 336/336L HYDRAULIC SYSTEMS DESIGN**

(2-1) 3 credits. Prerequisites: EM 331 and CEE 284. Analysis of flow in pipe systems, open channels, measuring devices, and model studies. Design of hydraulic systems associated with water supply, flood control, water storage and distribution, sewer systems, and other water resources.

### **CEE 337 ENGINEERING HYDROLOGY**

(3-0) 3 credits. Prerequisites: EM 331 or EM 328. A quantification study of the components of the hydrologic cycle with emphasis on engineering applications involving the design of water supplies, reservoirs, spillways, floodways, and urban drainage with computer applications. This course is cross-listed with ENVE 337.

### **CEE 346/346L GEOTECHNICAL ENGINEERING**

(2-1) 3 credits. Prerequisites: EM 321. Composition, structure, index, and engineering properties of soils; soil classification systems; introduction to soil engineering problems involving stability, settlement, seepage, consolidation, and compaction; and laboratory work on the determination of index and engineering properties of soils. Computer-aided

graphics and word processing required for lab reports.

### **CEE 347 GEOTECHNICAL ENGINEERING II**

(3-0) 3 credits. Prerequisites: CEE 346/346L. Composition of soils, origin, and deposition, exploration, frost problems, swelling of soils, erosion protection, soil improvement, groundwater flow and dewatering, slope stability of retaining structures, and rigid and flexible pavement design. The application of these topics to highway engineering will be stressed.

### **CEE 353 STRUCTURAL THEORY**

(3-0) 3 credits. Prerequisites: EM 321 and CEE 284. Basic concepts in structural analysis of beams, trusses, and frames. Determination of governing load conditions for moving loads by use of influence lines. Development of basic virtual work concept to obtain deflections for beams, trusses, and frames. Introduction to approximate analysis.

### **CEE 357/357L THEORY AND DESIGN OF METAL STRUCTURES I**

(2-1) 3 credits. Prerequisites: CEE 353. Correlation of analysis and design using the current building code requirements for steel structures. Design techniques are formulated for axial, transverse and combined loading conditions, for individual members and for connections between components of a structure. Comparisons between design requirements of materials to illustrate relative benefits in structural systems.

### **CEE 358 APPLIED STRUCTURAL DESIGN**

(3-0) 3 credits. Prerequisites: CEE 316/316L or CEE 353. Elements of structural design utilizing concrete, steel, or wood. Applied methods emphasizing practical, conservative, and economical solutions will be emphasized. Intended for students who will take no other structural design course.

**CEE 368/368L INTRODUCTION TO TRANSPORTATION ENGINEERING**

(2-1) 3 credits. Prerequisites: PHYS 211 and EM 214. Content includes fundamentals fundamentals of transportation engineering: air, marine, highway, and/or pipeline systems; design, operation, and planning of transportation facilities; the basics of driver, vehicle, and roadway system characteristics; elementary traffic flow theory, and introduction to capacity and level of service analyses. Current transportation engineering software is applied in the laboratory.

**CEE 421/521 ENVIRONMENTAL SYSTEMS ANALYSIS**

(3-0) 3 credits. Prerequisites: CEE/ENVE 327. Course emphasis is on applications of environmental chemistry and material balance in quantitative characterizations of operative processes in selected air, water, and land systems and environmental health impacts. Analytical and computer solutions are performed. Students enrolled in CEE 521 will be held to a higher standard than those enrolled in CEE 421. This course is cross-listed with ENVE 421.

**CEE 425/525 SUSTAINABLE ENGINEERING**

(3-0) 3 credits. Prerequisites: Junior standing. This course will serve as an introduction to the emerging field of sustainable engineering, with focus on understanding interactions between industrial processes and the environment. Identification and implementation of strategies to reduce the environmental impacts of products and processes associated with industrial systems will be explored and evaluated using tools such as life cycle analyses and materials balances. The course will also explore appropriate sustainable technologies employed within both developing and first world countries. Students enrolled in CEE 525 will be held to a higher standard than those enrolled in CEE 425. This course is cross-listed with ENVE 425.

**CEE 426/526 ENVIRONMENTAL ENGINEERING PHYSICAL/CHEMICAL PROCESS DESIGN**

(3-0) 3 credits. Prerequisites: CEE/ENVE 326. A

third course in the theory and practice of environmental engineering. Emphases are on the design and analysis of physical/chemical environmental engineering unit operations and processes. Students enrolled in CEE 526 will be held to a higher standard than those enrolled in CEE 426. This course is cross-listed with ENVE 426.

**CEE 426L/526L ENVIRONMENTAL PHYSICAL/CHEMICAL PROCESS LABORATORY**

(0-1) 1 credit. Pre- or Co-requisites: CEE/ENVE 426/526 or permission of instructor. A laboratory course to accompany CEE/ENVE 426/526. Examination of processes employed in design of environmental physical and chemical systems for renovation of contaminated waters and soils. Various bench-scale experiments will be performed with laboratory analysis using standard environmental web chemical and instrumental analytical techniques. Laboratory reports employing word processing, numerical and statistical analysis, and interpretation of process performance data will be written. Students enrolled in CEE 526L will be held to a higher standard than those enrolled in CEE 426L. This course is cross-listed with ENVE 426L.

**CEE 427/527 ENVIRONMENTAL ENGINEERING BIOLOGICAL PROCESS DESIGN**

(3-0) 3 credits. Prerequisites: CEE/ENVE 327. A fourth course in the theory and practice of environmental engineering. Emphases are on the design and analysis of biological environmental engineering unit operations and processes. Students enrolled in CEE 527 will be held to a higher standard than those enrolled in CEE 427. This course is cross-listed with ENVE 427.

**CEE 427L/527L ENVIRONMENTAL BIOLOGICAL PROCESS LABORATORY**

(0-1) 1 credit. Pre- or Co-requisites: CEE/ENVE 427/527 or permission of instructor. A laboratory course to accompany CEE/ENVE 427/527. Examination of processes employed in design of environmental biological systems for renovation of contaminated waters and soils. Various bench-

scale experiments will be performed with laboratory analysis using standard environmental web chemical, microbiological, and instrumental analytical techniques. Laboratory reports employing word processing, numerical and statistical analysis, and interpretation of process performance data will be written. Students enrolled in CEE 527L will be held to a higher standard than those enrolled in CEE 427L. This course is cross-listed with ENVE 427L.

### **CEE 428L/528L ENVIRONMENTAL ENGINEERING OPERATIONS AND PROCESSES LABORATORY**

(0-1) 1 credit. Prerequisites: CEE/ENVE 327 and CEE/ENVE 327L. Bench-scale experiments are performed in examination of physical/chemical operations and biological processes employed in systems for treatment of waters, wastewaters, and soils. Standard chemical and instrumental analytical techniques are employed. Data are acquired, processed, analyzed both numerically and statistically, and interpreted. Formal laboratory reports are written. Students enrolled in 528L will be held to a higher standard than those enrolled in 428L. This course is cross-listed with ENVE 428L.

### **CEE 433/533 OPEN CHANNEL FLOW**

(3-0) 3 credits. Prerequisites: CEE 336/336L. Application of continuity, momentum, and energy principles to steady flow in open channels; flow in the laminar and transition ranges; specific energy and critical depth; energy losses; channel controls; gradually and rapidly varied flow; and high velocity flow. Students enrolled in CEE 533 will be held to a higher standard than those enrolled in CEE 433.

### **CEE 437/437L/537/537L WATERSHED AND FLOODPLAIN MODELING**

(2-1) 3 credits. Prerequisites: CEE 337. This course will consist of the application of the HEC-HMS Flood Hydrograph Package and HEC-RAS Water Surface Profiles computer programs. Each model is applied to an actual watershed and conveyance channel. The student is responsible for two project reports, one for each model application. Data compilation and model

development and execution will be conducted in the lab portion of the class. Development of the model inputs will include review of hydrologic and hydraulic processes relating to model options. Students enrolled in CEE 537/537L will be held to a higher standard than those enrolled in CEE 437/437L.

### **CEE 447/547 FOUNDATION ENGINEERING**

(3-0) 3 credits. Prerequisites: CEE 346/346L. Application of the fundamental concepts of soil behavior to evaluation, selection, and design of shallow and deep foundation systems. Related topics such as temporary support systems for excavations and pile driving are also included. Students enrolled in CEE 547 will be held to a higher standard than those enrolled in CEE 447.

### **CEE 448/548 APPLIED GEOTECHNICAL ENGINEERING**

(3-0) 3 credits. Prerequisites: CEE 347. Content will include the application of principles taught in CEE 346 and CEE 347 to practical geotechnical engineering problems in the civil engineering profession, such as exploration, pavement design, slope stability, geosynthetics, geotechnical problems unique to the region, and dam design. Students enrolled in CEE 548 will be held to a higher standard than those enrolled in CEE 448.

### **CEE 451/451L/551/551L DESIGN OF WOOD STRUCTURES**

(2-1) 3 credits. Prerequisites: CEE 353. This course will cover the behavior and properties of timber, lumber and pre-engineered structural wood products. Students will learn to design members and systems using current methods and appropriate codes and specifications. An additional research requirement will be included for those taking the class for graduate credit. The course includes a lecture component complemented by a computational laboratory. Students enrolled in CEE 551 will be held to a higher standard than those enrolled in CEE 451.

### **CEE 453/453L DESIGN OF STEEL STRUCTURES**

(2-1) 3 credits. Prerequisites: CEE 358 and CEE

457/457L. Analysis and design of structural elements and connections for buildings, bridges, and specialized structures that utilize structural metals. Behavior of structural systems under elastic and plastic design.

### **CEE 456/456L CONCRETE THEORY AND DESIGN**

(2-1) 3 credits. Prerequisites: CEE 353. Properties and behavior of concrete and reinforcing steel. Analysis and design of structural slabs, beams, girders, columns, and footings with use of strength methods. Deflection of flexural members. Development of reinforcement.

### **CEE 457/457L INDETERMINATE STRUCTURES**

(2-1) 3 credits. Prerequisites: CEE 353. Analysis of indeterminate structures by classical and matrix methods. The classical methods are the force method, the slope-deflection equations and the moment-distribution method. The classical methods also are used to determine influence lines for indeterminate structures. Stiffness matrices for truss and beam elements are derived and used to analyze trusses, beams, and frames.

### **CEE 463 CIVIL ENGINEERING PROFESSION**

(2-0) 2 credits. Prerequisites: Senior in civil engineering. Lecture and discussion with emphasis on current civil engineering topics with emphasis on professional, personal, and ethical development.

### **CEE 464 CIVIL ENGINEERING CAPSTONE DESIGN I**

(0-1) 1 credit. Prerequisites: Senior standing or permission of instructor. Content will include major engineering design experience integrating fundamental concepts of mathematics, basic science, engineering science, engineering design, communications skills, humanities, and social science.

### **CEE 465 CIVIL ENGINEERING CAPSTONE DESIGN II**

(0-2) 2 credits. Prerequisites: CEE 464. Content

will include major engineering design experience integrating fundamental concepts of mathematics, basic science, engineering science, engineering design, communications skills, humanities, and social science.

### **CEE 466/566 ENVIRONMENTAL ENGINEERING PROCESS DESIGN**

(3-0) 3 credits. Prerequisites: CEE/ENVE 421 or graduate standing. Physical/chemical and biological unit operations and processes applicable in environmental engineering and analyzed and/or designed. Analyses and designs are documented in both informal memoranda and formal design reports. This course is cross-listed with ENVE 466.

### **CEE 468/568 HIGHWAY ENGINEERING**

(3-0) 3 credits. Prerequisites: CEE 368/368L. This course addresses highway location, drainage, and safety; earthwork volumes; design of cross-section alignment; and intelligent transportation system concepts and applications. Students enrolled in CEE 568 will be held to a higher standard than those enrolled in CEE 468 and complete additional design work or projects.

### **CEE 474 ENGINEERING PROJECT MANAGEMENT**

(3-0) 3 credits. Prerequisites: Senior standing or permission of instructor. Study of owner, engineer, and contractor organizational structures, project work break down structures, resource and asset allocation, computer and non-computer scheduling by Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT). Students enrolling will be required to perform an engineering project with written and oral presentations.

### **CEE 491 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting

frequency depends on the requirements of the topic.

### **CEE 492 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **CEE 498 UNDERGRADUATE RESEARCH/SCHOLARSHIP**

1 to 6 credits. Prerequisites: Permission of instructor. Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

### **CEE 500 RESEARCH METHODS**

(1-0) 1 credit. Students will gain the research skills needed to plan and implement an independent research project. Students will learn about the processes of research and writing, connections between writing and thinking/learning, and the essential components of scientific/engineering research documents, such as thesis, dissertations, research reports, and research or thesis proposals.

### **CEE 621 ENVIRONMENTAL CONTAMINANT FATE AND TRANSPORT**

(3-0) 3 credits. Prerequisites: CEE 421 or CEE 521 or permission of instructor. Mathematical analysis of the processes governing the fate and movement of anthropogenic contaminants in natural systems. Topics include: liquid-solid, vapor-solid, and vapor-liquid partitioning; liquid and vapor phase convection and diffusion; biotic and abiotic transformations; and mathematical modeling of coupled processes.

### **CEE 622 ADVANCED TREATMENT PLANT DESIGN**

(3-0) 3 credits. Prerequisites: CEE 327, CEE 336/336L, and CEE 426, or permission of

instructor. Advanced topics relating to the design of systems for the renovation of contaminated waters. Several major design problems will be completed.

### **CEE 627 TREATMENT, DISPOSAL, AND MANAGEMENT OF HAZARDOUS WASTE**

(3-0) 3 credits. Study of the types, sources and properties of hazardous waste generated from various industrial plants. Engineering systems and technologies for hazardous waste including: on-site handling, storage and processing; transfer and transportation; treatment and reuse; and ultimate disposal and destruction. Federal regulations, especially those developed under the Resource Conservation and Recovery Act will be described.

### **CEE 628/628L ENVIRONMENTAL ENGINEERING MEASUREMENTS**

(2-1) 3 credits. Prerequisites: Senior or graduate standing. It is highly recommended that the student have completed CEE 421 or CEE 521 or an equivalent course prior to enrolling in this course. Topics include: methods employed in assessment of environmental contamination and remediation effectiveness; methods used in obtaining and handling of water and soil samples; applications of analytical instrumentation (GC, LC, AAS, UV/Vis, and total carbon) to assays of environmental samples; field and lab QA/QC; preparation of investigative reports.

### **CEE 634 SURFACE WATER HYDROLOGY**

(3-0) 3 credits. Prerequisites: CEE 337 or permission of instructor. Review and advanced study of hydrologic cycle including precipitation, infiltration, evapotranspiration, and runoff. Applications to analysis and design of water supplies, reservoirs, spillways, floodways, urban runoff, and protection systems.

### **CEE 643 ADVANCED SOIL MECHANICS I**

(3-0) 3 credits. Prerequisites: CEE 346/346L or permission of instructor. One- and two-dimensional consolidation theory; field consolidation behavior; anisotropic consolidation; geotechnical material failure criteria; constitutive laws for geotechnical materials; flexible and rigid

beams on elastic foundations; analysis of single and group piles under various loadings; stress development in soil mass.

**CEE 644 ADVANCED SOIL MECHANICS II**

(3-0) 3 credits. Methods of geotechnical analysis; composite finite element method; movement dependent lateral earth pressure development; limiting equilibrium method of soil-structure analysis for bearing capacity, slope stability and retaining structures; and earth reinforcing techniques.

**CEE 645 ADVANCED FOUNDATIONS**

(3-0) 3 credits. Prerequisites: CEE 284 and CEE 346/346L or permission of instructor. Application of the principles of soil mechanics to foundation engineering; subsurface exploration; lateral earth pressures and retaining structures; bearing capacity and settlement of shallow and deep foundations; field instrumentation and performance observation; and case studies.

**CEE 646 STABILITY OF SOIL AND ROCK SLOPES**

(3-0) 3 credits. Prerequisites: CEE 346/346L or permission of instructor. Geologic aspects of slope stability; shear strength of geologic materials; soil and rock mechanics approaches to slope stability analysis; two-dimensional limiting equilibrium methods of slope stability analysis including sliding block methods, Fellenius' and Bishop's methods of slices, and the Morgenstern-Price method of slices; introduction to three-dimensional methods of stability analysis; field instrumentation and performance observations; and case studies.

**CEE 647 EARTH AND EARTH RETAINING STRUCTURES**

(3-0) 3 credits. Prerequisites: CEE 346/346L or permission of instructor. Engineering properties of compacted soils; use of the triaxial test in soil stability problems; methods of slope stability analysis with emphasis on Bishop's simplified method of slices; design considerations for earth embankments; field instrumentation and performance observations; and case studies. Application of principles of geotechnical

engineering to the design of retaining structures. Areas covered are lateral earth pressure theories, rigid and flexible retaining walls, anchored bulkheads, earthquake induced earth pressures, and braced excavations. Stabilization of slopes and reinforced earth applications are also treated, along with instrumentation observations.

**CEE 652 PRESTRESSED CONCRETE**

(3-0) 3 credits. Prerequisites: CEE 358 or CEE 456 /456L or permission of instructor. Principles of linear and circular prestressing. Behavior of steel and concrete under sustained load. Analysis and design of pre-tensioned and post-tensioned reinforced concrete members and the combination of such members into an integral structure.

**CEE 653 REINFORCED CONCRETE DESIGN**

(3-0) 3 credits. Prerequisites: CEE 456/456L. Design for torsion, simple space structural elements such as corner beams, curved beams, and free-standing staircases. Yield line theory and design of two-way reinforced slabs and floor systems. Design of a multi-story frame building system.

**CEE 655/655L APPLIED COMPOSITES**

(2-1) 3 credits. Prerequisites: CEE 353 or permission of instructor. Basic properties and principles of advanced composite materials such as fiberglass and graphite, and aramic design and testing of primary structural members including pre-stressing elements. Application of composite materials to engineering.

**CEE 657/657L ADVANCED STRUCTURAL ANALYSIS**

(2-1) 3 credits. Prerequisites: Senior or graduate standing. Analysis of statically indeterminate structural systems. Flexibility and stiffness methods of analysis for two- and three-dimensional orthogonal and non-orthogonal structures with reference to digital computer procedures. Special solution procedures including use of substructures. Energy methods of structural analysis and introduction to finite element method.

**CEE 668 ADVANCED HIGHWAY SYSTEMS ENGINEERING**

(3-0) 3 credits. Prerequisites: CEE 368/368L or equivalent, graduate standing, or permission of instructor. This course focuses on advanced traffic flow theory including traffic distributions, car-following models, and traffic stream models, and includes highway traffic operation analyses involving planning and management of highway systems.

**CEE 691 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Senior or graduate standing and permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

**CEE 692 TOPICS**

1 to 3 credits. Prerequisites: Senior or graduate standing. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors

**CEE 730 STATISTICAL METHODS IN WATER RESOURCES**

(3-0) 3 credits. Stochastic process, probability and statistics applied to hydrologic problems. Data synthesis, frequency analysis, correlation, time series, and spectral analysis.

**CEE 731 CURRENT TOPICS IN WATER QUALITY ASSESSMENT**

(3-0) 3 credits. Prerequisites: Permission of instructor. A review and discussion of federal programs concerning water quality and of current literature on national and regional water-quality assessments. Technical subjects covered may include but are not limited to: hydrologic and hydraulic modeling of watersheds, numerical water quality modeling, and total maximum daily

loads (TMDL's); eutrophication; urban runoff; non-point-source pollution. Oral presentations, detailed literature review, and term paper are required.

**CEE 739/739L TECHNIQUES OF SURFACE WATER RESOURCE AND WATER QUALITY INVESTIGATIONS I**

(1-2) 3 credits. Prerequisites: CEE 326, CEE 327 and CEE 336/336L or permission of instructor. A study of the theory, design and techniques used in hydrologic and water quality investigations by environmental engineers, hydrologists, and hydraulic engineers. Topics to be covered include, but are not limited to: surface water stream flow measurements and records compilation, water quality monitoring, storm water runoff sampling and permit process, bioassessment of water quality, sediment sampling, lake water quality assessment, and non parametric statistics.

**CEE 753 STABILITY OF METAL STRUCTURES**

(3-0) 3 credits. The course introduces fundamental concepts of structural stability, with an emphasis on stability of steel members and systems using equilibrium and energy solutions. Topics will include: fundamental stability formulations; elastic and inelastic column buckling; lateral stability of beams; column, beam and frame bracing; and stability design of steel frames.

**CEE 784 MODELING AND COMPUTATION IN CIVIL ENGINEERING**

(3-0) 3 credits. Prerequisites: CEE 284 or permission of instructor. Applications of statistical and advanced numerical and digital computation methods to various problems in all disciplines of civil engineering.

**CEE 785 APPLICATIONS OF FINITE ELEMENT METHODS IN CIVIL ENGINEERING**

(3-0) 3 credits. An introduction to the basic concepts including: interpolation functions, element stiffness and load matrices, assembly of element matrices into global matrices, and

solution techniques. Several one and two dimensional elements are studied and used to solve problems in solid mechanics, soils, and fluid mechanics using the variational method and Galerkin's method.

### **CEE 788 MASTER'S RESEARCH PROB/PROJECTS**

Credit to be arranged; not to exceed 3 credits toward fulfillment of M.S. degree requirements. Open only to students pursuing the M.S. non-thesis option. Independent research problems/projects that lead to a research or design paper but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between to two may be extensive and intensive. Does not include research courses which are theoretical. Oral defense of the report and research findings are required.

### **CEE 790 SEMINAR**

(1-0) 1 credit. May not be repeated for degree credit. A highly-focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as Internet and are at the upper division or graduate levels.

### **CEE 791 INDEPENDENT STUDY**

1 to 3 credits; not to exceed 3 credits toward fulfillment of M.S. degree requirements. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

### **CEE 792 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular

curriculum. Guest artists or experts may serve as instructors.

### **CEE 798 THESIS**

Credit to be arranged; not to exceed 6 credits toward fulfillment of M.S. degree requirements. Open only to students pursuing the M.S. thesis option. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

### **CENG 244/244L INTRODUCTION TO DIGITAL SYSTEMS**

(3-1) 4 Credits. This course is designed to provide computer engineering, electrical engineering, and computer science students with an understanding of the basic concepts of digital systems and their hardware implementation. Topics covered include combinational logic circuits, sequential logic circuits, and CPU control.

### **CENG 291 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. A maximum of 6 credits of independent studies is allowed for degree credits.

### **CENG 292 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A maximum of 6 credits of special topics is allowed for degree credits.

**CENG 314/314L ASSEMBLY LANGUAGE**  
(1.5-1.5) 3 credits. Prerequisites: CSC 250. A thorough introduction to assembly language programming and processor architecture. A study of low-level programming techniques, and the layout of a typical computer. The student will gain insight into the memory layout, registers, run-time stack, and global data segment of a running program. This course is cross listed with CSC 314/314L. Graduation credit will not be allowed for both this course and CSC 314/314L.

**CENG 342/342L DIGITAL SYSTEMS**  
(3-1) 4 credits. Prerequisites: CENG 244/244L. Presents the basic concepts and mathematical tools that are applicable to the analysis and design of digital systems, particularly state machines and digital processing systems. The VHDL hardware description language is also introduced as a design tool.

**CENG 391 INDEPENDENT STUDY**  
1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. A maximum of 6 credits of special topics is allowed for degree credits.

**CENG 392 TOPICS**  
1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A maximum of 6 credits of special topics is allowed for degree credits.

**CENG 415/415L/515/515L INTRODUCTION TO ROBOTICS**  
(2-1) 3 credits. Prerequisites: CSC 300 and MATH 321 or concurrent enrollment in CSC 505 or permission of instructor. An introduction to mechatronic systems and embedded systems for

robotics. This course will cover the basics required for autonomous mobile robotics. The course will begin with a survey of existing systems and some background mathematics. Core course topics will include electromechanical components, electronics for motor control, sensors and instrumentation, mobile robotic kinematics and movement, microcontrollers, real time computing, and embedded system design and development. Course projects will include student teams building task oriented mobile robots which emphasis on the hardware development. Students enrolled in CENG 515 will be held to a higher standard than those enrolled in CENG 415. This course is cross-listed with CSC 415/515.

**CENG 420/420L DESIGN OF DIGITAL SIGNAL PROCESSING SYSTEMS**  
(3-1) 4 credits. Prerequisites: EE 312/312L An introduction to the design of digital signal processing systems. Topics include discrete-time signals and systems, the Z transform, infinite impulse-response digital filters, finite impulse-response digital filters, discrete Fourier transforms, fast Fourier transforms. (Design content - 2 credits)

**CENG 440/440L VLSI DESIGN**  
(3-1) 4 credits. Prerequisites: EE 320/320L. Provides an introduction to the technology and design of VLSI integrated circuits. Topics include MOS transistors, switch and gate logic, scalable design rules, speed and power considerations, floor planning, layout techniques, and design tools.

**CENG 442/442L MICROPROCESSOR-BASED SYSTEM DESIGN**  
(3-1) 4 credits. Prerequisites: EE 351/351L. Presents the concepts required for the design of microprocessor-based systems. Emphasis is given to the problems of system specification, choice of architecture, design trade-offs and the use of development tools in the design process. Design projects will be implemented in the laboratory.

**CENG 444/444L/544/544L COMPUTER NETWORKS**  
(3-1) 4 credits. Prerequisites: CENG 244/244L,

MATH 381 or MATH 442. This course presents the basic principles of computer networks design and analysis. Topics covered include the layers of the OSI reference model. Current and proposed implementations of local, metropolitan and wide area networks are presented; inter-networking is discussed. The different implementations are compared and their performance evaluated. Students enrolled in CENG 544/544L will be held to a higher standard than those enrolled in CENG 444/444L. Graduation credit will not be allowed for both this course and CSC 463.

### **CENG 446/446L ADVANCED COMPUTER ARCHITECTURES**

(3-1) 4 credits. Prerequisites: CENG 342/342L. This course covers the basic principles of pipelining, parallelism and memory management. Topics covered include cache and virtual memory, pipelining techniques and vector processors, multiprocessors and distributed computing systems. Graduation credit will not be allowed for both this course and CSC 440.

### **CENG 447/447L/547/547L EMBEDDED AND REAL-TIME COMPUTER SYSTEMS**

(3-1) 4 credits. Prerequisites: EE 351/351L and CSC 150/150L. This course provides an introduction to programming embedded and real-time computer systems. It includes design of embedded interrupted driven systems and the use of commercial (for example: QNX) or open-source (for example: Linux RT) RTOS operating systems. Students registered for CENG 547/547L will be held to a higher standard than those registered for CENG 447/447L.

### **CENG 464 COMPUTER ENGINEERING DESIGN I**

(0-2) 2 credits. Prerequisites: CENG 342/342L, EE 320/320L Pre- or Co-requisites: EE 311/311L, EE 312/312L, CSC 470, and ENGL 289. This course will focus on the design process and culminate with the faculty approval of design projects (including schematics and parts list) for CENG 465. Typical topics included are the development of a product mission statement, identification of the customer and customer needs, development of target specifications,

consideration of alternate designs using a decision matrix, project management techniques, legal and ethical issues, FCC verification and certification, use of probability and statistics for reliable design, interpretation of data sheets, and component selection.

### **CENG 465 COMPUTER ENGINEERING DESIGN II**

(0-2) 2 credits. Prerequisites: CENG 464. The course requires students to conduct their own design projects in a simulated industrial environment. Requirements include detailed laboratory notebook, periodic written and oral progress reports, and a written and oral presentation of a final project report.

### **CENG 491 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. A maximum of 6 credits of special topics is allowed for degree credits.

### **CENG 492 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A maximum of 6 credits of special topics is allowed for degree credits.

### **CENG 498 UNDERGRADUATE RESEARCH/SCHOLARSHIP**

Credits to be arranged; not to exceed 4 credits toward fulfillment of B.S. degree requirements. Prerequisites: Permission of instructor. Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student.

Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

### **CHEM 106 CHEMISTRY SURVEY**

(3-0) 3 credits. Prerequisites: MATH 101. A one-semester survey of chemistry. Not intended for those needing an extensive chemistry background. Introduction to the properties of matter, atomic structure, bonding, stoichiometry, kinetics, equilibrium, states of matter, solutions, and acid-base concepts. May not be used for credit toward an engineering or science degree (except Interdisciplinary Sciences and Associate of Arts).

### **CHEM 106L CHEMISTRY SURVEY LAB**

(0-1) 1 credit. Pre- or Co-requisites: CHEM 106. Laboratory designed to accompany CHEM 106. May not be used for credit toward an engineering or science degree (except Interdisciplinary Sciences and Associate of Arts).

### **CHEM 108 ORGANIC AND BIOCHEMISTRY**

(4-0) 4 credits. Prerequisites: CHEM 106. A survey of the chemical principles important to biological systems. For students who do not plan to take additional chemistry. Not a prerequisite for any 200 level and above course. May not be used for credit toward an engineering or science degree (except Interdisciplinary Sciences and Associate of Arts).

### **CHEM 108L ORGANIC AND BIOCHEMISTRY LAB**

(0-1) 1 credit. Prerequisites: CHEM 106L, Pre- or Co-requisites: CHEM 108 Laboratory designed to accompany CHEM 108. May not be used for credit toward an engineering or science degree (except Interdisciplinary Sciences and Associate of Arts).

### **CHEM 112 GENERAL CHEMISTRY I**

(3-0) 3 credits. Prerequisites: MATH 102. An introduction to the basic principles of chemistry for students needing an extensive background in chemistry (including chemistry majors, science majors, and pre-professional students).

Completion of a high school course in chemistry is recommended.

### **CHEM 112L GENERAL CHEMISTRY I LAB**

(0-1) 1 credit. Pre- or Co-requisites: CHEM 112. Laboratory designed to accompany CHEM 112.

### **CHEM 114 GENERAL CHEMISTRY II**

(3-0) 3 credits. Prerequisites: CHEM 112 and MATH 102. A continuation of CHEM 112. An introduction to the basic principles of chemistry for students needing an extensive background in chemistry.

### **CHEM 114L GENERAL CHEMISTRY II LAB**

(0-1) 1 credit. Prerequisites: CHEM 112L, Pre- or Co-requisites: CHEM 114

### **CHEM 200 INTRODUCTION TO RESEARCH**

1 to 3 credits. Prerequisites: Permission of instructor. Directed research in chemistry including library and laboratory work supplemented with conferences with the instructor. At SDSM&T a formal report in the American Chemical Society (ACS) format is required to meet the requirements of this course.

### **CHEM 220L EXPERIMENTAL ORGANIC CHEMISTRY IA**

(0-1) 1 credit. Prerequisites: CHEM 114L. A one-semester laboratory course. Experiments demonstrating techniques for the separation, characterization and synthesis of organic compounds are performed. Functional groups are derivatized.

### **CHEM 230 ANALYTICAL CHEMISTRY FOR ENGINEERS**

(2-0) 2 credits. Prerequisites: CHEM 114. An introduction to modern analytical chemistry. Topics include the theory and application of acid-base and solubility equilibria, titrimetric and gravimetric analysis, statistical treatment of data, and an introduction to spectroscopy (UV-Vis, IR, and AA).

**CHEM 252 SYSTEMATIC INORGANIC CHEMISTRY**

(3-0) 3 credits. Prerequisites: CHEM 114. A systematic survey of the chemistry of elements. Periodic properties of the elements; fundamental chemical bonding and structure; acid-base and redox reactions; solid state chemistry; nonaqueous solvents; introduction to materials science.

**CHEM 290 SEMINAR**

(0.5-0) 0.5 credits. A highly focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as Internet and are at the upper division or graduate levels. Enrollment is generally limited to fewer than 20 students. This course is cross-listed with CHEM 490.

**CHEM 316 FUNDAMENTALS OF ORGANIC CHEMISTRY**

(3-0) 3 credits. Prerequisites: CHEM 114. A one-semester introductory course in organic chemistry. Functional classes of organic compounds are discussed in terms of characteristic functional group, properties, structure, nomenclature, synthesis, and reactivity.

**CHEM 326 ORGANIC CHEMISTRY I**

(3-0) 3 credits. Prerequisites: CHEM 114. A systematic treatment of the chemistry of carbon compounds, including nomenclature, structure-reactivity relationships, reaction mechanisms, synthesis, and spectroscopy.

**CHEM 326L ORGANIC CHEMISTRY I LAB**

(0-2) 2 credits. Prerequisites: CHEM 114L. Pre- or Co-requisites: CHEM 326. A laboratory designed to accompany CHEM 326. Introduction to organic functional groups and methods for the separation and purification of organic compounds.

**CHEM 328 ORGANIC CHEMISTRY II**

(3-0) 3 credits. Prerequisites: CHEM 326. A continuation of CHEM 326. A systematic treatment of the chemistry of carbon compounds, including nomenclature, structure-reactivity relationships, reaction mechanisms, synthesis, and

spectroscopy.

**CHEM 328L ORGANIC CHEMISTRY II LAB**

(0-2) 2 credits. Prerequisites: CHEM 326L. Pre- or Co-requisites: CHEM 328. Laboratory designed to accompany CHEM 328. Syntheses of organic compounds. Structural characterization is performed by instrumental methods of analysis including infrared and nuclear magnetic resonance spectrometry.

**CHEM 332 ANALYTICAL CHEMISTRY**

(3-0) 3 credits. Prerequisites: CHEM 114. Fundamental concepts and principles of quantitative chemical analysis including quantitative chemical equilibrium calculations and error analysis applied to the evaluation of experimental measurements and data.

**CHEM 332L ANALYTICAL CHEMISTRY LAB**

(0-1) 1 credit. Pre- or Co-requisites: CHEM 114L and CHEM 332 or CHEM 230. Laboratory to accompany CHEM 332 and CHEM 230. Experimental methods and techniques of gravimetry, titrimetry, pH, and UV-Vis and AA spectrometry.

**CHEM 341 PHYSICAL CHEMISTRY FOR ENGINEERS I**

(2-0) 2 credits. Prerequisites: CBE 222. Pre- or Co-requisites: PHYS 213. Physical transformations of pure substances; simple mixtures and phase diagrams; chemical equilibrium and equilibrium electrochemistry. Duplicate credit for CHEM 341 and CHEM 342 not allowed.

**CHEM 342 PHYSICAL CHEMISTRY I**

(3-0) 3 credits. Prerequisites: CHEM 114 and MATH 321. Pre- or Co-requisites: PHYS 213. A study of the fundamental principles governing the behavior of chemical systems. Topics covered in the two-semester sequence include thermodynamics, chemical kinetics, quantum mechanics, and statistical mechanics. Properties of gases; first and second laws of thermodynamics; physical transformations of pure

substances; simple mixtures and phase diagrams; chemical equilibrium and equilibrium electrochemistry. Duplicate credit for CHEM 341 and CHEM 342 not allowed.

**CHEM 342L PHYSICAL CHEMISTRY I LAB**

(0-1) 1 credit. Pre- or Co-requisites: CHEM 342. Laboratory designed to accompany CHEM 342.

**CHEM 343 PHYSICAL CHEMISTRY FOR ENGINEERS II**

(2-0) 2 credits. Prerequisites: PHYS 213 and CHEM 341 or CHEM 342. Kinetic theory of gases; statistical thermodynamics and properties of solids; chemical kinetics and kinetics at interfaces. Duplicate credit for CHEM 343 and CHEM 344 not allowed.

**CHEM 344 PHYSICAL CHEMISTRY II**

(3-0) 3 credits. Prerequisites: CHEM 342 and PHYS 213. A continuation of Physical Chemistry I. A study of the fundamental principles governing the behavior of chemical systems. Kinetic theory of gases; statistical thermodynamics and properties of solids; chemical kinetics and kinetics at interfaces; quantum mechanics and spectroscopy. Duplicate credit for CHEM 343 and CHEM 344 not allowed.

**CHEM 344L PHYSICAL CHEMISTRY II LAB**

(0-1) 1 credit. Prerequisites: CHEM 342L. Pre- or Co-requisites: CHEM 344. Co requisite course to CHEM 344. Laboratory designed to accompany CHEM 344.

**CHEM 345L PHYSICAL CHEMISTRY FOR ENGINEERS LAB**

(0-1) 1 credit. Prerequisites: CHEM 220L, CHEM 332L, and CHEM 341. Pre- or Co-requisites: CHEM 343. Experimental methods used in modern physical chemistry. Spectroscopic, kinetic, thermostatic, and electrochemical techniques are studied.

**CHEM 370 CHEMICAL LITERATURE**

(1-0) 1 credit. Prerequisites: CHEM 230 or

CHEM 332 and CHEM 252. Pre- or Co-requisites: CHEM 328. The use of the chemical library. Character of the various chemical journals, dictionaries, reference books, computer literature searching, and other sources of information. Written reports on chemical literature.

**CHEM 420/520 ORGANIC CHEMISTRY III**

(3-0) 3 credits. Prerequisites: CHEM 328. Advanced considerations of organic chemistry. Case studies in the synthesis of complex organic molecules are drawn from historical and recent organic chemical literature, which exemplify particular conformational, synthetic, and technical challenges to the organic student. Students enrolled in CHEM 520 will be held to a higher standard than those enrolled in CHEM 420.

**CHEM 421/521 SPECTROSCOPIC ANALYSIS**

(3-0) 3 credits. Prerequisites: CHEM 328 and CHEM 230 or CHEM 332. Determination of the structure of organic compounds using spectroscopic methods. Problems involving library and laboratory work. Students enrolled in CHEM 521 will be held to a higher standard than those enrolled in CHEM 421.

**CHEM 426/526 POLYMER CHEMISTRY**

(3-0) 3 credits. Prerequisites: CHEM 328 and CHEM 342. An introduction to the fundamental chemistry, characterization, and fabrication of polymeric substances. Students enrolled in CHEM 526 will be held to a higher standard than those enrolled in CHEM 426.

**CHEM 434 INSTRUMENTAL ANALYSIS**

(3-0) 3 credits. Prerequisites: CHEM 230 or CHEM 332 and CHEM 342. Theory and application of modern instrumental methods to chemical analysis.

**CHEM 434L INSTRUMENTAL ANALYSIS LAB**

(0-2) 2 credits. Pre- or Co-requisites: CHEM 434. The laboratory designed to accompany CHEM 434. This laboratory includes an introduction to laboratory methods and techniques of

potentiometry, conductimetry, electrogravimetry, voltametry, TLC, GC, and HPLC.

**CHEM 452/552 INORGANIC CHEMISTRY**  
(3-0) 3 credits. Prerequisites: CHEM 252, CHEM 328, CHEM 342. Theoretical and periodic aspects of inorganic chemistry. Discussion of the important models and concepts of modern inorganic chemistry. Students enrolled in CHEM 552 will be held to a higher standard than those enrolled in CHEM 452.

**CHEM 452L/552L INORGANIC CHEMISTRY LAB**  
(0-1) 1 credit. Prerequisites: CHEM 328L. Pre- or Co-requisites: CHEM 452. Synthesis and characterization of inorganic compounds. Laboratory techniques in inorganic chemistry including: synthesis of air-sensitive compounds, transition metal complexes and silicon polymers, chemical characterization of inorganic compounds using spectroscopic, magnetic and analytical approaches. Students enrolled in CHEM 552L will be held to a higher standard than those enrolled in CHEM 452L.

**CHEM 460/560 BIOCHEMISTRY**  
(3-0) 3 credits. Prerequisites: CHEM 328. A one-semester course in biomolecules, metabolism, and transmission of genetic information. The structures, properties, and biochemical functions of mono- and polysaccharides, lipids, amino acids, proteins, and nucleic acids are introduced. Metabolic pathways and cycles for the catabolism and anabolism of sugars, triglycerides, steroids, amino acids, proteins, and polynucleotides are detailed. Energetics, the potential fates of chemical intermediates, and information storage and transmission are studied. Students enrolled in CHEM 560 will be held to a higher standard than those enrolled in CHEM 460.

**CHEM 482/582 ENVIRONMENTAL CHEMISTRY**  
(3-0) 3 credits. Prerequisites: CHEM 316 or CHEM 328. Examination of the chemistry and chemical processes of the environment, including the role of chemistry in current environmental issues. Students enrolled in CHEM 582 will be

held to a higher standard than those enrolled in CHEM 482.

**CHEM 490 SEMINAR**  
(0.5-0)0 .5 credits. A highly focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as Internet and are at the upper division or graduate levels. Enrollment is generally limited to fewer than 20 students. Repeatable for a maximum of 2 credits. This course is cross-listed with CHEM 290.

**CHEM 491 INDEPENDENT STUDY**  
1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. A maximum of 6 credits of special topics and independent study credits will be allowed for degree credit.

**CHEM 492 TOPICS**  
1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A maximum of 6 credits of special topics and independent study credits will be allowed for degree credit.

**CHEM 498 UNDERGRADUATE RESEARCH/SCHOLARSHIP**  
1 to 12 credits. Prerequisites: Permission of instructor. Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical. A

maximum of 6 credit hours of undergraduate research will be allowed for degree credit. At SDSM&T a formal report in the American Chemical Society (ACS) format is required to meet the requirements of this course.

**CHIN 101 INTRODUCTORY CHINESE I**  
(4-0) 4 credits. An opportunity to develop skills in everyday spoken Chinese. Emphasis will be on correct pronunciation, listening skills, and fluency.

**CHIN 102 INTRODUCTORY CHINESE II**  
(4-0) 4 credits. A continuation of CHIN 101, except that 200 new Chinese characters will be introduced.

**CM 506 SUSTAINABLE CONSTRUCTION**  
(3-0) 3 credits. Prerequisites: Graduate standing or permission of instructor. This course addresses the management of sustainable construction and the constructor's role in creating a sustainable environment through construction practices. The impact of the various sustainable building systems and standards on project management and performance will be evaluated from the constructor's perspective.

**CM 508 CONSTRUCTION PROCUREMENT SYSTEMS**  
(3-0) 3 credits. Prerequisites: Graduate standing. Course addresses the roles and responsibilities of the project team, project delivery methods, the preparation of accurate and enforceable specifications, and the effective administration of construction contracts. Contract documents including project plans and specifications will be analyzed from the perspective of coordination, interpretation, and enforcement. Guidelines and documents from various organizations such as CSI, AIA, and AGC will be examined to develop an understanding of the design process, product selection, and improved communication among the project participants involved in all aspects of managing a project from initial planning to completion.

**CM 610 CONSTRUCTION PROJECT MANAGEMENT**  
(3-0) 3 credits. Prerequisites: Graduate standing. Course addresses advanced study and application of estimating, scheduling, and project control principles utilized within the construction industry. Course will make extensive use of computer modeling in the analysis and development of realistic construction estimates and schedules. Conceptual, assembly, and detailed estimating topics are addressed. Network, linear, matrix and bar chart schedules are analyzed. Project control topics including cost, resource, and schedule control are addressed and applied to cash flow analysis, project duration optimization, and resource balancing problems.

**CM 615 REGULATORY ENVIRONMENT OF CONSTRUCTION**  
(3-0) 3 credits. Prerequisites: Graduate standing. Course addresses the principles, materials and systems of building construction as they relate to codes and regulations. Basic and advanced principles of architectural design and construction including sustainability are covered in depth. Methods used in obtaining, interpreting and applying provisions of various federal, state, and local regulatory requirements and permitting processes applicable to the construction industry will be explored. Various types of permits and associated permitting entities are examined.

**CM 619 CONSTRUCTION COMPANY MANAGEMENT**  
(3-0) 3 credits. Students will study topics as they relate to managing a construction company. These include financial management, strategic planning, business development, human resources management, information management, quality management, and risk management.

**CM 665 CONSTRUCTION EQUIPMENT MANAGEMENT**  
(3-0) 3 credits. Prerequisites: Graduate standing. Course addresses equipment and methods used in building, heavy-highway and utility construction; equipment and crew productivity; ownership and operating costs; production rates and operating characteristics of major construction equipment

and operations. Critical thinking, leadership and management skills, written and verbal communication, and listening skills vital to the role and responsibilities of a professional constructor are developed and enhanced.

### **CM 691 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **CM 692 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **CM 788 MASTER'S RESEARCH PROBLEMS/PROJECTS**

Credit to be arranged; not to exceed 3 credits toward fulfillment of M.S. degree requirements. Independent research problems/projects that lead to a research or design paper but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

### **CM 790 SEMINAR**

(1-0) 1 credit. May not be repeated for degree credit. A highly focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media, such as Internet, and are at the upper division or graduate levels. Enrollment is generally limited to 20 or fewer students.

### **CM 791 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **CM 792 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **CM 798 THESIS**

Credit to be arranged; not to exceed 6 credits toward fulfillment of the M.S. degree requirements. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

### **CP 297/397/497 COOPERATIVE EDUCATION**

1 to 3 credits. Applied, monitored and supervised, field-based learning experience for which the student may or may not be paid. Students gain practical experience; they follow a negotiated and or directed plan of study established between the student, instructor and field experience supervisor. Due to the presence of a field experience supervisor, a lower level of supervision is provided by the instructor in these courses than is the case with an internship or practicum course. Students must satisfy departmental co-op requirements, which include a written report of the co-op work experience and an employer's evaluation, to earn credit for the course. Minimum GPA and other co-op eligibility

requirements vary among employers. Because the work performed by a student while on co-op is equivalent to the workload of a full-time student, a student on co-op assignment who is registered for CP credit shall be considered to have full-time status.

### **CP 697 COOPERATIVE EDUCATION**

1 to 3 credits. A single semester work experience at the employer's location. Students will be asked to utilize specialized skills learned in the classroom and will be permitted to develop human relations skills and maturity in a degree-relevant work environment. Each student must satisfy departmental requirements in order to earn credit for the course. Requirements will include but not be limited to a written report of the work experience and an employer's evaluation of work performance. Students must have the approval of their graduate committee in order to enroll.

### **CSC 105 INTRODUCTION TO COMPUTERS**

(3-0) 3 credits. Overview of computer applications with emphasis on word processing, spreadsheets, database, presentation tools and Internet-based applications. May not be used for credit toward an engineering or science degree (except Interdisciplinary Sciences and Associate of Arts).

### **CSC 150/150L COMPUTER SCIENCE I**

(2-1) 3 credits. Pre- and Co-requisites: MATH 123. An introduction to computer programming. Focus on problem solving, algorithm development, design, and programming concepts. Topics include sequence, selection, repetition, functions, and arrays.

### **CSC 210 WEB AUTHORIZING**

(3-0) 3 credits. Prerequisites: CSC 105 or permission of instructor. This course focuses on techniques and methods for writing specifically for the Internet. Topics will include designing and creating documents for the World Wide Web, design considerations, and publishing and maintaining websites. Students will use HTML, web authoring software, and other software for

web development.

### **CSC 250 COMPUTER SCIENCE II**

(4-0) 4 credits. Prerequisites: CSC 150 /150L completed with a minimum grade of "C". Problem solving, algorithm design, standards of program style, debugging and testing. Extension of the control structures and data structures of the high-level language introduced in CSC 150. Elementary data structures and basic algorithms that include sorting and searching. Topics include more advanced treatment of functions, data types such as arrays and structures, and files.

### **CSC 251 FINITE STRUCTURES**

(4-0) 4 credits. Prerequisites: CSC 150/150L or permission of instructor. Selected topics from Boolean algebra, set theory, congruencies, equivalence relations, complexity, graph theory, combinatorics, induction, difference equations, and logic.

### **CSC 291 INDEPENDENT STUDY**

1 to 5 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. May be repeated to a total of 5 credit hours.

### **CSC 292 TOPICS**

1 to 5 credits. Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. May be repeated to a total of 6 credit hours.

### **CSC 300 DATA STRUCTURES**

(4-0) 4 credits. Prerequisites: CSC 250 completed with a minimum grade of "C" and CSC 251. A systematic study of data structures and the accompanying algorithms used in computing problems; structure and use of storage; methods of

representing data; techniques for implementing data structures; linear lists; stacks; queues; trees and tree traversal; linked lists; and other structures.

**CSC 314/314L ASSEMBLY LANGUAGE**  
(2-2) 4 credits. Prerequisites: CSC 250. A thorough introduction to assembly language programming and processor architecture. A study of low-level programming techniques, and the layout of a typical computer. The student will gain insight into the memory layout, registers, run-time stack, and global data segment of a running program. This course is cross listed with CENG 314/314L. Graduation credit will not be allowed for both this course and CENG 314/314L.

**CSC 317/317L COMPUTER ORGANIZATION AND ARCHITECTURE**  
(3-1) 4 credits. Prerequisites: CSC 31/314L and CENG 244. A course in computer organization with emphasis on the hierarchical structure of computer systems. Covers such topics as: components of computer systems and their configuration, design of basic digital circuits, the microprogram level, the conventional machine level, the operating system level, assembly language, addressing modes, interpreters/translators, computer arithmetic.

**CSC 372 ANALYSIS OF ALGORITHMS**  
(3-0) 3 credits. Prerequisites: MATH 125 and a "C" or better in CSC 300. Design and analysis of algorithms for numeric and nonnumeric problems, general problem-solving approaches, theory of computation. Topics will be selected from searching, sorting, graph algorithms, numerical algorithms, geometric algorithms, cryptography, and parallel algorithms.

**CSC 391 INDEPENDENT STUDY**  
1 to 5 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting

frequency depends on the requirements of the topic. May be repeated to a total of 5 credit hours.

### **CSC 392 TOPICS**

1 to 5 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. May be repeated to a total of 6 credit hours.

**CSC 405/505 SURVEY OF DATA STRUCTURES AND ALGORITHMS**  
(3-0) 3 credits. Prerequisites: CSC 150/150L and senior or graduate standing. This is the CSC leveling course for non-CSC majors who are entering the graduate program in the computer science department. It will lay the necessary foundation in data structures and algorithms to prepare students from other disciplines to take advanced courses in the Computer Science department. Topics covered in this course include recursion, linked lists, stacks, queues, trees, graphs, searching, sorting, and the basics of software development. This course may not be used for credit toward the B.S. in computer science. Students may not obtain credit for this course and CSC 300. Student enrolled in CSC 505 will be held to a higher standard than those enrolled in CSC 405.

**CSC 410/510 PARALLEL COMPUTING**  
(3-0) 3 credits. Prerequisites: CSC 300. The fundamental ideas and issues involved in programming and using parallel computers. A survey of modern architectures and operating systems. Parallel programming applications in business, economic modeling, and science. The School of Mines emphasizes scientific applications. Students enrolled in CSC 510 will be held to a higher standard than those enrolled in CSC 410.

**CSC 412/512 CRYPTOGRAPHY**  
(3-0) 3 credits. Prerequisites: MATH 413 and CSC 250, or permission of instructor. This course provides an introduction to cryptography and the mathematics behind current encryption

algorithms. It covers classical cryptosystems, private-key cryptosystems (such as DES and AES), and public-key cryptosystems (such as RSA).

### **CSC 415/415L/515/515L INTRODUCTION TO ROBOTICS**

(2-1) 3 credits. Prerequisites: CSC 300 and MATH 321. Pre- or Co- requisites: CSC 405/505 or permission of instructor. An introduction to mechatronic systems and embedded systems for robotics. This course will cover the basics required for autonomous mobile robotics. The course will begin with a survey of existing systems and some background mathematics. Core course topics will include electromechanical components, electronics for motor control, sensors and instrumentation, mobile robotic kinematics and movement, microcontrollers, real time computing, and embedded system design and development. Course projects will include student teams building task oriented mobile robots which emphasis on the hardware development. Students enrolled in CSC 515 will be held to a higher standard than those enrolled in CSC 415. This course is cross-listed with CENG 415/515.

### **CSC 416/416L/516/516L INTRODUCTION TO AUTONOMOUS SYSTEMS**

(2.5-0.5) 3 credits. Prerequisites: CSC 415/415L/515/515L or permission of instructor. An introduction to autonomous systems. This course will cover the basics behind intelligent autonomous machines focusing on autonomous mobile robotics. Core course topics will include perception and vision, robot localization, mapping, navigation, standard mobile robot tasks and environmental issues. Course projects will include student teams building task oriented mobile robots. Student enrolled in CSC 516/516L will be held to a higher standard than those enrolled in CSC 416/416L.

### **CSC 421/521 GRAPHICAL USER INTERFACES WITH OBJECT-ORIENTED PROGRAMMING**

(3-0) 3 credits. Prerequisites: CSC 300 with a minimum grade of "C". This course provides an introduction to graphical user interface (GUI)

programming, using an object-oriented programming (OOP) approach. Topics include an introduction to GUI design, fundamental concepts in GUI programming, and advanced OOP subjects. Course projects will make use of current GUI development environments (e.g., C++ with Qt, Java, C#). Students enrolled in CSC 521 will be held to a higher standard than those enrolled in CSC 421.

### **CSC 433/533 COMPUTER GRAPHICS**

(3-0) 3 credits. Prerequisites: CSC 300 and MATH 225. Graphical programming concepts. Display media and device characteristics. Point, line, and circle plotting. Coordinate systems and transformations. Polygon clipping and filling. Spline methods, hidden surface elimination, and shading. Students enrolled in CSC 533 will be held to a higher standard than those enrolled in CSC 433.

### **CSC 440/440L ADVANCED DIGITAL SYSTEMS**

(3-1) 4 credits. Prerequisites: CSC 317/317L or permission of instructor. Memory and disk systems, bus and I/O systems, parallel processing. Applications of digital systems in real-time processing. Graduation credit will not be allowed for both this course and CENG 446/446L.

### **CSC 445/545 INTRO TO THEORY OF COMPUTATION**

(3-0) 3 credits. Prerequisites: CSC 251. Introduction to a series of models for computation and their relationship to formal languages that are useful in the definition of programming languages along with a look at the theoretical limits of computers. Topics include finite and pushdown automata, Turing machines, grammars, decidability and computational complexity. Students enrolled in CSC 545 will be held to a higher standard than those enrolled in CSC 445.

### **CSC 447/547 ARTIFICIAL INTELLIGENCE**

(3-0) 3 credits. Prerequisites: CSC 300. Concepts in Artificial Intelligence: programming in languages such as Prolog or LISP; knowledge representation; search algorithms. Students

enrolled in CSC 547 will be held to a higher standard than those enrolled in CSC 447.

### **CSC 448/548 MACHINE LEARNING**

(3-0) 3 credits. Prerequisites: CSC 300. A systematic study of the theory and algorithms that constitute machine learning. It covers learning based on examples including genetic algorithms, case-based reasoning, decision trees, and Bayesian methods. Students enrolled in CSC 548 will be held to a higher standard than those enrolled in CSC 448.

### **CSC 449/549 PATTERN RECOGNITION**

(3-0) 3 credits. Prerequisites: CSC 300, MATH 225 and MATH 381 or MATH 442 or permission of instructor. Introduction to pattern recognition algorithms. Topics covered include statistical pattern recognition, machine learning, and neural networks. Students enrolled in CSC 549 will be held to a higher standard than those enrolled in CSC 449.

### **CSC 456/456L OPERATING SYSTEMS**

(3-1) 4 credits. Prerequisites: CSC 314/314L or CENG 314/314L and a minimum grade of "C" in CSC 300. A study of the functions and structures associated with operating systems with respect to process management, memory management, auxiliary storage management, and processor management. Topics include concurrent and distributed computing, deadlock, real and virtual memory, job and processor scheduling, security and protection. Graduation credit will not be allowed for both this course and CENG 456.

### **CSC 461 PROGRAMMING LANGUAGES**

(3-0) 3 credits. Prerequisites: CSC 300 with a minimum grade of "C". This course consists of two parts. The first part introduces how programming languages are designed, including an introduction to the concepts of parsing and compiling. Issues related to implementation such as type checking, binding, and memory management are discussed. Secondly, the course will survey the spectrum of programming languages paradigms, including traditional imperative, object oriented, functional, and logic languages.

### **CSC 463/563 DATA COMMUNICATIONS**

(4-0) 4 credits. Prerequisites: CSC 250. A study of the principles of data communications, computer networks, and open systems, following the outline provided by the ISO/OSI model. Students enrolled in CSC 563 will be held to a higher standard than those enrolled in CSC 463.

### **CSC 464/564 INTRODUCTION TO DIGITAL IMAGE PROCESSING AND COMPUTER VISION**

(3-0) 3 credits. Prerequisites: CSC 300 and MATH 125. Introduction to digital image processing and computer vision, including image digitization and display, image enhancement and restoration, frequency domain techniques using the Fourier transform, image encoding, segmentation, and feature detection. Students enrolled in CSC 564 will be held to a higher standard than those enrolled in CSC 464.

### **CSC 465 SENIOR DESIGN I**

(0-2) 2 credits. Prerequisites: CSC 470 and senior standing or permission of instructor. This is a team-based project-design course. This course will focus on the design process and culminate with the faculty approval of design projects. Typical topics included are the development of a design document, identification of customer needs, development of specifications, consideration of alternate designs using a decision matrix, project management techniques, legal, global and ethical issues.

### **CSC 467 SENIOR DESIGN II**

(0-2) 2 credits. Prerequisites: CSC 465 or permission of instructor. This course is a continuation of CSC 465. The student will complete the project approved in CSC 465. It will require that the students implement the design projects in a simulated industrial environment. Specific requirements may include detailed laboratory notebook, periodic written and oral progress reports, and a written and oral presentation of the final project report.

### **CSC 470 SOFTWARE ENGINEERING**

(3-0) 3 credits. Prerequisites: CSC 300 with a minimum grade of "C" or or permission of

instructor. An introduction to the software engineering process, including lifecycle phases, problem analysis, specification, project estimation and resource estimation, design, implementation, testing/maintenance, and project management. In particular, software validation and verification as well as scheduling and schedule assessment techniques will be discussed.

### **CSC 484 DATABASE MANAGEMENT SYSTEMS**

(3-0) 3 credits. Prerequisites: CSC 300 with a minimum grade of "C". The study of formalized database design. This course will focus on relational model design and the use of SQL. Students will use a modern relational database to implement designs and learn the basics of data management.

### **CSC 491 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. May be repeated to a total of 5 credit hours.

### **CSC 492 TOPICS**

1 to 3 credits. Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. May be repeated to a total of 6 credit hours.

### **CSC 498 UNDERGRADUATE RESEARCH/SCHOLARSHIP**

Credit to be arranged; not to exceed 6 credits toward fulfillment of B.S. degree requirements. Prerequisites: Permission of instructor. Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student.

Contact between the two may be extensive and intensive. Does not include research courses which are theoretical. May be repeated to a total of 6 credit hours.

### **CSC 691 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Student should have obtained permission of an instructor in the Department of Mathematics and Computer Science prior to registering for this course. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic. May be repeated to a total of 5 credit hours.

### **CSC 692 TOPICS**

1 to 3 credits. Students should have obtained permission of an instructor in the Department of Mathematics and Computer Science prior to registering for this course. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. May be repeated to a total of 6 credit hours.

### **CSC 752 COMPUTER VISION**

(3-0) 3 credits. Prerequisites: Permission of instructor. Low-level processing for extraction of intrinsic image features (edges, range, surface orientation, motion and optical flow, texture), relaxation methods, image segmentation, pattern recognition, geometric and relational structures, knowledge representation, and neural network approaches.

### **CSC 761 ADVANCED ARTIFICIAL INTELLIGENCE**

(3-0) 3 credits. Prerequisites: Permission of instructor. The objective of this course is to provide students with a background in advanced artificial intelligence problem solving methods. Topics covered include: Expert systems, fuzzy

logic and fuzzy expert systems, genetic algorithms, case-based reasoning, and current research work on new areas of problem solving.

### **CSC 762 NEURAL NETWORKS**

(3-0) 3 credits. Prerequisites: CSC 300 or permission of instructor. This course presents a survey of the architecture and algorithms of neural networks. Topics covered include perceptrons, competitive learning, multi-layer networks, back propagation, and selected topics from pattern recognition.

### **CSC 772 ADVANCED OPERATING SYSTEMS**

(3-0) 3 credits. Prerequisites: CSC 456/456L or permission of instructor. Advanced topics in operating systems design for multiprocessing and distributed systems. Topics will include areas such as methods of interprocess communication, reliability, maintainability, security, and large-scale design considerations.

### **CSC 784 DATABASE DESIGN**

(3-0) 3 credits. Prerequisites: CSC 300 or permission of instructor. This course will include an overview of the relational and entity relationship (E-R) models. It will cover database design, advanced data models, emerging trends in the database field, including data warehouse, data mining, and distributed and parallel databases. Oracle database design tools and programming will be taught.

### **CSC 788 MASTER'S RESEARCH PROBLEMS/PROJECTS**

Credit to be arranged; not to exceed 3 credits toward fulfillment of M.S. degree requirements. Open only to students pursuing the M.S. non-thesis option. Independent research problems/projects that lead to a research or design paper but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical. Oral defense of the report and findings are required.

### **CSC 790 SEMINAR**

(1-0) 1 credit. May not be repeated for degree credit. A highly-focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as Internet and are at the upper division graduate levels.

### **CSC 791 INDEPENDENT STUDY**

1 to 5 credits. Prerequisites: Permission of instructor. Student should have obtained permission of an instructor in the Department of Mathematics and Computer Science prior to registering for this course. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic. May be repeated to a total of 5 credit hours.

### **CSC 792 TOPICS**

1 to 5 credits. Student should have obtained permission of an instructor in the Department of Mathematics and Computer Science prior to registering for this course. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. May be repeated to a total of 6 credit hours.

### **CSC 798 THESIS**

Credit to be arranged; not to exceed 6 credits toward fulfillment of M.S. degree requirements. Open only to students pursuing the M.S. thesis option. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

**EE 220/220L CIRCUITS I**

(3-1) 4 credits. Prerequisites: MATH 125 completed with a minimum grade of "C". Pre- or Co-requisites: MATH 321. This course is designed to provide the electrical engineering student with an understanding of the basic concepts of the profession. Topics covered include resistive circuits, transient circuits, and sinusoidal analysis. Students also investigate essential principles by conducting laboratory experiments related to the topics studied in the classroom. P-spice is used to analyze electrical circuits using personal computers.

**EE 221/221L CIRCUITS II**

(3-1) 4 credits. Prerequisites: EE 220/220L completed with a minimum grade of "C" and MATH 321. This course is designed to provide the electrical engineering student with an understanding of the basic concepts of the profession. Topics covered include resistive circuits, transient circuits, and sinusoidal analysis. Students also investigate essential principles by conducting laboratory experiments related to the topics studied in the classroom. P-spice is used to analyze electrical circuits using personal computers.

**EE 264/264L SOPHOMORE DESIGN**

(1-1) 2 credits. Prerequisites: Sophomore standing. This course focuses on the design process including project management and teamwork; formal conceptual design methods; acquiring and processing information; design management tools; design for manufacturability, reliability, maintainability, sustainability; design communication: reports and presentations; ethics in design; prototyping designs; case studies. This course is cross-listed with ME 264/264L.

**EE 291 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students

negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

**EE 292 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

**EE 301/301L INTRODUCTORY CIRCUITS, MACHINES, AND SYSTEMS**

(3-1) 4 credits. Prerequisites: MATH 125 completed with a minimum grade of "C" and MATH 321 completed or concurrent. Not for majors in electrical engineering or computer engineering. Introduces the essential concepts of electrical engineering concerning circuits, machines, electronics, and systems.

**EE 303/303L BASIC CIRCUITS**

(2-1) 3 credits. Not for majors in Electrical or Computer Engineering. Introduces basic concepts in electrical DC and AC circuits including analysis techniques and applications. Concepts will be reinforced through lab work.

**EE 311/311L SYSTEMS**

(3-0.5) 3.5 credits. Prerequisites: EE 221/221L completed with a minimum grade of "C" and EM 216 completed or concurrent. Mathematical, topological, and circuit models of electro-systems, such as electromagnetic, electromechanical, electro thermal, etc.

**EE 312/312L SIGNALS**

(3-0.5) 3.5 credits. Prerequisites: EE 221/221L completed with a minimum grade of "C". Characterization of signals; the complex plane as a representative of the transient and frequency responses, continuous and discrete signal processing.

**EE 320/320L ELECTRONICS I**

(3-1) 4 credits. Pre- or Co-requisites: EE 221/221L. Presents concepts of electronic devices and circuits including modeling of semiconductor

devices, analysis and design of transistor biasing circuits, and analysis and design of linear amplifiers. Use of computer simulation tools and breadboarding as part of the circuit process is emphasized. Students are introduced to methods for designing circuits that still meet specifications even when there are statistical variations in the component values.

### **EE 322/322L ELECTRONICS II**

(3-1) 4 credits. Prerequisites: EE 221/221L and EE 320/320L. A continuation of EE 320 with emphasis on design applications of linear and nonlinear integrated circuits.

### **EE 330/330L ENERGY SYSTEMS**

(3-1) 4 credits. Prerequisites: EE 221/221L. Production, transmission, and utilization of energy in systems with major electrical subsystems, with particular emphasis on electromagnetic and electromechanical systems and devices.

### **EE 351/351L MECHATRONICS AND MEASUREMENT SYSTEMS**

(3-1) 4 credits. Prerequisites: CSC 150/150L and EE 220/220L or EE 301/301L. This course will encompass general measurement techniques found in mechanical and electrical engineering. These include measurement of force, strain, frequency, pressure flow rates, and temperatures. Elements of signal conditioning and data acquisition will be introduced. In addition to this material, the course will have a mechatronics approach reflected in the combined applications of electronic mechanical and control systems. This course is cross-listed with ME 351/351L.

### **EE 362 ELECTRIC AND MAGNETIC PROPERTIES OF MATERIALS**

(3-0) 3 credits. Prerequisites: MATH 225, MATH 321, and PHYS 213. This course studies the behavior of materials of interest to electrical engineers and covers fundamental issues such as energy band theory, density of states, Fermi-Dirac statistics, equilibrium statistics in semiconductors, and Fermi energy. This foundation is then used to study a variety of topics such as conduction,

semiconductor devices, ferromagnetism, lasers, gaseous electronics, and thermoelectric phenomena.

### **EE 381 ELECTRIC AND MAGNETIC FIELDS**

(3-0) 3 credits. Prerequisites: EE 221/221L, MATH 225, and PHYS 213. Fundamentals of field theory (i.e., Maxwell's equations) as applied to static electric and magnetic phenomena. Also, theory and applications of lossless transmission lines are covered.

### **EE 382/382L APPLIED ELECTROMAGNETICS**

(2.5-0.5) 3 credits. Prerequisites: EE 381. Field theory (e.g., Maxwell's equations) for time-varying electromagnetic phenomena. Applications include transmission lines, plane waves, and antennas. Students are introduced to typical laboratory equipment associated with applied electromagnetics (e.g., vector network analyzer).

### **EE 391 INDEPENDENT STUDY**

1 to 4 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **EE 392 TOPICS**

1 to 4 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **EE 421/421L COMMUNICATION SYSTEMS**

(3-1) 4 credits. Prerequisites: EE 312/312L and EE 322/322L. Fundamentals of analog- and digital-signal transmission. Performance characteristics such as channel loss, distortion,

bandwidth requirements, signal-to-noise ratios, and error probability.

### **EE 431/431L POWER SYSTEMS**

(3-1) 4 credits. Prerequisites: EE 311/311L and EE 330/330L. The principles of energy conversion and transmission in modern power systems. Specialized problems of design, control, and protection are included.

### **EE 432/432L POWER ELECTRONICS**

(3-1) 4 credits. Prerequisites: EE 330/330L. The conversion, regulation, and control of electric power by means of electronic switching devices; inverter and chopper circuits; pulse width modulation; motor drives.

### **EE 453/453L CONTROL SYSTEMS**

(3-1) 4 credits. Prerequisites: ME 352 or EE 311/311L. Analysis and design of automatic control and process systems by techniques encountered in modern engineering practice, including both linear and nonlinear systems with either continuous or discrete signals. This course is cross-listed with ME 453/453L

### **EE 464 SENIOR DESIGN I**

(0-2) 2 credits. Prerequisites: Senior standing. Pre- or Co-requisites: EE 311/311L, EE 312/312L, EE 322/322L and ENGL 289. This course will focus on the design process and culminate with the EE faculty approval of design projects (including schematics and parts list) for EE 465. Typical topics included are the development of a product mission statement, identification of the customer and customer needs, development of target specifications, consideration of alternate designs using a decision matrix, project management techniques, legal and ethical issues, FCC verification and certification, use of probability and statistics for reliable design, interpretation of data sheets, and component selection.

### **EE 465 SENIOR DESIGN II**

(0-2) 2 credits. Prerequisites: EE 464. Sequel to EE 464. Seniors build project in simulated environment incorporating engineering standards and realistic constraints. Requirements include

laboratory notebook, progress reports, final oral presentation, and written report.

### **EE 481/481L MICROWAVE ENGINEERING**

(3-1) 4 credits. Prerequisites: EE 382/382L. Presentation of basic principles, characteristics, and applications of microwave devices and systems. Development of techniques for analysis and design of microwave circuits.

### **EE 483/483L/583/584L ANTENNAS FOR WIRELESS COMMUNICATIONS**

(3-1) 4 credits. Prerequisites: EE 382/382L. Introduction to antenna design, measurement, and theory for wireless communications including fundamental antenna concepts and parameters (directivity, gain, patterns, etc.), matching techniques, and signal propagation. Theory and design of linear, loop, and patch antennas, antenna arrays, and other commonly used antennas. Students will design, model, build, and test antenna(s). Students enrolled in EE 583/583L will be held to a higher standard than those enrolled in EE 483/483L

### **EE 491 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **EE 492 TOPICS**

1 to 4 credits. Includes current topics, advanced topics, and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **EE 498 UNDERGRADUATE RESEARCH/SCHOLARSHIP**

Credit to be arranged: not to exceed 4 credits toward fulfillment of B.S. degree requirements.

Prerequisites: Permission of instructor. Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

### **EE 505/505L SURVEY OF CIRCUITS AND SYSTEMS**

(2-1) 3 credits. Prerequisites: CSC 150/150L, MATH 321 or permission of instructor. This course provides the necessary foundation in circuits, circuit analysis, transient circuits, sinusoidal analysis, electromechanical systems, electromagnetic systems, topological and mathematical models for the study of robotic and autonomous systems. May not be used for credit by computer engineering, electrical engineering, and mechanical engineering majors.

### **EE 552/552L ROBOTIC CONTROL SYSTEMS**

(2.5-0.5) 3 credits. Prerequisites: CSC 150/150L MATH 321, EE 311/311L or EE 505/505L or permission of instructor. Applications of discrete control systems for robotics and autonomous systems: analysis and design of automatic control systems, including both linear and nonlinear systems with continuous and discrete signals.

### **EE 612/612L HIGH-SPEED DIGITAL DESIGN**

(2.5-0.5) 3 credits. Prerequisites: EE 220/220L and EE 320/320L or equivalent courses in introductory circuits and introductory electronics. This course is an introduction to signal integrity and the design of high-speed circuits and interconnects. Topics include signal Integrity issues such as ringing, ground bounce, clock skew, jitter, crosstalk, and unwanted radiation, time-domain analysis and spice simulation of lumped and distributed high speed circuits, micro-strip and strip-line design, ground and power plane design, proper capacitor decoupling, line termination, and multi-layer routing strategies. The student is also introduced to high-speed measurement techniques and equipment.

### **EE 618/618L SENSORS AND SIGNAL PROCESSING**

(2-1) 3 credits. Presentation of principles, characteristics, and applications of instrumentation systems including sensors, filters, instrumentation amplifiers, analog-to-digital and digital-to-analog conversions, and noise. This course will be useful to graduate students beginning their laboratory thesis research. It is available to students from other departments with permission of instructor.

### **EE 621 INFORMATION AND CODING THEORY**

(3-0) 3 credits. Principles and techniques of information theory and coding theory and their application to the design of information handling systems. Topics include: entropy, Shannon theory, channel capacity, coding for data translation, compaction, transmission and compression, block codes, and Markov processes.

### **EE 622 STATISTICAL COMMUNICATION SYSTEMS**

(3-0) 3 credits. Concepts of probability and random processes; linear systems and random processes; performance of amplitude angle and pulse modulation systems in noisy environments; digital data transmission; and basic concepts of information theory.

### **EE 623 RANDOM SIGNALS AND NOISE**

(3-0) 3 credits. Prerequisites: Permission of instructor. Selected topics in the theory of probability and statistics; spectral analysis; shot noise and Gaussian processes; noise figures; signal-to-noise ratios; random signals in linear systems; optimum linear systems. Taught as required.

### **EE 624/624L ADVANCED DIGITAL SIGNAL PROCESSING**

(2.5-0.5) 3 credits. Prerequisites: CENG 420/420L or equivalent. This course develops the theory essential to understanding the algorithms that are increasingly found in modern signal processing applications, such as speech, image processing, digital radio and audio, statistical and

adaptive systems. Topics include: analysis of non-stationary signals, transform techniques, Wiener filters, Kalman filters, multirate rate systems and filter banks, hardware implementation and simulation of filters, and applications of multirate signal processing. Matlab will be used extensively.

**EE 633 POWER SYSTEM ANALYSIS I**  
(3-0) 3 credits. Prerequisites: EE 431/431L or equivalent. Synchronous machine theory and modeling; short-circuit, load flow, and stability studies in large scale systems. Taught as required.

**EE 634 POWER SYSTEM ANALYSIS II**  
(3-0) 3 credits. Prerequisites: EE 633. Advanced topics in power system analysis; excitation and speed-control systems; protective relaying and relay applications. Taught as required.

**EE 641 DIGITAL SYSTEMS DESIGN**  
(3-0) 3 credits. Prerequisites: Permission of instructor. Design of digital systems (including computer systems) and implementation by fixed logic and programmed logic (microprocessors and microprogramming). Taught as required.

**EE 643 ADVANCED DIGITAL SYSTEMS**  
(3-0) 3 credits. Study of current advanced topics in digital systems; multiprocessors; computer networks; digital communication; pattern recognition systems. Taught as required.

**EE 644 FAULT TOLERANT COMPUTING**  
(3-0) 3 credits. Prerequisites: CENG 342/342L or equivalent or permission of instructor. The objective of this course is to provide students with a background in the various techniques used in fault tolerant approaches. After an introduction to fault tolerance, deterministic testing and probabilistic testing will be presented. Important topics in the area of fault tolerant computing will be covered, such as random testing, error detection and correction, reliability analysis, fault-tolerant design techniques, and design faults including software reliability methods.

**EE 647/647L HDL DESIGN**  
(2.5-0.5) 3 credits. Prerequisites: CENG

342/342L or permission of instructor. This course explores modern design techniques utilizing hardware description languages (HDLs) such as VHDL, VHDL-A, and Verilog. Fundamental language syntax will be covered in addition to advanced language constructs. Various hierarchical design styles such as dataflow, structural, and behavioral descriptions will be presented. Emphasis will be placed on both design simulation and synthesis. Synthesis platforms (e.g., FPGAs and ASICs) will also be examined. Other current issues will also be discussed such as reconfigurability, system-on-a-chip solutions, testbenches, soft processors, etc.

**EE 648/648L ADVANCED VLSI DESIGN**  
(2.5-0.5) 3 credits. Prerequisites: CENG 440/440L. This course presents more advanced material related to the technology and design of modern VLSI integrated circuits including topics such as mixed logic design, BiCMOS logic design, memory design, low power design, silicon-on-insulator chips, deep sub-micron design issues, crosstalk, parasitic parameter extraction and optimization, gallium arsenide logic devices, design-for-test, fault-tolerant VLSI architectures, etc.

**EE 651 DIGITAL CONTROL SYSTEMS**  
(3-0) 3 credits. Prerequisites: EE 453 or equivalent. Study of topics in digital control systems, digital compensation techniques; real-time digital control of dynamic systems; optimization of digital systems; digital control of robotic systems, digital to continuous system interfacing. Taught as required.

**EE 652 NONLINEAR AND OPTIMAL CONTROL SYSTEMS**  
(3-0) 3 credits. The study of nonlinear and optimal systems using the phase plane method, describing functions, Lyapunov's theory, nonlinear control systems design, linear, dynamic and integer programmer, parameter optimization, and system optimization using calculus of variation.

**EE 691 INDEPENDENT STUDY**  
1 to 3 credits. Prerequisites: Permission of

instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

### **EE 692 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **EE 791 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

### **EE 788 MASTER'S RESEARCH PROBLEMS/PROJECTS**

Credits to be arranged. Not to exceed 3 credits hours. Independent research problems/projects that lead to research or design paper, but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

### **EE 792 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **EE 798 THESIS**

Credit to be arranged; not to exceed 6 credits toward fulfillment of the M.S. degree requirements. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

### **EM 214 STATICS**

(3-0) 3 credits. Prerequisites: MATH 123. The study of the effects of external forces acting on stationary rigid bodies in equilibrium. Vector algebra is used to study two and three dimensional systems of forces. Trusses, frames and machines, shear and moment in beams, friction, centroids, moments of inertia, and mass moments of inertia are discussed.

### **EM 215 DYNAMICS**

(3-0) 3 credits. Prerequisites: EM 214. Newton's laws of motion are applied to particles and rigid bodies. Absolute and relative motion; force, mass and acceleration; work and energy; and impulse and momentum.

### **EM 216 STATICS AND DYNAMICS**

(4-0) 4 credits. Prerequisites: MATH 123. Statics: the study of effects of external forces acting on stationary rigid bodies in equilibrium. Frames and machines, friction, centroids and moments of inertia of areas and mass are discussed. Dynamics: Newton's laws of motion are applied to particles and rigid bodies. Topics considered are absolute and relative motion; force, mass, and acceleration (or particles and rigid bodies); work and energy; and impulse and momentum (of particles).

### **EM 321 MECHANICS OF MATERIALS**

(3-0) 3 credits. Prerequisites: EM 214 with a minimum grade of "C". Basic concepts of stress and strain that result from axial, transverse, and

torsional loads on bodies loaded within the elastic range. Shear and movement equations and diagrams; combined stresses; Mohr's circle; beam deflections; and column action and equations.

### **EM 328 APPLIED FLUID MECHANICS**

(3-0) 3 credits. Prerequisites: EM 214 or concurrent enrollment in EM 216. Topics will include an introduction to the static and dynamic properties of real and ideal fluids; application of continuity, energy, and momentum principles to laminar, turbulent, compressible, and incompressible flows; laminar and turbulent flow of fluids in closed conduits and open channels; flow through orifices, weirs, and venturi meters. Flow in pipe networks and pumping systems will be investigated using a projectized team approach.

### **EM 331 FLUID MECHANICS**

(3-0) 3 credits. Prerequisites: EM 214. An introduction to the static and dynamic properties of real and ideal fluids; application of continuity, energy, and momentum principles to laminar, turbulent, compressible, and incompressible flows; and laminar and turbulent flow of fluids in closed conduits and around immersed bodies.

### **EM 680 ADVANCED STRENGTH OF MATERIALS**

(3-0) 3 credits. Study of advanced concepts in strength of materials. Topics will be selected from the following: theories of stress and strain, failure criteria, energy methods, torsion, nonsymmetrical beams on elastic foundation, plates, shells, stress concentrations, contact stresses, finite element methods, and plastic behavior of solids. This course is cross-listed with ME 680.

### **ENGL 003 ENGLISH AS A SECOND LANGUAGE: GRAMMAR REVIEW AND INTERMEDIATE COMPOSITION**

(3-0) 3 credits. Conversations, listening and reading comprehension, vocabulary and idioms, grammar review and intermediate composition. Does not count toward graduation

### **ENGL 013 ENGLISH AS A SECOND LANGUAGE: MORE COMPLEX STRUCTURAL PATTERNS AND ADVANCED COMPOSITION**

(3-0) 3 credits. Prerequisites: ENGL 003 or placement. Conversation, listening and reading comprehension, vocabulary and idioms, more complex structural patterns, and advanced composition. Does not count toward graduation.

### **ENGL 023 ENGLISH AS A SECOND LANGUAGE: LISTENING AND READING, GRAMMAR, COMPREHENSION.**

(3 to 5) 3 to 5 credits. Prerequisites: Placement or permission of the instructor. Written and oral responses to written and oral sources. Reading and listening comprehension, vocabulary building, pronunciation, grammar and sentence structure, and formal and informal written and spoken English. Does not count toward graduation.

### **ENGL 033 BASIC WRITING**

1 to 3 credits. Appropriate student placement based on entry level assessment. Intensive work in grammar and usage, punctuation, and paragraph development. Does not count toward graduation.

### **ENGL 101 COMPOSITION I**

(3-0) 3 credits. Appropriate student placement based on entry level assessment or completion of ENGL 033. Practice in the skills, research, and documentation needed for effective academic writing. Analysis of a variety of academic and non-academic texts, rhetorical structures, critical thinking, and audience will be included.

### **ENGL 201 COMPOSITION II**

(3-0) 3 credits. Prerequisites: ENGL 101 or permission of instructor. Study of and practice in writing persuasive prose, with the aim to improve writing skills in all disciplines. Includes literary analysis and requires a research report.

**ENGL 210 INTRODUCTION TO LITERATURE**

(3-0) 3 credits. Readings in fiction, drama, and poetry to acquaint students with literature and aesthetic form.

**ENGL 212 WORLD LITERATURE II**

(3-0) 3 credits. Selected works of world literature in translation since the Renaissance.

**ENGL 221 BRITISH LITERATURE I**

(3-0) 3 credits. A chronological survey of British literature from Old English through the 18th Century. ENGL 221 and ENGL 222 need not be taken in sequence.

**ENGL 222 BRITISH LITERATURE II**

(3-0) 3 credits. A chronological survey of British literature from the 19th century to the present. ENGL 221 and ENGL 222 need not be taken in sequence.

**ENGL 241 AMERICAN LIT I**

(3-0) 3 credits. Background to and survey of major works from the beginnings to the Civil War. ENGL 241 and ENGL 242 need not be taken in sequence.

**ENGL 242 AMERICAN LIT II**

(3-0) 3 credits. Background to and survey of major works from the Civil War to the present. ENGL 241 and ENGL 242 need not be taken in sequence.

**ENGL 250 SCIENCE FICTION**

(3-0) 3 credits. A survey of short stories and novels from the 19th century to the present.

**ENGL 279 TECHNICAL COMMUNICATIONS I**

(3-0) 3 credits. Prerequisites: ENGL 101 or equivalent and sophomore standing. Introductory written and oral technical communications with emphasis on research and explanations of scientific and engineering topics.

**ENGL 289 TECHNICAL COMMUNICATIONS II**

(3-0) 3 credits. Prerequisites: ENGL 279 or

equivalent and sophomore standing. Advanced written and oral technical communications with emphasis on the research, preparation, and delivery of complex technical documents.

**ENGL 300 THE LITERARY EXPERIENCE OF NATURE**

(3-0) 3 credits. Prerequisites: Junior or senior standing. An interdisciplinary survey of writing about nature, examining the relationship between literary, cultural, and scientific perspectives.

**ENGL 330 SHAKESPEARE**

(3-0) 3 credits. Prerequisites: ENGL 101 or permission of instructor. Representative comedies, tragedies, and histories of Shakespeare.

**ENGL 343 SELECTED AUTHORS**

(1-0) 1 credit. Prerequisites: ENGL 101 or permission of instructor. A study of the work of one or several major literary figures. Authors may change each time the course is offered. May be taken up to three (3) times with different authors.

**ENGL 350 HUMOR IN AMERICAN CULTURE**

(3-0) 3 credits. Prerequisites: Junior or senior standing. The interdisciplinary study of American literary humor and its relationship to significant historical and regional issues.

**ENGL 360 STUDIES IN EUROPEAN LITERATURE**

(3-0) 3 credits. Prerequisites: Junior or senior standing. The interdisciplinary study of a facet of European literature through focus on literature of a particular century, a specific country or individual authors such as 19th century nationalism, literature of France, or James Joyce. May be repeated to maximum of credit of six hours on different topics.

**ENGL 374 STUDIES IN AMERICAN LITERATURE**

1 to 3 credits. Prerequisites: Junior or senior standing. The interdisciplinary study of American literature through focus on a particular facet of the American experience, such as a national issue or

concern, a unique historical period or literary genre, or a distinct segment of U.S. society. May be repeated to maximum credit of six (6) hours on different topics.

### **ENGL 383 CREATIVE WRITING**

(3-0) 3 credits. Prerequisites: Junior standing. Study and practice in the techniques of writing fiction, poetry, and/or drama.

### **ENGL 391 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **ENGL 392 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A maximum of 6 credits of special topics will be allowed for degree credit.

### **ENGM 620 QUALITY MANAGEMENT**

(3-0) 3 credits. This course is intended as an introduction to the philosophies, concepts, and tools of Total Quality Management. Topics include: An introduction to the philosophies of Juran, Deming, and Taguchi; total quality and quality improvement; quality and technology; and managing a quality environment. Elements of statistical process control, including pareto diagrams, box plots, histograms, and control charts will also be investigated using a commercial software package. Special projects and current readings in quality management will be assigned.

### **ENGM 625 INNOVATION AND COMMERCIALIZATION**

(3-0) 3 credits. This course covers the practical

aspects of developing an innovative idea or new technology from conceptualization through commercialization. Course topics include product innovation, product development, technology forecasting, technology transfer, small business development resources, and commercialization.

### **ENGM 631 OPTIMIZATION TECHNIQUES**

(3-0) 3 credits. The course develops basic judgment and competence in using quantitative methods in engineering or management decisions. Students will study various types of linear programming techniques, including simplex, transportation and assignment methods and post-optimal sensitivity analysis. In addition, network-type problems, critical-path methods, dynamic and decision tree techniques will be covered. Some basic mathematical theory is taught and the computer is used to solve both assigned problems and problems developed by the student in a particular field of interest.

### **ENGM 640 BUSINESS STRATEGY**

(3-0) 3 credits. This course provides a financial management approach within a systems context approach. Financial concepts are analyzed from the perspective of three basic types of decisions for any ongoing business: investment, operations, and financing. Course materials are structured around the viewpoints of major parties interested in the performance of business: managers, owners, and creditors. Financial concepts are reinforced by simulating the impact various business strategies have on the financial health of the virtual enterprise.

### **ENGM 650 SAFETY MANAGEMENT**

(3-0) 3 credits. Management aspects of occupational safety and health. Topics include: Development and implementation of safety programs and ergonomics programs, risk management, economic impact, legislation (including OSHA, Workers Compensation, and ADA), legal issues, wellness programs, system safety, certification, ethics, and professionalism.

### **ENGM 655 ERGONOMICS FOR MANAGERS**

(3-0) 3 credits. Management aspects of

ergonomics and human factors engineering. Topics include: Introduction to ergonomics and human factors principles, the business case for ergonomics, understanding cumulative trauma and neurovascular disorders, development and implementation of ergonomics programs, economic and regulatory aspects, work organization, job satisfaction, quality and productivity aspects, strategic issues and trends, and certification.

### **ENGM 661 ENGINEERING ECONOMICS FOR MANAGERS**

Credit: Variable 1 to 4. Students are expected to have prerequisite skills in the time value of money and basic probability. Students not having these skills require the permission of instructor. The course is divided into four 1-credit modules, which include: economic valuation for decision making, problems with uncertainty and risk, budgeting and cost management, and financial statements and enterprise management. (Manufacturing elective)

### **ENGM 663 OPERATIONS PLANNING**

(3-0) 3 credits. Organization, functions, and responsibilities of the production control department and some related functions in industry. It includes: planning, authorizing, routing, scheduling, dispatching, and controlling the flow of production. The course also introduces the student to the fundamentals of inventory control, statistical quality control, pert-cpm, and operations research. (Manufacturing elective)

### **ENGM 675 LEGAL AND ETHICAL ISSUES IN ENGINEERING MANAGEMENT**

(3-0) 3 credits. This course will introduce students to many of the legal and ethical issues from a manager's perspective. Topics include: employment contracts, consulting, harassment, ADA compliance, Whistle Blower Act, research ethics, and helping employees with professional development.

### **ENGM 720 STATISTICAL PROCESS CONTROL**

(3-0) 3 credits. This course covers the application

of statistical methods to problems in quality and process control. Statistical topics include: basics of processes and variability, statistically controlled processes, variable and attribute control charts, moving averages, and process capability.

### **ENGM 732 STOCHASTIC MODELS IN OPERATIONS RESEARCH**

(3-0) 3 credits. Probabilistic quantitative methods are developed. These include project control (PERT), decision trees, risk analysis, queuing, Markov chains, mathematical modeling and Monte Carlo simulation. Computer programs are used to solve practical problems after the techniques are developed and understood.

### **ENGM 742 ENGINEERING MANAGEMENT AND LABOR RELATIONS**

(3-0) 3 credits. Principles of management, supervision, administrative policies, human-factors engineering, and labor-management relationships.

### **ENGM 745 FORECASTING FOR BUSINESS AND TECHNOLOGY**

(3-0) 3 credits. This course provides an introduction to the quantitative and qualitative tools that may be used to identify and assess emerging technological advances. Topics include multiple regression, ARIMA forecast models and estimation, econometric models, and delphi techniques. Special projects and current readings in technology may be assigned.

### **ENGM 788 MASTER'S RESEARCH PROBLEMS/PROJECTS**

Credit to be arranged; not to exceed 3 credits toward fulfillment of M.S. degree requirements. Open only to students pursuing the M.S. non-thesis option. Independent research problems/projects that lead to a research or design paper but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

### **ENGM 791 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic. Student may enroll in this course only twice and for no more than a total of 6 credits.

### **ENGM 792 TOPICS**

1 to 3 credits. Includes Current Topics, Advanced Topics, and Special Topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. Student may enroll in this course only twice and for no more than a total of 6 credits.

### **ENGM 798 THESIS**

Credits to be arranged; not to exceed 6 credits toward fulfillment of M.S. degree requirements. Open only to students pursuing the master of science in Engineering Management thesis option. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

### **ENVE 111/111L INTRODUCTION TO CHEMICAL PROCESS MODELING**

(1-1) 2 credits. Pre- or Co-requisites: CHEM 112. The primary objectives of this course are: introduction to mathematical modeling of physical and chemical systems; verification of mathematical models by experiment; introduction to engineering software like Excel; development and interpretation of engineering drawings, process flow diagrams (PFD's), and piping and instrumentation diagrams (P&ID's); use of drawing program, such as Visiotec; and

introduction to the process simulator AspenPlus; Oral and written communication of technical content to technical and non- technical audiences; and a focus on professional and academic paths in chemical engineering and related fields. This course is cross-listed with ENVE 111/111L. This course is cross-listed with CBE 111/111L.

### **ENVE 217 CHEMICAL ENGINEERING MATERIAL BALANCES**

(3-0) 3 credits. Pre- or Co-requisites: CHEM 114 and MATH 123 or permission of instructor. The course on the theory and practice of chemical engineering with emphasis on material and energy balances. This course is cross-listed with CBE 217.

### **ENVE 307 ENVIRONMENTAL GEOSTATISTICS**

(2-0) 2 credits. Prerequisites: GEOE 221/221L. The application of the theory of geostatistics to quantify the concepts of (1) area of influence of a sample, (2) the continuity of the regionalized variable within a deposit, (3) the lateral changes in the regionalized variable according to the direction. Basic concepts and theory of probability and statistics will be introduced, including probability distributions, sampling distributions, treatment of data, the mean, variance, and correlation. Computer techniques will be extensively used for geostatistical estimation of sampling attributes. This course constitutes the first two-thirds of and is cross-listed with MEM 307.

### **ENVE 315 FUNDAMENTALS OF HEAT TRANSFER**

((2-0) 2 credits. Prerequisites: CBE 218, CBE 250 and MATH 321 or permission of instructor. Course topics address theory and application of principles of heat transfer by conduction, convection and radiation. Completion of ENVE 315 will not meet the requirement for completion of CBE 317 for a B.S. in chemical engineering. This course is cross-listed with CBE 317.

**ENVE 316 FUNDAMENTALS OF MASS TRANSFER**

(2-0) 2 credits. Prerequisites: ENVE 315 or permission of instructor. Course topics address theory and application of principles of mass transfer by convection and diffusion. Completion of ENVE 316 will not meet the requirement for completion of CBE 318 for a B.S. in chemical engineering. This course is cross-listed with CBE 318.

**ENVE 325 INTRODUCTION TO SUSTAINABLE DESIGN**

(3-0) 3 credits. Prerequisites: Junior standing. Theories and principles employed in sustainable design are introduced and employed in various contexts. Analyses of engineering systems will be performed both analytically and quantitatively. Principles will be employed in problem solving as well as in fundamental design efforts. This course is cross-listed with CEE 325.

**ENVE 326 INTRODUCTORY ENVIRONMENTAL ENGINEERING DESIGN**

(3-0) 3 credits. Prerequisites: CHEM 114. As the first course in the theory and practice of environmental engineering, emphases are on the acquisition of introductory knowledge pertaining to natural and engineered environmental engineering systems, identification and mitigation of societal impacts upon the Earth, and application of environmental engineering principles in the design and analysis of systems for water and wastewater treatment and solid/hazardous waste management. This course is cross-listed with CEE 326.

**ENVE 327 ENVIRONMENTAL ENGINEERING PROCESS ANALYSIS**

(3-0) 3 credits. Prerequisites: CEE 326. Pre- or Co-requisites: CEE 284 and one of the following: EM 328, EM 331, CBE 218 or ME 331. As the second course in the theory and practice of environmental engineering, emphasis is on application of material balance concepts in environmental analysis and design with consideration of water chemistry, environmental process kinetics, ideal and non-ideal reactors,

biological process fundamentals, and inter-phase mass transfer phenomena. These fundamental principles are applied in selected natural and engineered environmental contexts spanning air, water and land systems and the effects of society on environmental systems. This course is cross-listed with CEE 327.

**ENVE 327L ENVIRONMENTAL ENGINEERING PROCESS ANALYSIS LAB**

(0-1) 1 credit. Co-requisites: ENVE 327. A laboratory course to accompany ENVE 327, in which students will perform hands on laboratory experiments; collect, analyze and interpret data; and document findings in scholarly written reports. The course is cross-listed with CEE 327L.

**ENVE 337 ENGINEERING HYDROLOGY**

(3-0) 3 credits. Prerequisites: EM 331 or EM 328. A quantification study of the components of the hydrologic cycle with emphasis on engineering applications involving the design of water supplies, reservoirs, spillways, floodways, and urban drainage with computer applications. This course is cross-listed with CEE 337.

**ENVE 390 SEMINAR**

0 to 1 credit. Prerequisites: Sophomore standing. A highly focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as Internet and are at the upper division or graduate levels. Enrollment is generally limited to fewer than 20 students. The course is repeatable up to three times for a total of 2 credits.

**ENVE 421 ENVIRONMENTAL SYSTEMS ANALYSIS**

(3-0) 3 credits. Prerequisites: CEE/ENVE 327. Course emphasis is on applications of environmental chemistry and material balance in quantitative characterizations of operative processes in selected air, water, and land systems and environmental health impacts. Analytical and computer solutions are performed. This course is

cross-listed with CEE 421/521.

### **ENVE 425 SUSTAINABLE ENGINEERING**

(3-0) 3 credits. Prerequisites: Junior standing. This course will serve as an introduction to the emerging field of sustainable engineering, with focus on understanding interactions between industrial processes and the environment. Identification and implementation of strategies to reduce the environmental impacts of products and processes associated with industrial systems will be explored and evaluated using tools such as life cycle analyses and materials balances. The course will also explore appropriate sustainable technologies employed within both developing and first world countries. This course is cross-listed with CEE 425/525.

### **ENVE 426 ENVIRONMENTAL ENGINEERING PHYSICAL/CHEMICAL PROCESS DESIGN**

(3-0) 3 credits. Prerequisites: CEE/ENVE 326. A third course in the theory and practice of environmental engineering. Emphases are on the design and analysis of physical/chemical environmental engineering unit operations and processes. This course is cross-listed with CEE 426/526.

### **ENVE 426L ENVIRONMENTAL PHYSICAL/CHEMICAL PROCESS LABORATORY**

(0-1) 1 credit. Pre- or Co-requisites: CEE/ENVE 426/526 or permission of instructor. A laboratory course to accompany CEE/ENVE 426/526. Examination of processes employed in design of environmental physical and chemical systems for renovation of contaminated waters and soils. Various bench-scale experiments will be performed with laboratory analysis using standard environmental web chemical and instrumental analytical techniques. Laboratory reports employing word processing, numerical and statistical analysis, and interpretation of process performance data will be written. This course is cross-listed with CEE 426L/526L.

### **ENVE 427 ENVIRONMENTAL ENGINEERING BIOLOGICAL PROCESS DESIGN**

(3-0) 3 credits. Prerequisites: CEE/ENVE 327. A fourth course in the theory and practice of environmental engineering. Emphases are on the design and analysis of biological environmental engineering unit operations and processes. This course is cross-listed with CEE 427/527.

### **ENVE 427L ENVIRONMENTAL BIOLOGICAL PROCESS LABORATORY**

(0-1) 1 credit. Pre- or Co-requisites: CEE/ENVE 427/527 or permission of instructor. A laboratory course to accompany CEE/ENVE 427/527. Examination of processes employed in design of environmental biological systems for renovation of contaminated waters and soils. Various bench-scale experiments will be performed with laboratory analysis using standard environmental web chemical, microbiological, and instrumental analytical techniques. Laboratory reports employing word processing, numerical and statistical analysis, and interpretation of process performance data will be written. This course is cross-listed with CEE 427L/527L.

### **ENVE 428L ENVIRONMENTAL ENGINEERING OPERATIONS AND PROCESSES LABORATORY**

(0-1) 1 credit. Prerequisites: CEE/ ENVE 327/327L. Bench-scale experiments are performed in examination of physical/chemical operations and biological processes employed in systems for treatment of waters, wastewaters, and soils. Standard chemical and instrumental analytical techniques are employed. Data are acquired, processed, analyzed both numerically and statistically, and interpreted. Formal laboratory reports are written. This course is cross-listed with CEE 428L/528L.

### **ENVE 464 ENVIRONMENTAL ENGINEERING PROJECT DESIGN I**

(0-1) 1 credit. Prerequisites: Senior standing. Students in this course will undertake a design effort integrating principles from prior coursework into completion of an overall project that will require both individual and team efforts.

This first design course will concentrate on definition of the design problem, preliminary design with investigation of various options, and screening of the various design options prior to undertaking detailed design. Economic and legal constraints, general social considerations and personnel factors will be considered along with the technical aspects of the design. Both oral and written engineering reports delineating project activities and results will be completed.

### **ENVE 465 ENVIRONMENTAL ENGINEERING PROJECT DESIGN II**

(0-2) 2 credits. Prerequisites: ENVE 464. Students in this course will undertake a design effort integrating principles from prior coursework into completion of the overall project that will require both individual and team efforts. This second design course will involve completion of the detailed design, construction of bench or pilot-scale units in accord with detailed design and demonstration of design effectiveness. Economic and legal constraints, general social considerations and personnel factors will be considered along with the technical aspects of the design. Both oral and written engineering reports delineating project activities and results will be completed.

### **ENVE 466 ENVIRONMENTAL ENGINEERING PROCESS DESIGN**

(3-0) 3 credits. Prerequisites: CEE/ENVE 421 or graduate standing. Physical/chemical and biological unit operations and processes applicable in environmental engineering and analyzed and/or designed. Analyses and designs are documented in both informal memoranda and formal design reports. This course is cross-listed with CEE 466/566.

### **ENVE 475/475L GROUND WATER**

(2-1) 3 credits. Prerequisites: GEOL 201 or GEOE 221/221L and MATH 225, or permission of instructor. Note: engineering majors must complete the equivalent of Calculus III before registration. Geohydrologic principles, applications, and design considerations concerning ground-water occurrence, flow, and quality. Ground-water and surface-water

relations; theory of aquifer tests; flow nets; head distribution by graphical, analytical, and digital models; ground-water contamination.

Laboratories include water budgets, chemistry of ground water, design of exploration programs and aquifer tests, computer solutions, and field trips to areas of geohydrologic interest. A design project with written and oral presentations is required.

This course is cross-listed with GEOE 475/475L.

### **ENVE 491 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **ENVE 492 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **ENVE 498 UNDERGRADUATE RESEARCH/SCHOLARSHIP**

1 to 6 credits. Prerequisites: Permission of instructor. Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical.

### **EXCH 289 STUDENT EXCHANGE-INTERNATIONAL**

0 to 18 credits. This course allows students to register as full-time School of Mines students while taking part in an Exchange Program. Students will register on the School of Mines campus for the amount of credit hours they intend to take while enrolled at another campus.

**EXCH 389 STUDENT EXCHANGE-INTERNATIONAL**

0 to 16 credits. This course allows students to register as full- time School of Mines students while taking part in an Exchange Program. Students will register on the School of Mines campus for the amount of credit hours they intend to take while enrolled at another campus.

**EXCH 487 STUDY ABROAD**

(0-0) 0 credits. Designed to keep a student active at the School of Mines if out for one to two semester(s) for study abroad program and not enrolling in credit at the School of Mines. Does not guarantee eligibility for financial aid. Repeatable, but for no more than three consecutive terms at any one point.

**EXCH 489 STUDENT EXCHANGE-INTERNATIONAL**

0 to 18 credits. This course allows students to register as full- time School of Mines students while taking part in an Exchange Program. Students will register on the School of Mines campus for the amount of credit hours they intend to take while enrolled at another campus.

**GE 130/130L INTRODUCTION TO ENGINEERING**

(1-1) 2 credits. Prerequisites: MATH 102. This course serves as an introduction to engineering profession and to its various disciplines. This course is designed to give students the opportunity to learn how to solve engineering analysis and design problems. Students will develop various computational skills, sharpen communication skills, and be exposed to professional development in the form of team building, technology tools, and project management. In addition, students will have the opportunity to learn from professional engineers and scientists through interaction with industry.

**GE 498 INTERDISCIPLINARY CAPSTONE SENIOR DESIGN**

(0-3) 3 credits. Prerequisites: Senior standing or permission of instructor. Content will include major interdisciplinary engineering design

experience integrating fundamental concepts of mathematics, basic science, engineering science, engineering design, communications skills, humanities and social science.

**GEOE 110/110L INTRODUCTION TO GEOLOGICAL AND MINING ENGINEERING**

(1-1) 2 credits. An introductory course for incoming freshmen in geological and mining engineering covering fundamental engineering practices in both disciplines. The course will include short field exercises, hands-on practical exercise, group projects, problem solving (using spreadsheets and other current methods), and engineering ethics. When applicable, industry experts will be invited as guest lecturers to discuss current trends and practices in the industry. This course is cross-listed with MEM 110/110L.

**GEOE 211/211L EARTH SYSTEMS ENGINEERING ANALYSIS**

(1-1) 2 credits. Application of computational analysis using spreadsheets to geological engineering problems in the earth system. Typical problems will include those found in energy systems, ground water and environmental systems, and economic evaluations having a significant geologic aspect. Examples and problems from the Black Hills region will be emphasized.

**GEOE 221/221L GEOLOGY FOR ENGINEERS**

(2-1) 3 credits. Basic concepts in the study of the earth, with emphasis on geological processes acting on the earth's surface. Topics include rock forming processes and identification, mass wasting, ground water, streams, glaciers, coastal erosion, and earthquakes. Emphasis is given to engineering significance of processes and their resulting deposits.

**GEOE 322/322L STRUCTURAL GEOLOGY**

(2-1) 3 credits. Prerequisites: GEOL 331 and either GEOL 341/341L or GEOL 314/314L. A study of the character and genesis of large-scale and small-scale deformational structures and their patterns in the earth's crust. Laboratory work

includes various trigonometric, geometric, and stereographic methods applicable to structural analysis and presents open-ended problems in geologic, structure contour, and isopach map interpretation, as well as engineering design problems including drilling exploration projects.

### **GEOE 324/324L ENGINEERING GEOPHYSICS I**

(2-1) 3 credits. Prerequisites: MATH 125 and PHYS 213. Application of the more commonly used methods of geophysical prospecting in mineral exploration, petroleum exploration, and engineering construction. Includes field design and interpretation of surveys using the engineering seismograph, gravity meter, electrical resistivity equipment, scintillometers, and magnetometers. Extensive use of computers is made in the laboratory work.

### **GEOE 410 ENGINEERING FIELD GEOLOGY**

5 to 6 credits. Prerequisites: Completion of junior-year studies. Instruction, practice, and independent work involving field techniques for geological engineering. Includes use of aerial photography and field mapping for completing large-scale and intermediate-scale geologic maps, structural sections, and structural contour maps of designated areas in the Black Hills region. Written reports will accompany the maps and sections. Three weeks of the five-week course are devoted to engineering problems including surface-water and ground-water hydrology, geotechnics, and minerals. Conducted for five weeks during the summer in the northern Black Hills. Arrangements for transportation, room, and board are made through the Black Hills Natural Sciences Field Station.

### **GEOE 412/512 SCIENCE AND ENGINEERING FIELD APPLICATIONS**

3 to 6 credits. Prerequisites: Permission of instructor. Field course offered by Black Hills Natural Sciences Field Station to accommodate field education needs of scientists and engineers in multiple disciplines such as geology, geological engineering, petroleum engineering, environmental engineering, etc. Course offerings

will take place in the summer months and content of each camp will be defined by staff from SDSM&T GEOL/GEOE department and industry partners. Students enrolled in GEOE 512 will be held to a higher standard than those enrolled in GEOE 412. This course is cross-listed with GEOL 412/512.

### **GEOE 425/425L/525/525L ENGINEERING GEOPHYSICS II**

(2-1) 3 credits. Prerequisites: MATH 125, GEOE 324/324L, and GEOE 211/211L. The course concentrates on geophysical techniques applicable to petroleum exploration and production, including the acquisition of seismic data, its preparation, interpretation, and use in engineering design. Use of computer packages and individual program design is emphasized. Students enrolled in GEOE 525/525L will be held to a higher standard than those enrolled in GEOE 425/425L.

### **GEOE 451/451L ECONOMIC GEOLOGY**

(2-1) 3 credits. Prerequisites: Junior or senior standing. Co-requisites: GEOE 322/322L. Study of the economics and distribution of mineral resources, geologic characteristics and origins of metallic ore deposits, and the application of genetic models, geochemical techniques, and geophysical methods to the design of mineral exploration programs. Laboratory work includes ore mineralogy and textures, sample suites from ore deposits, calculation of ore reserves (manual and computer), and design and implementation of exploration programs (computer exercises). A term paper is required on the design of exploration programs. Field trips are arranged to nearby ore deposits.

### **GEOE 452/452L/552/552L GEOCHEMICAL EXPLORATION**

(2-1) 3 credits. Prerequisites: GEOE 451/451L or permission of instructor. An integrated application of geochemical principles, trace-element analytical techniques, basic statistical methods, and computer techniques to the design and implementation of geochemical exploration programs for the detection of mineral deposits. An area of the Black Hills will be selected for the design and implementation of a geochemical

exploration program. A term paper will result from this study. Students enrolled in GEOE 552/552L will be held to a higher standard than those enrolled in GEOE 452/452L

**GEOE 461 PETROLEUM PRODUCTION**  
(3-0) 3 credits. Characteristics of hydrocarbon reservoirs and geological considerations in well completion design. Well in-flow performance. Tubing string and packer completion design. Design and analysis of artificial lift systems. Acidizing and stimulation operations Computer-aided design. Single-phase and multi-phase flow measurements, physical modeling of oil production, and permeability tests. Global oil production and use, and societal implications.

**GEOE 462 DRILLING AND COMPLETION ENGINEERING**

(3-0) 3 credits. Prerequisites: EM 321 or permission of instructor. Introduction to modern oil and gas field terminology. Topics include design and analysis of oil or gas well drilling operations (including horizontal and casing drilling), interpretation of wellbore and formation properties using geophysical logging techniques, casing design, cementing, and perforating. Computer-aided design for well control, hydraulics, and logging. Field trip to a local drilling operation is available.

**GEOE 464 GEOLOGICAL ENGINEERING DESIGN PROJECT I**

(0-3) 3 credits. Prerequisites: EM 328, GEOL 331/331L, GEOE 322/322L, GEOE 475/475L or permission of instructor. Independent engineering design work by students on a comprehensive geological engineering project that integrates 1) ground water, and 2) fuels or minerals. Economic and legal constraints, environmental concerns, safety, and aesthetic considerations will be included. Engineering reports (oral and written) with analysis, specifications, a results are required.

**GEOE 465 GEOLOGICAL ENGINEERING DESIGN PROJECT II**

(0-3) 3 credits. Prerequisites: GEOL 331/331L, GEOE 322/322L, GEOE 324/324L, and CEE

346//346L. Independent engineering design work by students on a comprehensive geological engineering project that integrates 1) environmental site planning and natural hazards, and 2) geomechanics and geotechnics. Economic and legal constraints, environmental concerns, safety, and aesthetic considerations will be included. Engineering reports (oral and written) with analysis, specifications, and results are required.

**GEOE 466/466L/566/566L ENGINEERING AND ENVIRONMENTAL GEOLOGY**

(2-1) 3 credits. Prerequisites: Junior or senior standing. The application of geology to engineering, including topics such as landslides, earthquakes, fluvial processes, land subsidence, and their global context. Field trips and laboratory exercises illustrate the influence of geology on the environment. Computer applications are required for problem assignments and a final comprehensive report (oral and written) involving the design of engineering works in complex geological terrain. Students enrolled in GEOE 566/566L will be held to a higher standard than those enrolled in GEOE 466/466L.

**GEOE 468/468L/568/568L GEOHAZARDS**

(2-1) 3 credits. Prerequisites: CEE 346/346L or permission of instructor. A comprehensive analysis of the mechanisms behind geologic processes that affect the human environment in catastrophic ways. Topics include earthquake and volcanic hazards, mass movements, and land subsidence. Assignments, labs, and final projects will be focus on rigorous analyses using common industry-utilized software packages to monitor and mitigate these hazards. Field experiences will allow students to apply the principles discussed to real-world situations. Students enrolled in GEOE 568/568L will be held to a higher standard than those enrolled in GEOE 468/468L.

**GEOE 475/475L GROUND WATER**

(2-1) 3 credits. Prerequisites: GEOL 201 or GEOE 221/221L, and MATH 225, or permission of instructor. Note: Engineering majors must complete the equivalent of Calculus III before

registration. Geohydrologic principles, applications, and design considerations concerning ground-water occurrence, flow, and quality. Ground-water and surface-water relations; theory of aquifer tests; flow nets; head distribution by graphical, analytical, and digital models; ground-water contamination. Laboratories include water budgets, chemistry of ground water, design of exploration programs and aquifer tests, computer solutions, and field trips to areas of geohydrologic interest. A design project with written and oral presentations is required. This course is cross-listed with ENVE 475/475L.

### **GEOE 482/482L APPLIED GEOMORPHOLOGY**

(2-1) 3 credits. Prerequisites: GEOL 201/201L or GEOE 221/221L, GEOE 322/322L. A systematic analysis of landform evolution with emphasis on process and terrain analysis. Topics include process-response in geomorphic systems and quantitative techniques used in engineering design applications. Laboratory consists of aerial photos, topographic map interpretation and the application of geomorphology as an engineering tool. Field trips taken to regional areas of interest. Computer solutions in engineering analysis and a design project are required.

### **GEOE 491 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. May be repeated to a total of 3 credit hours. Research findings are required.

### **GEOE 492 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A description of the work to be

performed must be filed in the Department of Geology and Geological Engineering.

### **GEOE 615 ADVANCED FIELD METHODS IN GROUND WATER**

(0-3) 3 credits. Prerequisites: GEOE 475/475L or equivalent. Advanced instruction and independent work involving field techniques such as aquifer mapping, water quality sampling and interpretation, piezometer tests, and the design, conduct, and analysis of aquifer tests.

### **GEOE 641 GEOCHEMISTRY**

(3-0) 3 credits. Geochemical principles, applications, and design considerations, including thermodynamics, kinetics, and transport phenomena. Applications in low-temperature aqueous systems, carbonate equilibria, geothermal and hydrothermal systems, petroleum generation, metamorphism, and igneous processes. Computer solutions to geochemical problems will be used. An engineering design project is required.

### **GEOE 661 PETROLEUM GEOLOGY**

(3-0) 3 credits. Prerequisites: GEOE 322/322L and GEOL 331/331L. Part 1. Worldwide occurrence, current and future demand, OPEC cartel and prices, and ethics of exploitation. Part 2. Petroleum source rocks and generation, migration, and entrapment. Geology of major oil-producing regions of world. Petroleum exploration methods.

### **GEOE 662 ANALYTICAL METHODS IN GROUND WATER**

(3-0) 3 credits. Prerequisites: GEOE 475/475L or equivalent. Quantitative methods used to evaluate ground-water resources, including pumping tests as well as physical and computer methods.

### **GEOE 663/663L GROUND-WATER GEOCHEMISTRY**

(2-1) 3 credits. Prerequisites: GEOE 475/475L or equivalent. A study of the natural chemistry of ground water and the effects of man's activities on ground-water quality. Laboratories include dispersion experiments and several field trips to areas of interest relating to ground-water

geochemistry.

### **GEOE 664/664L ADVANCED GROUND WATER**

(2-1) 3 credits. Prerequisites: GEOL 201 or GEOE 221/221L or equivalent. Basic hydrologic principles with emphasis on hydrologic and geologic interrelationships. Design problems of location, development, and conservation of ground water. Use of quantitative techniques for aquifer evaluation. Studies of ground-water contamination. Laboratories, field trips, and problem assignments require use of analytical methods.

### **GEOE 668 ENGINEERING GEOLOGY OF SURFICIAL DEPOSITS**

(3-0) 3 credits. Review of weathering, soils, and Quaternary deposits. Emphasis on engineering design problems such as those found in highway construction, landfills, water supply, waste disposal, landslides, and land subsidence. Engineering geology of surficial deposits including alluvium, loess, clay, and glacial and periglacial deposits. Two field trips are required.

### **GEOE 682 FLUVIAL PROCESSES**

(3-0) 3 credits. The systematic study of watershed evolution and the development and function of the attendant stream composition. Emphasis is placed on morphometry, quasi-equilibrium, classification, fluvial mechanics, fluvial landforms, and stream restoration technology. Study and discussion of current literature will focus on process and results. Students will partake in lecture presentation of specified topics.

### **GEOE 691 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and Special Projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the

requirements of the topic. A description of the work to be performed must be filed in the Department of Geology and Geological Engineering.

### **GEOE 692 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A description of the work to be performed must be filed in the Department of Geology and Geological Engineering.

### **GEOE 766/766L DIGITAL MODELING OF GROUND-WATER FLOW SYSTEMS**

(2-1) 3 credits. Prerequisites: GEOE 475/475L or CEE 634, or equivalent. Practical applications of digital models as tools in the study of ground-water flow systems. Methods of simulating aquifer systems and solute transport will be used. Specific emphasis will be placed on the development, application, and limitations of finite-difference and finite-element computer models.

### **GEOE 790 SEMINAR**

(1-0) 1 credit. May be repeated once for degree credit. A highly focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as Internet and are at the upper division graduate levels.

### **GEOE 798 THESIS**

Credit to be arranged; not to exceed 6 credits toward fulfillment of M.S. degree requirements. Open only to students pursuing the M.S. thesis option. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

### **GEOE 898 DISSERTATION**

Credit to be arranged; not to exceed 30 credits toward fulfillment of Ph.D. degree requirements. Open only to doctoral candidates. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee. Oral defense of dissertation and research findings are required.

### **GEOG 101 INTRODUCTION TO GEOGRAPHY**

(3-0) 3 credits. The course presents a broad, introductory overview of geographic concepts, themes, and elements designed to help students better understand and analyze the world from a geographic perspective. It provides a background to earth's physical and human elements and systems. It also emphasizes the unique quality of world regions, and the spatial interaction of people, elements, and regions, as well as major global and regional problems and prospects.

### **GEOG 210 WORLD REGIONAL GEOGRAPHY**

(3-0) 3 credits. A survey of Earth from a broad global framework through the differentiation of the world in terms of both natural and human environmental features and characteristics on a regional basis.

### **GEOG 212 GEOGRAPHY OF NORTH AMERICA**

(3-0) 3 credits. A regional and topical analysis of the geographic patterns of the United States and Canada. Focus is upon the interaction of groups of people with the natural environment to produce regional differentiation. Geographic aspects of the physical geography, population, culture groups, economy, settlement system, land division, and use of natural resources.

### **GEOG 400 CULTURAL GEOGRAPHY**

(3-0) 3 credits. A detailed analysis of the concept of culture in a geographical context, including such applications as culture and nature, cultural

growth and change, cultural universals, culture and economy, cultural relativity, cultural landscape, cultural region, and cultural conflict.

### **GEOG 492 TOPICS**

1 to 3 credits. Includes current topics advanced topics and special topics. A course devoted to a particular issue in geography. Course content is not wholly included in the regular curriculum. A maximum of 6 credits will be allowed for degree credit.

### **GEOL 201 PHYSICAL GEOLOGY**

(3-0) 3 credits. Basic concepts in the study of the earth and its history. Brief introduction to the earth's place in the universe and solar system and the evolution, composition and structure of the earth. Introduction to minerals, and igneous, sedimentary and metamorphic rocks. Survey of geological processes acting at the surface of the earth such as wind, rivers, glaciers, ground water and the sea; introduction to internal processes regarding plate tectonics theory and growth of mountains. Societal implications of geological processes are emphasized throughout the course. Students taking GEOL 201L should take it concurrently with GEOL 201.

### **GEOL 201L PHYSICAL GEOLOGY LABORATORY**

(0-1) 1 credit. Pre- or Co-requisites: GEOL 201. Classification and identification of the important rocks and minerals. Interpretation of topographic and geologic maps. Field trips to view representative rock types of the Black Hills area.

### **GEOL 212/212L MINERALOGY AND CRYSTALLOGRAPHY**

(2-1) 3 credits. A study of morphological and geometrical crystallography followed by determinative mineralogy. The 32 crystal classes and about 120 minerals are studied in detail. Course includes a brief introduction to optical microscopy. Emphasis in the laboratory is directed toward descriptive and determinative mineralogy.

### **GEOL 214L MINERALOGY FOR MINING ENGINEERS**

(0-1) 1 credit. Prerequisites: CHEM 114. Systematic description and identification of silicate and non-silicate minerals are address in this course.

### **GEOL 314/314L MINERALOGY AND PETROLOGY FOR MINING ENGINEERS**

(3-1) 4 credits. Prerequisites: GEOL 201 or GEOE 221/221L, and CHEM 112. A study of the identifying characteristics of the many classes of minerals and rocks with emphasis on the application to the Mining Engineering discipline. Discussion of the role that these characteristics play in mine design and management will be included whenever possible. The laboratory will focus on hands-on sample description and identification of common silicate and non-silicate minerals and the description and classification of igneous, sedimentary and metamorphic rocks. The course will include lecture, laboratory and field trips.

### **GEOL 323 SEARCH FOR OUR PAST**

(3-0) 3 credits. Prerequisites: GEOL 201 or GEOE 221/221L. Study of the geologic history of North America. The formation and early history of the earth, the tectonic evolution of the continents, and the history of evolution of life are studied. Current scientific issues regarding tectonics and the biosphere are also discussed, such as evolutionary theory, the Gaia hypothesis, and biocomplexity.

### **GEOL 331/331L STRATIGRAPHY AND SEDIMENTATION**

(2-1) 3 credits. Prerequisites: GEOL 201/201L or GEOE 221/221L or permission of instructor. The principles of correlation and sediment analysis are discussed. A background in sedimentary source materials, depositional environments, nomenclature and classification of stratigraphic units, and the interpretation of stratigraphic units will be presented. Emphasis is placed on modern depositional systems and their ancient counterparts. Laboratory exercises stress field trips to local sections, facies descriptions, rock

analysis, and interpretation of an exploration prospect.

### **GEOL 341/341L IGNEOUS AND METAMORPHIC PETROLOGY**

(2-1) 3 credits. Prerequisites: CHEM 112/112L, GEOL 201L or GEOE 221/221L and GEOL 212/212L or GEOL 314/314L. Identification and classification of igneous and metamorphic rocks in hand sample and thin section. Emphasis is on environments of formation as deduced from textures and structures. Lecture, laboratory, and field trips.

### **GEOL 351 EARTH RESOURCES AND THE ENVIRONMENT**

(3-0) 3 credits. Prerequisites: GEOL 201 or GEOE 221/221L or permission of instructor. This course will examine the distribution, origin, use, and future of earth's energy, metallic, and non-metallic resources. Economic, political, sociological, and environmental implications of the resource industries will be emphasized. Resource issues of topical interest will be discussed.

### **GEOL 361 OCEANOGRAPHY I**

(3-0) 3 credits. An introductory course in oceanography that focuses on ocean basins of the world, their composition and processes by which they formed. Other subjects to be examined include the "hot springs" of the deep oceans, patterns of sediment distribution, life in the oceans, the role of the oceans as an integral part of global climatic cycles including the "greenhouse effect."

### **GEOL 371 FIELD PALEONTOLOGY**

(0-2) 2 credits. An introduction to the methods of prospecting, collecting, and documenting fossils for exhibition and research. Field trips will be made to the productive fossil sites in western South Dakota and elsewhere. This course can only be taken twice to fulfill graduation requirements.

### **GEOL 372 DINOSAURS**

(3-0) 3 credits. An in-depth introduction to dinosaur paleontology. This course will utilize

geologic and biologic principles to foster a comprehension of dinosaur systematic, phylogeny, biology, and evolution. Dinosaurs will also be used as a focus to examine the scientific method, critical thinking, and the public perception of science.

### **GEOL 376 GEOSPATIAL FIELD METHODS**

(0-3) 3 credits. Prerequisites: GEOL 416/416L or permission of instructor. This course covers fundamental methods of gathering spatial information in the field, including navigation, global positioning systems, aerial photo mapping, ground data collection, spatial sampling design, and accuracy assessment.

### **GEOL 403/503 REGIONAL FIELD GEOLOGY**

(0-1) 1 credit. Prerequisites: GEOL 201 or GEOE 221/221L. A one-week guided field trip to an area of outstanding geological interest in a global context. Students enrolled in GEOL 503 will be held to a higher standard than those enrolled in GEOL 403.

### **GEOL 410 FIELD GEOLOGY**

(0-6) 6 credits. Prerequisites: Completion of junior year studies. This five-week course focuses on the instruction and practice in the use of surveying instruments and aerial photographs for the purpose of completing large and intermediate-scale geologic maps, structure sections, and structure contour maps of Precambrian metasediments, Phanerozoic sedimentary rocks, and Tertiary intrusions within designated areas of the Black Hills region. A written geologic report will accompany the maps and sections conducted for five weeks during the summer in the northern Black Hills. Field equipment will be furnished by the department. Arrangements for transportation, room, and board are made through the Black Hills Natural Sciences Field Station.

### **GEOL 412/512 SCIENCE AND ENGINEERING FIELD APPLICATIONS**

3 to 6 credits. Prerequisites: Permission of instructor. Field course offered by Black Hills

Natural Sciences Field Station to accommodate field education needs of scientists and engineers in multiple disciplines such as geology, geological engineering, petroleum engineering, environmental engineering, etc. Course offerings will take place in the summer months and content of each camp will be defined by staff from the School of Mines Department of Geology and Geological Engineering and industry partners. Students enrolled in GEOL 512 will be held to a higher standard than those enrolled in GEOL 412. This course is cross-listed with GEOE 412/512.

### **GEOL 416/416L/516/516L INTRODUCTION TO GIS**

(2-1) 3 credits. Introduction to principles and applications of geographic information systems (GIS) including data management and analysis. Laboratory work will include introduction to PC-based GIS software and data sets. Students are expected to have basic computer system, word processing, and spreadsheet skills prior to taking the class. Students enrolled in GEOL 516/516L will complete a more extensive project than those enrolled in GEOL 416/416L

### **GEOL 417/517 GEOSPATIAL DATABASES**

(3-0) 3 credits. Prerequisites: GEOL 416 /416L or GEOL 516/516L or permission of instructor. Building on basic principles of Geographic Information Systems, this course launches students into developing geospatial databases for research projects in science and engineering. Students learn to compile and manage spatial data using industry standard data models. Assignments include hands-on practice downloading, processing, editing, scanning and digitizing data. The class includes an extensive introduction of the software documentation to build independent learning and problem-solving ability. Students are expected to complete a semester project that relates to their own interests. Students enrolled in GEOL 517 will be held to a higher standard than those enrolled in GEOL 417.

### **GEOL 419/519 ADVANCED GEOSPATIAL ANALYSIS**

(3-0) 3 credits. Prerequisites: GEOL 416/416L/516/516L or permission of instructor.

This course will introduce those already familiar with GIS and basic statistical principles to advanced spatial analysis techniques including interpolation, sampling, spatial distributions, surface analysis, and geospatial modeling. Emphasis is placed on developing the knowledge to effectively and soundly employ geospatial analysis techniques in a variety of applications. Students enrolled in GEOL 519 will be held to a higher standard than those enrolled in GEOL 419.

### **GEOL 420/520 INTRODUCTION TO REMOTE SENSING**

(3-0) 3 credits. Prerequisites: Junior Standing  
An introduction to the theory and applications of remote sensing. Students will study the electromagnetic spectrum as it applies to remote sensing as well as the physical principles of imaging system technologies. Imaging and applications of visible, near-infrared, thermal infrared, and microwave band remote sensing are discussed. Environmental remote sensing applications to be covered include terrestrial and ocean ecology, resource exploration, land use and land cover change, natural hazards, and atmospheric constituents. Image processing techniques will be introduced. Students enrolled in GEOL 520 will be held to a higher standard than those enrolled in GEOL 420.

### **GEOL 442/442L/542/542L OPTICAL PETROLOGY**

(2-1) 3 credits. Prerequisites: GEOL 341/341L or GEOL 314/314L. The study of igneous, sedimentary, and metamorphic rocks and ore samples in thin and polished section, with emphasis on their identification, classification, and genesis. Students enrolled in GEOL 542/542L will be held to a higher standard than those enrolled in GEOL 442/442L.

### **GEOL 461/461L INVERTEBRATE PALEONTOLOGY**

(2-1) 3 credits. A systematic study of the structure and classification of selected invertebrate taxa. The course will provide a useful tool for field and laboratory work involving fossil-bearing rocks and will form a background

for advanced work in paleontology or paleontological stratigraphy.

### **GEOL 464 SENIOR RESEARCH I**

(0-1) 1 credit. Prerequisites: GEOL 410. A study of scientific research methodology with emphasis on identifying research problems and formulating a methodology to address a specific research question. Students will identify a topic of study chosen with the advise and approval of an instructor, and develop a proposal for their senior research project.

### **GEOL 465 SENIOR RESEARCH II**

(0-3) 3 credits. Prerequisites: GEOL 464. The student undertakes a field and/or laboratory study of a topic chosen with the advice and approval of an instructor. This work is the basis for a thesis written in a standard format.

### **GEOL 472/472L/572/572L MUSEUM CONSERVATION AND CURATION**

(2-1) 3 credits. Ethics, theories, and methodology behind conservation and curation in natural history museums. Laboratory covers conservation techniques and curation training in systematically organizing a collection, in addition to training in computer database collection management systems. Students enrolled in GEOL 572/572L will be held to a higher standard than those enrolled in GEOL 472/472L.

### **GEOL 473/473L/573/573L MUSEUM PREPARATION TECHNIQUES AND EXHIBIT DESIGN**

(1-2) 3 credits. Techniques in vertebrate fossil preparation and museum exhibit design will be the focus in this course. Students will be required to prepare fossils and design an exhibit for actual display in the museum or other designated locations. Proposal writing is another important facet of this course and will provide the background needed to those that pursue a museum career. Students enrolled in GEOL 573/573L will be held to a higher standard than those enrolled in GEOL 473/473L.

### **GEOL 474/574 PALEONTOLOGICAL RESOURCE MANAGEMENT**

(3-0) 3 credits. This course is designed to provide intensive background and professional training for resource management work in the paleontological and geological sciences, with a focus on Federal and state land management agency issues. Topics include analysis of applicable laws and regulations, understanding standards and compliance requirements, managing permits and reports, managing repositories for Federal and state earth science collections and archives, and learning formal monitoring and mitigation procedures for managing paleontological resources affected by highway, pipeline and other construction efforts. Students enrolled in GEOL 574 will be held to a higher standard than those enrolled in GEOL 474.

### **GEOL 491 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. May be repeated to a total of 3 credit hours.

### **GEOL 492 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **GEOL 516/516L GIS FOR RESEARCH**

(2-1) 3 credits. Introduction to principles and application of geographic information systems (GIS) with emphasis on preparing students for its use in graduate study. Laboratory work will include introduction to PC-based GIS software and data sets, and students will develop and carry out significant GIS project related to their field interest. Students are expected to have basic computer system, word processing, and

spreadsheet skills prior to taking this class.

### **GEOL 604 ADVANCED FIELD GEOLOGY**

(0-3) 3 credits. Prerequisites: GEOL 410. Field techniques and related laboratory methods of investigation in moderately complicated geologic environments. Includes data collection, presentation, and interpretation. Laboratory work involving aerial photographs, drilling projects, and miscellaneous work may be introduced during inclement weather in December.

### **GEOL 621/621L ADVANCED STRUCTURAL GEOLOGY**

(2-1) 3 credits. Prerequisites: GEOE 322/322L or permission of instructor. Examination of selected geologic terrains such as fold-thrust belts, Laramide foreland uplifts and basins, wrench and rift systems, etc., concentrating on geometric styles, sequential and mechanical development and regional models. Includes selected readings and laboratory examinations of maps regarding the various types of terrains.

### **GEOL 622 GEOTECTONICS**

(3-0) 3 credits. The course examines development of regional and world-wide structures of the earth in regard to plate tectonic processes and current thought regarding concepts of sea-floor spreading, continental drift, paleomagnetism, origin of continents, ocean basins, and mountain building.

### **GEOL 632 ROCKY MOUNTAIN STRATIGRAPHY**

(3-0) 3 credits each. Prerequisites: Senior or graduate standing in geology or geological engineering. Stratigraphic sequences in the Rocky Mountain area are studied with emphasis on the paleoenvironmental and tectonic conditions under which the strata were deposited. First semester considers Paleozoic strata; the second semester considers Mesozoic and Cenozoic rocks.

### **GEOL 633/633L SEDIMENTATION**

(2-1) 3 credits. Sedimentary process-response models are studied. The procedures for classification and description of sedimentary rocks are reviewed. Numerous field trips to

localities illustrating a variety of sedimentary facies are conducted. Laboratory determinations are made of such parameters of sedimentary particles as size, shape, and degree of roundness, mineralogy, and chemical composition. An analysis is made of field and laboratory data by graphical and statistical methods and a geological interpretation is made of the results. Natural resources associated with various facies are emphasized.

**GEOL 644/644L PETROLOGY OF THE IGNEOUS AND METAMORPHIC ROCKS**  
(2-1) 3 credits. Prerequisites: GEOL 542/542L or permission of instructor. This course will emphasize phase diagrams, phase equilibria and geochemistry of igneous and metamorphic rocks from the standpoint of constraining evolutionary models. Problems will involve quantitative modeling of natural samples using field observations, petrographic observations, mineral chemistry, and whole rock chemistry. Field trips are planned.

**GEOL 650 SEMINAR IN ORE DEPOSITS**  
1 to 3 credits. Prerequisites: GEOE 451 /451L or permission of instructor. Studies by a group of advanced students, under the guidance of one or more selected instructors, of topics of special and current interest to the group. Involves a combination of lectures, papers, readings, oral and/or written presentations, and discussions. Course focuses on different themes in ore deposits, and varies each time offered. Themes that will be offered include such topics as the geology of gold deposits, uranium deposits, porphyry copper deposits, volcanogenic massive sulfides, and sediment-hosted metal deposits. Emphasis is placed on gaining an in-depth knowledge on the controls of localization of a specific class of mineral deposits.

**GEOL 652 PROBLEMS IN ORE DEPOSITS**  
(3-0) 3 credits. Prerequisites: GEOE 451 /451L or permission of instructor. Emphasis is placed on the principles of hydrothermal ore deposits, and techniques used to study hydrothermal ore deposits. Modern theories on metallic ore

deposition will be applied to the critical study of major classes of metallic ore deposits.

### **GEOL 656L SCANNING ELECTRON MICROSCOPY**

(0-1) 1 credit. A practical introduction to the use of the scanning electron microscope for geologists, paleontologists, and materials scientists and engineers.

### **GEOL 670 PRINCIPLES OF X-RAY DIFFRACTION**

(3-0) 3 credits. Prerequisites: PHYS 213 and MET 232 or GEOL 212/212L or permission of instructor. This course will cover the principles of crystallography in materials science, theory and production of x-rays, interaction of x-rays with matter, and the principles of x-ray diffraction. The application of x-ray diffraction methods to analytical measurement techniques in materials science and metallurgical engineering will also be covered. This course is cross-listed with MES 670.

**GEOL 672/672L MICROPALAEONTOLOGY**  
(2-1) 3 credits. A study of the morphology, ecology, and stratigraphic significance of selected groups of protozoans and invertebrate and plant microfossils with special emphasis on Foraminifera and conodonts. This course is cross-listed with PALE 672/672L.

### **GEOL 673/673L COMPARATIVE OSTEOLOGY**

(2-1) 3 credits. A comparison of recent and fossil vertebrate skeletons and dentitions with emphasis on the skeletons and teeth of sharks, bony fish, salamanders, frogs, turtles, alligators, lizards, birds, and mammals to establish a thorough understanding of diversity of the form and function of the vertebrate skeleton. A major objective is the identification of vertebrates based on osteology and odontology. This course is cross-listed with PALE 673/673L.

### **GEOL 676/676L VERTEBRATE PALEONTOLOGY**

(3-1) 4 credits. An in-depth assessment of the fossil record of vertebrates with special emphasis

on current problems in the evolution of vertebrates and the tangible record preserved in the collections of the Museum of Geology. This course is cross-listed with PALE 676/676L.

### **GEOL 678/678L VERTEBRATE BIOSTRATIGRAPHY**

(3-1) 4 credits. Prerequisites: GEOL/PALE 676/676L. The principles and practices for establishing the distribution of vertebrate fossils in the rock record. This course will include a brief history of biostratigraphy, methodology, and the content and assessment of vertebrate ages, particularly of Mesozoic and Cenozoic mammals. This course is cross-listed with PALE 678/678L.

### **GEOL 691 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic. A description of the work to be performed must be filed in the department office. This course is cross-listed with PALE 691.

### **GEOL 692 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A description of the work to be performed must be filed in the Department of Geology and Geological Engineering. This course is cross-listed with PALE 692.

### **GEOL 790 SEMINAR**

(1-0) 1 credit. May be repeated once for degree credit. A highly focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as Internet and are at the upper division graduate

levels. This presentation normally will directly precede the final oral defense of the thesis. This course is cross-listed with PALE 790.

### **GEOL 798 THESIS**

Credit to be arranged; not to exceed 6 credits toward fulfillment of M.S. degree requirements. Open only to students pursuing the M.S. thesis option. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

### **GEOL 808 FUNDAMENTAL PROBLEMS IN ENGINEERING AND SCIENCE**

(3-0) 3 credits. The course, available only for doctoral candidates, involves description, analysis, and proposed methods of attack of long-standing, fundamental problems in science and engineering. Independent work is emphasized with goals of understanding these basic questions and proposing practical designs and experiments for the solution. This course is cross-listed with AES 808.

### **GEOL 898 DISSERTATION**

Credit to be arranged; not to exceed 30 credits toward fulfillment of Ph.D. degree requirements. Open only to doctoral candidates. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Oral defense of dissertation and research findings are required.

### **GER 101 INTRODUCTORY GERMAN I**

### **GER 102 INTRODUCTORY GERMAN II**

(4-0) 4 credits each. Becoming sensitized to authentic listening, speaking, reading, writing and culture skills at the elementary level. Introduction to basic functional grammar and sentence

structure. GER 102-Prerequisite: GER 101 or permission of instructor. Continued emphasis on authentic listening, speaking, reading, writing, and culture skills at the elementary level.

**GES 115M UNIVERSITY MENTORING**  
(0-0) 0 credit. This course is designed to provide new college students the opportunity to learn how to succeed at the South Dakota School of Mines and Technology. Students will be introduced and matched to a professional mentor who will provide academic and career advice that will help ensure professional development. In addition, students will have the opportunity to learn from peer advisors who are successful upper-classmen in selected majors.

**GS 900 VISITING SCHOLARS**  
(0-0) 0 credit. A zero credit tracking course used to identify participants in the Visiting Scholars Program.

**HIST 121 WESTERN CIVILIZATION I**  
(3-0) 3 credits. Surveys the evolution of western civilization from its beginnings into the Reformation and religious wars.

**HIST 122 WESTERN CIVILIZATION II**  
(3-0) 3 credits. Surveys the development of western civilization from the Reformation era to the present.

**HIST 151 UNITED STATES HISTORY I**  
(3-0) 3 credits. Surveys the background and development of the United States from its colonial origins to the Civil War and Reconstruction.

**HIST 152 UNITED STATES HISTORY II**  
(3-0) 3 credits. Surveys development of the United States since the Civil War and Reconstruction.

**HIST 492 TOPICS**  
1 to 4 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. May be repeated once for credit when

the topic is different and with permission of department head.

### **HUM 100 INTRODUCTION TO HUMANITIES**

(3-0) 3 credits. This interdisciplinary course introduces students to humanistic knowledge, inquiry, and values by focusing on connections among humanities disciplines (such as art, languages, literature, music, philosophy, and religion).

### **HUM 200 CONNECTIONS: HUMANITIES AND TECHNOLOGY**

(3-0) 3 credits. A thematic approach to human values stressing the relationship between technology and the humanities; traces the development and social impact of our major technologies.

### **HUM 291 INDEPENDENT STUDY**

1 to 4 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **HUM 292 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A maximum of 6 credits of special topics will be allowed for degree credit.

### **HUM 350 AMERICAN SOCIAL HISTORY**

(3-0) 3 credits. Prerequisites: Junior or senior standing. A study of the lives, customs, and beliefs of ordinary Americans, using fiction and nonfiction from various periods.

### **HUM 375 COMPUTERS IN SOCIETY**

(3-0) 3 credits. Prerequisites: Junior or senior

standing. Examines the social impact of computers with emphasis on the development of the computer establishment, the cultural blueprint being shaped for the future, and the question of values and social responsibility in personal, business, and governmental sectors.

#### **HUM 491 INDEPENDENT STUDY**

1 to 4 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

#### **HUM 492 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A maximum of 6 credits of special topics will be allowed for degree credit.

#### **IENG 215 COST ESTIMATING FOR ENGINEERS I**

(1-0) 1 credit. Prerequisites: MATH 123. This course covers the fundamentals of financial statements and analysis. Topics include the structure of accounts, the balance sheet, the income statement, changes in owner equity, statement of cash flows, and analysis of financial statements to determine the financial health of a business entity.

#### **IENG 216 COST ESTIMATING FOR ENGINEERS II**

(1-0) 1 credit. Prerequisites: MATH 123. This course covers the fundamentals of building the operational budgets needed for modern industrial practice. Topics include sales forecasting, sale budget, production budget, material budget, direct labor budget, factory overhead, cost-of-goods sold, and budget variances.

#### **IENG 217 COST ESTIMATING FOR ENGINEERS III**

(1-0) 1 credit. Prerequisites: MATH 123. This course covers the fundamentals of cost accounting and cost estimating. Topics include estimation of factory overhead, operation estimating, product estimating, job order costing, process costing, and activity based costing.

#### **IENG 241L INTRO TO QUALITY METHODS AND TEAMS**

(0-2) 2 credits. Prerequisites: Sophomore standing or permission of instructor. Quality improvement methods, team processes, and related ways of thinking are introduced. Students will be exposed to the data collection and analysis tools often used for quality improvement across multiple disciplines. Laboratory activities involve teams and team processes including decision making, communications, and customer relations. This course meets the quality requirement for the six-sigma greenbelt certificate.

#### **IENG 301 BASIC ENGINEERING ECONOMICS**

(2-0) 2 credits. Junior or higher standing preferred. Introduces the concepts of economic evaluation regarding capital investments, including the time value of money and income tax effects. Graduation credit cannot be given for both IENG 301 and IENG 302.

#### **IENG 302 ENGINEERING ECONOMICS**

(3-0) 3 credits. Junior or higher standing preferred. Studies economic decision making regarding capital investment alternatives. Covers compound interest and depreciation models, replacement and procurement models. Analysis is made variously assuming certainty, risk and uncertainty. Graduation credit cannot be given for both IENG 301 and IENG 302.

#### **IENG 311/311L WORK METHODS AND MEASUREMENT**

(2-1) 3 credits. Pre -or Co-requisites: IENG/MATH 381. This course presents the underlying theory and basic methodology for work methods and measurement techniques. Emphasis is placed on knowledge of the basis for

selection of a technique appropriate for the individual as related to the task to be performed.

### **IENG 321/321L ERGONOMICS/HUMAN FACTORS ENGINEERING**

(2-1) 3 credits. Prerequisites: PSYC 101 or permission of instructor. Pre- or Co-requisite: MATH 281 or IENG/MATH 381 or higher statistics. Topics covered include: Engineering anthropometry, workplace design, biomechanical modeling, work kinesiology, and musculoskeletal disorders, cognitive engineering and office ergonomics.

### **IENG 331 SAFETY ENGINEERING**

(3-0) 3 credits. Prerequisites: Junior or senior standing. Overview to the field of Safety Engineering emphasizing quantitative problem solving. Will draw on fundamental knowledge from the fields of chemistry, physics, mechanics, mathematics, and statistics. Contents: fundamental concepts and terminology, injury and accident statistics, ethics, certification, regulations, standards, hazards and their control, and management aspects.

### **IENG 345 ENTREPRENEURSHIP**

(4-0) 4 credits. Prerequisites: ACCT 211 and IENG 301 or IENG 302 or permission of instructor. Covers topics on the legal aspects, management skills, business plans, and sources of capital as well as case studies of successful and unsuccessful entrepreneurial initiatives.

### **IENG 352 CREATIVITY AND INNOVATION**

(1-0) 1 credit. This course focuses on the Herrmann Whole Brain model and creative thinking to strengthen team processes and the tools necessary for product and process innovations. Students will receive an exposure to the whole brain model and to a variety of problems that will require more creative and innovative thought processes to solve the problem.

### **IENG 353 COMMERCIALIZATION OF NEW TECHNOLOGY**

(1-0) 1 credit. This course provides the student with an understanding of the intellectual property considerations for new innovations as well as how to adapt new technologies for commercialization in the market place. Topics include patents, trademarks, copyrights, trade secrets, technology transfer, SBIR and STTR. This course is required for the Technology Innovation certificate program.

### **IENG 354 MARKETING TECHNOLOGY INNOVATIONS**

(1-0) 1 credit. This course introduces the student to the tools and strategies needed to understand the voice of the customer and provides the rudiments of a marketing plan for commercialization of new or innovative technologies. Topics include environmental analysis, diffusion of technology and innovations, early adopters, and market research and strategies.

### **IENG 355 FINANCING TECHNOLOGY INNOVATIONS**

(1-0) 1 credit. Prerequisites: IENG 215 and IENG 216 or ACCT 210 or ACCT 406 or ENGM 661. Beginning with technology business forecasts, this course develops the sales budget, production budget, material budget, overhead expenses, and cash flow budgets in sequence. Proforma income and balance sheets are then derived from these budgets. Sources of capital during different stages of the technology life cycle are also covered. This course is required for the Technology Innovation certificate.

### **IENG 356 TECHNOLOGY START UPS**

(1-0) 1 credit. This course presents timing and innovation to be considered during the early stages of the technology life cycle and provides the basis for the development of a business plan. Topics include technology and innovation strategies, dimensions of technological innovations, new technology ventures, corporate new ventures, organizational structures, and elements of a business plan.

**IENG 362 STOCHASTIC MODELS**

(3-0) 3 credits. Prerequisites: IENG/MATH 381 or permission of instructor. This course covers stochastic models in operations research and is a complementary course to MATH 353. Topics include queuing theory, Markov chains, Pert/CPM, decision theory, dynamic programming and inventory control models.

**IENG 366 ENGINEERING MANAGEMENT**

(3-0) 3 credits. A course designed to acquaint the student with engineering management discipline through the formation and operation of business and industrial enterprises. In addition to engineering management decision tools, students will be exposed to emergent trends in learning organizations, systems thinking, change management, and processes utilizing all four quadrants of Herrmann Whole Brian model for advanced problem solving.

**IENG 381 INTRO TO PROB AND STAT**

(3-0) 3 credits. Prerequisites: MATH 125. Pre- or Co-requisite: MATH 225. Introduction to probability, discrete and continuous distributions, sampling distributions, central limit theorem, and general principles for statistical inference. This course is cross-listed with MATH 381. Individuals may apply at most 4 credits toward a degree from the following list of courses: MATH 281, IENG/MATH 381, MATH 442.

**IENG 382 PROBABILITY THEORY AND STATISTICS II**

(3-0) 3 credits. Prerequisites: IENG /MATH 381. Review of general principles for statistical inference, linear regression and correlation, multiple linear regression, ANOVA, and statistical design of experiments. This course is cross-listed with MATH 382.

**IENG 425 PRODUCTION AND OPERATION**

(3-0) 3 credits. Prerequisites: MATH 123; IENG/MATH 381 or BADM 221. Management of the production environment. Topics such as bills of materials, inventory control, production control, production scheduling and MRP will be discussed. The impact of production management

on the design process and how products can be designed for better manufacture.

**IENG 431/531 INDUSTRIAL HYGIENE**

(3-0) 3 credits. Prerequisites: Senior or graduate standing or permission of instructor. Principles of industrial hygiene, including the identification and evaluation of chemical, physical, and biological agents which affect the health and safety of employees; the application of control measures for the various agents; study of threshold limit values and occupational health toxicology. Students enrolled in IENG 531 will be held to a higher standard than those enrolled in IENG 431.

**IENG 441 SIMULATION**

(3-0) 3 credits. Prerequisites: IENG/MATH 381 or MATH 442. Development of computer simulation models of real or conceptual systems. Interpretation of results of computer simulation experiments.

**IENG 451/451L OPERATIONAL STRATEGIES**

(2-1) 3 credits. Prerequisites: Junior standing or permission of instructor. Review of philosophies, systems, and practices utilized by world-class organizations to meet current operational challenges. Focuses include "lean production" in the manufacturing industries, including material flow, plant-floor quality assurance, job design, work and management practices as well as the most effective practices in the service industries. Students complete lab projects and tour organizations to analyze the extent and potential of the philosophies.

**IENG 452 INTRODUCTION TO SIX SIGMA**

(1-0) 1 credit. This course introduces students to the philosophy of Six Sigma. Topics include the history of Six Sigma and the Six Sigma problem solving methodology.

**IENG 461 SIX SIGMA GREENBELT EXAM**

(1-0) 1 credit. This self-paced, pass/fail course culminates in a written exam. Passing this exam is necessary component of the Six Sigma Greenbelt Certification.

### **IENG 462 INDUSTRIAL AND ENGINEERING MANAGEMENT PROFESSION**

(1-0) 1 credit. Prerequisites: Senior standing or permission of instructor. This course covers professional aspects of the industrial engineering and engineering management professions including personal, professional, and ethical development as well as professional practice.

### **IENG 463 SIX SIGMA GREENBELT PROJECT**

(1-0) 1 credit. Taken in conjunction with another course requiring a project, students in this course will use the Six Sigma problem solving philosophy in the completion of the project. Students will then document how they use the Six Sigma process and the results of the project in a written report.

### **IENG 464 SENIOR DESIGN PROJECT I**

(0-2) 2 credits. Prerequisites: Senior standing or graduation within three semesters. Small groups of students work on original design projects. Topics are solicited from local companies, hospitals, banks, mines, government agencies, thus providing students the opportunity to apply their knowledge and techniques to real problems in business and industry.

### **IENG 465 SENIOR DESIGN PROJECT II**

(0-3) 3 credits. Continuation of IENG 464. Small groups of students work on original design projects. Topics are solicited from local companies, hospitals, banks, mines, government agencies, thus providing students the opportunity to apply their knowledge and techniques to real problems in business and industry. As applicable, these are continuation projects started in IENG 464.

### **IENG 466/566 PROJECT PLANNING AND CONTROL**

(3-0) 3 credits. Prerequisites: PSYC 101 preferred. Project planning, execution and control of less repetitive types of work. This includes quantitative aspects such as costs, time and performance specifications; and qualitative

aspects such as organization structures, psychological and sociological relationships. Students enrolled in IENG 566 will be held to a higher standard than those enrolled in IENG 466.

### **IENG 471 FACILITIES PLANNING**

(3-0) 3 credits. Prerequisites: Senior standing or graduation within three semesters. Topics covered include: material handling, computerized layout planning, storage facilities, flexible manufacturing systems, and "Factory of the Future."

### **IENG 475/475L COMPUTER-CONTROLLED MANUFACTURING SYSTEMS AND ROBOTICS**

(2-1) 3 credits. Prerequisites: Senior standing or permission of instructor. Fundamental concepts of using computers in the design of a computer integrated, discrete-item, manufacturing facility are covered. Basic ideas of Computer Aided Design (CAD), Group Technology (GT), process planning, integrated production control and computer numerical control are covered. The manufacturability issues and concepts of selecting and using robots in the workplace are explored.

### **IENG 479/579 RESEARCH ETHICS**

(1-0) 1 credit. This course introduces students the ethical and professional issues involved in performing research. Topics include: human and animal subjects, research review boards, fiscal responsibilities and audits, and dealing with research teams. Students enrolled in IENG 579 will be held to a higher standard than those enrolled in IENG 479.

### **IENG 486 STATISTICAL QUALITY AND PROCESS CONTROL**

(3-0) 3 credits. Prerequisites: IENG/MATH 381 or MATH 442 or permission of instructor. This course covers the development of statistical methods for application to problems in quality and process control. Statistical topics include: basics of processes and variability, statistically controlled processes, variable and attribute control charts, moving averages, individual trend and others, process capability, sampling plans for attributes and variables. This course is cross-

listed with MATH 486.

### **IENG 491 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **IENG 492 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **IS 110 EXPLORATIONS**

(2-0) 2 credits. This course will provide a theme-based interdisciplinary approach to studying the relationships between science and society. The course will consist of lectures, student-led activities, and fieldwork, complemented by visiting lecturers and opportunities to gain regional, national, and global perspectives through organized trips.

### **IS 191 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. This course cannot be counted for social science/humanities credit.

### **IS 192 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course

content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A maximum of 6 credits will be allowed for degree credit. This course cannot be counted for social science/humanities credit.

### **IS 201 INTRODUCTION TO SCIENCE, TECHNOLOGY, AND SOCIETY**

(3-0) 3 credits. Prerequisites: ENGL 101, IS 110 and sophomore standing. Includes study of current issues within the IS specializations. Introduces students to how science and technology affect individual, societal, and global change (e.g., how science and technology influence ethical choices, the political and economic systems, and the relationship between humans and the natural world.) Required for all students seeking a B.S. in interdisciplinary sciences.

### **IS 291 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. This course cannot be counted for social science/humanities credit.

### **IS 292 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A maximum of 6 credits will be allowed for degree credit. This course cannot count for social science/humanities credit.

### **IS 380 INTERNSHIP IN INTERDISCIPLINARY STUDIES**

1 to 4 credits. Prerequisites: Permission of Instructor. The opportunity for a student to complete a plan for an internship and thereby acquire practical job-related experience. A

maximum of 6 credits will be allowed for degree credit. This course cannot be counted for social science/humanities credit.

### **IS 391 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. This course cannot be counted for social science/humanities credit.

### **IS 392 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A maximum of 6 credits will be allowed for degree credit. This course cannot be counted for social science/humanities credit.

### **IS 396 FIELD EXPERIENCE**

1-0) 1 credit. Applied, monitored, and supervised field-based learning experience for which the student may or may not be paid. Students gain practical experience; they follow a negotiated and/or directed plan of study established by the student, instructor, and field-based supervisor. Due to the presence of a field experience supervisor, a lower level of supervision is provided by the instructor in these courses than is a case with an internship or practicum course.

### **IS 401 WRITING AND RESEARCH IN THE INTERDISCIPLINARY SCIENCES**

(3-0) 3 credits. Prerequisites: IS 201, ENGL 289, and senior standing. Advanced writing in the interdisciplinary sciences with emphasis on research and explanation of science topics in the IS specializations. This course provides students with a basic understanding of the various styles of science writing, including writing for popular and professional audiences, and the use of library

and/or laboratory research in formal research papers. This course is required for all students pursuing the B.S. degree in interdisciplinary sciences.

### **IS 491 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. This course cannot be counted for social science/humanities credit.

### **IS 492 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A maximum of 6 credits will be allowed for degree credit. This course cannot be counted for social science/humanities credit.

### **IS 498 UNDERGRADUATE RESEARCH/SCHOLARSHIP**

(0-3) 3 credits. Prerequisites: Senior standing, permission of instructor, an approved Letter of Intent on file in the IS Office and successful completion of IS 401. Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical. This course is required for all students pursuing the B.S. degree in interdisciplinary sciences.

### **IS 691 INDEPENDENT STUDY**

.5 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-

one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic. This course cannot be counted for social science/humanities credit.

### **IS 692 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. This course cannot be counted for social science/humanities credit.

### **MATH 021 BASIC ALGEBRA**

(3-0) 3 credits. Prerequisites: Appropriate mathematics placement. This course prepares students for college level mathematics. Topics generally include: basic properties of real numbers, exponents and radicals, rectangular coordinate geometry, solutions to linear and quadratic equations, inequalities, polynomials and factoring. Students may also be introduced to functions and systems of equations. Note: This is remedial level course and no credit for MATH 021 will be granted for graduation.

### **MATH 101 INTERMEDIATE ALGEBRA**

(3-0) 3 credits. Prerequisites: MATH 021 or appropriate mathematics placement. Basic properties of real numbers, linear equations and inequalities, quadratic equations, systems of equations, polynomials and factoring, rational expressions and equations, and radical expressions and equations, and an introduction to functions such as polynomial, exponential and logarithmic functions. May not be used for credit toward a baccalaureate degree, but may be used toward the associate degree.

### **MATH 102/102L COLLEGE ALGEBRA**

(3-1) 4 credits. Prerequisites: MATH 101 with a minimum grade of "C" or appropriate mathematics placement. Co-requisite: MATH 102L. Equations and inequalities; polynomial functions and graphs; exponents, radicals, binomial theorem, zeros of polynomials; systems of equations; exponential, logarithmic, and

inverse functions, applications and graphs. Other topics selected from sequences, series, and complex numbers. This course may not be used for credit toward an engineering or science degree (except for interdisciplinary science, chemistry, and associate of arts).

### **MATH 115 PRECALCULUS**

(5-0) 5 credits. Prerequisites: MATH 101 with a minimum grade of "C" or appropriate mathematics placement. A preparatory course for the calculus sequence. Topics include: polynomial, rational, exponential, logarithmic and trigonometric functions and their graphs; systems of equations, inequalities and complex numbers. May not be used for credit toward an engineering or science degree (except for interdisciplinary science, chemistry, and associate of arts).

### **MATH 120 TRIGONOMETRY**

(3-0) 3 credits. Prerequisites: MATH 102 with a minimum grade of "C" or appropriate mathematics placement. Topics include: trigonometric functions, equations, and identities; inverse trigonometric functions; exponential and logarithmic functions, and applications of these functions. This course may not be used for credit toward an engineering or science degree (except for interdisciplinary science, chemistry, and associate of arts).

### **MATH 123 CALCULUS I**

(4-0) 4 credits. Prerequisites: MATH 115 with a minimum grade of "C" or appropriate mathematics placement or permission of instructor. Students who are initially placed into MATH 102 or below must complete MATH 102 and MATH 120 with a minimum grade of "C" before enrolling in MATH 123. Students who are placed in MATH 120 should consult their advisor to determine whether their placement score was sufficiently high to allow concurrent registration in MATH 123. The study of limits, continuity, derivatives, applications of the derivative, antiderivatives, the definite and indefinite integral, and the fundamental theorem of calculus.

### **MATH 125 CALCULUS II**

(4-0) 4 credits. Prerequisites: MATH 120 with a

minimum grade of “C” or appropriate score on departmental Trigonometry Placement Examination and MATH 123 with a minimum grade of “C.” A continuation of the study of calculus, including the study of sequences, series, polar coordinates, parametric equations, techniques of integration, applications of integration, indeterminate forms, and improper integrals.

### **MATH 205 MINING AND MANGEMENT MATHEMATICS I**

(2-0) 2 credits. Prerequisites: MATH 125 with a minimum grade of “C” or permission of instructor. A survey of calculus in higher dimensions that includes an introduction to vectors, vector valued functions, and partial derivatives. This course may not be used for credit toward an engineering or science degree (except for mining engineering and management).

### **MATH 211 MINING AND MANGEMENT MATHEMATICS II**

(3-0) 3 credits. Prerequisites: Math 125 with a minimum grade of “C” or permission of instructor. Selected topics from ordinary differential equations including first order, higher order equations and systems of linear equations. The class will also cover a survey of general solutions and solutions to initial-value problems using matrices. This course may not be used for credit toward an engineering or science degree (except for mining engineering and management).

### **MATH 221 INTRODUCTION TO DISCRETE MATHEMATICS**

(2-0) 2 credits. Prerequisites: MATH 123 with a minimum grade of “C” or permission of instructor. The main purpose of this course is to provide background and experience on the structure of proofs. Topics may include: elementary logic, basic set theory, and sequences and summations, functions, matrices, and proof techniques.

### **MATH 225 CALCULUS III**

(4-0) 4 credits. Prerequisites: MATH 125 with a minimum grade of “C.” A continuation of the study of calculus, including an introduction to vectors, vector calculus, partial derivatives, and

multiple integrals.

### **MATH 281 INTRODUCTION TO STATISTICS**

(3-0) 3 credits. Prerequisites: MATH 102 or MATH 115. A study of descriptive statistics including graphs, measures of central tendency and variability and an introduction to probability theory, sampling and techniques of statistical inference with an emphasis on statistical applications. Individuals may apply at most 4 credits toward a degree from the following list of courses: MATH 281, IENG/MATH 381, MATH 442.

### **MATH 291 INDEPENDENT STUDY**

1 to 5 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. May be repeated to a total of 5 credit hours.

### **MATH 292 TOPICS**

1 to 5 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. May be repeated to a total of 6 credit hours.

### **MATH 315 LINEAR ALGEBRA**

(3-0) 3 credits. Prerequisites: MATH 225 or permission of instructor. Course topics include: the theory and applications of systems of linear equations, matrices, determinants, vector spaces, linear transformations and applications.

### **MATH 321 DIFFERENTIAL EQUATIONS**

(3-0) 3 credits. Prerequisites: MATH 125 with a minimum grade of “C.” Selected topics from ordinary differential equations including development and applications of first order, higher order linear and systems of linear

equations, general solutions and solutions to initial-value problems using matrices. Additional topics may include Laplace transforms and power series solutions. MATH 225 and MATH 321 may be taken concurrently or in either order. In addition to analytical methods this course will also provide an introduction to numerical solution techniques.

### **MATH 353 LINEAR OPTIMIZATION**

(3-0) 3 credits. Prerequisites: MATH 225 or permission of instructor. Convex sets and functions, linear inequalities and combinatorial problems; topics in linear programming from fundamental theorems of simplex method through sensitivity analysis, duality, transportation, and assignment problems.

### **MATH 373 INTRODUCTION TO NUMERICAL ANALYSIS**

(3-0) 3 credits. Prerequisites: MATH 321 and CSC 150/150L or permission of instructor. This course is an introduction to numerical methods. Topics include elementary discussion of errors, polynomial interpolation, quadrature, non-linear equations, and systems of linear equations. The algorithmic approach and efficient use of the computer will be emphasized. Additional topics may include: calculation of eigenvalues and eigenvectors, numerical differentiation and integration, numerical solution of differential equations.

### **MATH 381 INTRO TO PROB AND STAT**

(3-0) 3 credits. Prerequisites: MATH 125. Pre- or Co-requisite: MATH 225. Introduction to probability theory, discrete and continuous distributions, sampling distributions and the Central Limit Theorem with general principles for statistical inference and applications of random sampling to hypothesis testing, confidence limits, correlation, and regression. This course is cross-listed with IENG 381. Individuals may apply at most 4 credits toward a degree from the following list of courses: MATH 281, IENG/MATH 381, MATH 442.

### **MATH 382 PROBABILITY THEORY AND STATISTICS II**

(3-0) 3 credits. Prerequisite: MATH /IENG 381. Review of general principles of statistical inference, linear regression and correlation, multiple linear regression, ANOVA, and statistical design of experiments. This course is cross-listed with MATH/IENG 382.

### **MATH 391 INDEPENDENT STUDY**

1 to 5 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. May be repeated to a total of 5 credit hours.

### **MATH 392 TOPICS**

1 to 5 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. May be repeated to a total of 6 credit hours.

### **MATH 402 COMMUNICATING MATHEMATICS**

(0-1) 1 credit. Prerequisites: MATH 498. The student will produce a word-processed technical report of research conducted in MATH 498 and give a department colloquium talk summarizing her or his work. Department faculty member(s) will provide guidance in the production of the technical report and in the preparation for the colloquium talk.

### **MATH 413 ABSTRACT ALGEBRA I**

(3-0) 3 credits. Prerequisites: MATH 225 and CSC 251 or MATH 225 and MATH 221 or permission of instructor. Introduction to the theory and applications of algebraic structures including groups, rings, and fields.

**MATH 421 COMPLEX ANALYSIS**

(3-0) 3 credits. Prerequisites: MATH 225. The algebra of complex numbers; complex functions; contour integration and Cauchy integral theorems; Taylor and Laurent series and the residue theorem; the evaluation of real definite integrals; elementary mapping problems.

**MATH 423 ADVANCED CALCULUS I**

(4-0) 4 credits. Prerequisites: MATH 225 and CSC 251 or MATH 225 and MATH 221 or permission of instructor. A theoretical treatment of calculus that covers: limits; continuity and differentiability of functions of a single variable.

**MATH 424 ADVANCED CALCULUS II**

(4-0) 4 credits. Prerequisites: MATH 423. A continuation of MATH 423 that covers calculus of several variables; convergence of sequences and series; integration; and applications.

**MATH 431 DYNAMICAL SYSTEMS**

(3-0) 3 credits. Prerequisites: MATH 315 and MATH 321 or permission of instructor. This course is a study of both discrete and continuous dynamical systems. Topics include analysis of planar autonomous systems, stability analysis, bifurcation, chaos, and strange attractors. In addition, this course may include the study of Van der Pol's equation, Lorenz equations, Duffing's equation, Hamiltonian systems, and Poincare maps.

**MATH 432 PARTIAL DIFFERENTIAL EQUATIONS**

(3-0) 3 credits. Prerequisites: MATH 225 and MATH 321. Fourier series, partial differential equations, Frobenius series, Bessel functions, and transform methods.

**MATH 442 ENGINEERING STATISTICS**

(4-0) 4 credits. Prerequisites: MATH 225. An introduction to the core ideas in probability and statistics. Computation of probabilities using, for instance, counting techniques and Bayes' rule. Introduction to discrete and continuous random variables, joint and conditional distributions, expectation, variance and correlation, random sampling from populations, hypothesis tests and

confidence intervals, and least squares. Other topics include building multiple regression models, parameter estimation, and reliability. Individuals may apply at most 4 credits toward a degree from the following list of courses: MATH 281, IENG/MATH 381, and MATH 442.

**MATH 447/547 DESIGN OF EXPERIMENTS**

(3-0) 3 credits. Prerequisites: MATH /IENG 382 or MATH 442 or permission of instructor. Single and multifactor experiments, analysis of variance, factorial designs, the use of multiple regression, and response surface methodology. Topics may include nonparametric and permutation / randomization alternatives to the traditional parametric tests. Students enrolled in MATH 557 will be held to a higher standard than those enrolled in MATH 457.

**MATH 451 MATH MODELING**

(3-0) 3 credits. Prerequisites: MATH 321 or permission of instructor. The primary goal of this course is to present the mathematical formulation and analysis utilized in scientific modeling. Applications from both Science and Engineering will be covered. The types of models will include deterministic and stochastic models. Topics may include: epidemiology, biomass, elasticity, heat flow, electrical circuits, mechanical vibrations and optimization.

**MATH 463 SCIENTIFIC COMPUTING**

(3-0) 3 credits. Prerequisites: MATH 373 or CSC 372 or permission of instructor. This course is an introduction to the elements of numerical analysis and modern scientific computing. The primary focus will be on the mathematical analysis of computational methods and the effective use of scientific computation as it relates to the needs of engineering and science. Topics will include: machine arithmetic and error analysis, the approximation of eigenvalues, and numerical solutions of ordinary differential equations. Additional topics in numerical analysis will be included as time permits.

**MATH 471 NUMERICAL ANALYSIS I**

(3-0) 3 credits. Prerequisites: MATH 373 or

CSC 372. Analysis of rounding errors, numerical solutions of nonlinear equations, numerical differentiation, numerical integration, interpolation and approximation, numerical methods for solving linear systems.

### **MATH 486 STATISTICAL QUALITY AND PROCESS CONTROL**

(3-0) 3 credits. Prerequisites: IENG/MATH 381 or MATH 442 or permission of instructor. This course covers the development of statistical methods for application to problems in quality and process control. Statistical topics include: basics of processes and variability, statistically controlled processes, variable and attribute control charts, moving averages, individual trend and others, process capability, sampling plans for attributes and variables. This course is cross-listed with IENG 486.

### **MATH 491 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic. May be repeated to a total of 3 credit hours.

### **MATH 492 TOPICS**

1 to 6 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. May be repeated to a total of 6 credit hours.

### **MATH 498 UNDERGRADUATE RESEARCH/SCHOLARSHIP**

(0-1) 1 credit. Prerequisites: Permission of instructor. Includes senior project, and capstone experience. Independent research problems/projects or scholarship activities. The plan of study is negotiated by the faculty member and the student. Contact between the two may be

extensive and intensive. Does not include research courses which are theoretical.

### **MATH 691 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Student should have obtained permission of an instructor in the Department of Mathematics and Computer Science prior to registering for this course. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic. May be repeated to a total of 6 credit hours.

### **MATH 692 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. May be repeated to a total of 6 credit hours.

### **ME 110/110L INTRODUCTION TO MECHANICAL ENGINEERING**

(1-1) 2 credits. An introductory course for incoming mechanical engineering freshmen which will introduce the student to the profession they have chosen. Topics to be covered include: Solid modeling, CAD lab, professional development, engineering design, technical communication, personal development, and academic success skills.

### **ME 211 INTRODUCTION TO THERMODYNAMICS**

(3-0) 3 credits. Prerequisites: MATH 125 and PHYS 211. An introduction to the basic concepts of energy conversion, including the first and second laws of thermodynamics, energy and entropy, work and heat, thermodynamic systems analysis, and the concepts of properties and state. Application of these fundamentals to energy conversion systems will be presented.

### **ME 216 INTRODUCTION TO SOLID MECHANICS**

(3-0) 3 credits. Prerequisites: EM 214 with a minimum grade of "C". This course covers the fundamental concepts of solid mechanics including the definition of stress, transformations and states of stress; plane stress, plane strain, octahedral stresses, three dimensional stresses, and principal stresses in two and three dimensions. Additional topics include strain analysis, strain measurements and rosette analysis, generalized Hooke's law, and orthotropic materials. Specific applications are an introduction to composite materials, analysis of thin and thick cylinders, statically indeterminate members, torsional loading of shafts, power transmission and the shaft analysis, torsional loads in non-circular components and thin tubes, stress concentrations, and combined loads.

### **ME 221 DYNAMICS OF MECHANISMS**

(3-0) 3 credits. Prerequisites: PHYS 211, EM 214, MATH 125. Brief review of dynamics of a particle. Kinetics and kinematics of two and three-dimensional mechanisms. Emphasis will include free body diagrams, vector methods, and various coordinate systems. Newton's law and energy methods will both be used.

### **ME 262 PRODUCT DEVELOPMENT**

(2-0) 2 credits. Prerequisites ME 110 and sophomore standing. The course presents in a detailed fashion useful tools and structured methodologies that support the product development practice. Also, it attempts to develop in the students the necessary skills and attitudes required for successful product development in today's competitive marketplace. The cornerstone is a semester-long project in which small teams of students conceive, plan and design a simple physical product. Each student brings his/her own background to the team effort, and must learn to synthesize his/her perspective with those of the other students in the team to develop a marketable product. An introduction to manufacturing aspects that must be taken into consideration during product development is provided in the context of the project.

### **ME 264/264L SOPHOMORE DESIGN**

(1-1) 2 credits. Prerequisites: Sophomore standing. This course focuses on the design process including project management and teamwork; formal conceptual design methods; acquiring and processing information; design management tools; design for manufacturability, reliability, maintainability, sustainability; design communication: reports and presentations; ethics in design; prototyping designs; case studies. This course is cross-listed with EE 264/264L.

### **ME 312 THERMODYNAMICS II**

(3-0) 3 credits. Prerequisites: ME 211 and ME 221. Thermodynamic power cycles using vapors and gases. One-dimensional compressible flow. Energy analysis. Refrigeration cycles. Mixtures and psychrometry. Maxwell's relations. Combustion and thermochemistry.

### **ME 313/313L HEAT TRANSFER**

(2-1) 3 credits. Pre- or Co-requisites: ME 331, MATH 373 or permission of instructor. A study of the transfer of heat by conduction, convection and radiation. Application to thermal systems.

### **ME 316 SOLID MECHANICS**

(3-0) 3 credits. Prerequisites: ME 216 and ME 221 both with a minimum grade of "C". Covers stress analysis and failure theories of both brittle and ductile materials and energy methods. Also includes such topics as elastic impact, stability, axis-symmetric loaded members in flexure and torsion, and an introduction to plastic behavior of solids.

### **ME 322 MACHINE DESIGN I**

(3-0) 3 credits. Prerequisites: ME 316 and ME 264/264L both with a minimum grade of "C". Applications of the fundamentals of strength of materials, basic elastic theory, material science and how they apply to the design and selection of machine elements. Elements include shafts, gears, fasteners, and drive components such as gears and chains.

### **ME 331 THERMO FLUID DYNAMICS**

(3-0) 3 credits. Prerequisites: ME 211 and ME 221 and MATH 321. A study of the nature of

fluids, constitutive relations, fluid statics/buoyancy, and the equations governing the motion of ideal (inviscid) and viscous, incompressible fluids, as well as inviscid, compressible fluids (1-dimensional gas dynamics). Internal and external flows, including viscous pipe flow, the Moody diagram, lift, drag and separation. Laminar and turbulent boundary layer theory, and dimensional analysis, modeling, and similitude.

### **ME 351/351L MECHATRONICS AND MEASUREMENT SYSTEMS**

(3-1) 4 credits. Prerequisites: CSC 15/150L and EE 220/220L or EE 301/301L. This course will encompass general measurement techniques found in mechanical and electrical engineering. These include measurement of force, strain, frequency, pressure flow rates and temperatures. Elements of signal conditioning and data acquisition will be introduced. In addition to this material, the course will have a Mechatronics approach reflected in the combined applications of electronic mechanical and control systems. This course is cross-listed with EE 351/351L.

### **ME 352 INTRODUCTION TO DYNAMIC SYSTEMS**

(3-0) 3 credits. Prerequisites: MATH 321, ME 221. This is an introductory course in the control of dynamic systems. The course presents the methodology for modeling and linearizing of electrical, mechanical, thermal, hydraulic and pneumatic systems. The course also covers control system analysis and synthesis in the time and the frequency domains.

### **ME 391 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **ME 392 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **ME 402/502 GAS DYNAMICS**

(3-0) 3 credits. Prerequisites: ME 312, ME 313/313L, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor. This course will review fundamental concepts from thermodynamics including isentropic flow and normal shock functions. The equations of motion will be derived in differential form and wave theory will be introduced. Multidimensional flows and oblique shock theory will be discussed. Integral methods for inviscid, compressible flow will be developed and numerical methods (including the method of characteristics for hyperbolic equations) will be employed in the second half of the course. Students enrolled in ME 502 will be held to a higher standard than those enrolled in ME 402.

### **ME 404 HEATING, VENTILATING, AND AIR CONDITIONING**

(3-0) 3 credits. Prerequisites: ME 312, ME 313/313L, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor. A study of space heating and cooling systems and equipment, building heating and cooling load calculations, solar radiation concepts, and moist air properties/conditioning processes. Indoor air quality/comfort and health issues will be discussed. Basic heat and mass transfer processes will be introduced; pump and fan performance issues along with duct and piping system design. Heat exchangers and mass transfer devices will also be studied.

### **ME 419/419L THERMO-FLUID SYSTEMS DESIGN**

(3-1) 4 credits. Prerequisites: ME 312, ME 313/313L, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor. Investigation and design of thermal and fluid systems and components, emphasizing the major thermal/fluid design issues that arise in internal

combustion engine power conversion; analysis and synthesis involving modeling and optimization of thermo-fluid systems, components and processes. Development and application of fundamental numerical tools and algorithms for thermal and fluid problems. A central design problem for a thermal/fluid system or component will be selected to meet an existing or future project need and will be decomposed into the relevant thermal and fluid aspects which will be studied throughout the course. Review of the basics of the design process and physical processes important to thermal-fluid problems (basic thermodynamics, heat transfer and fluid mechanics), the fundamentals of building and solving mathematical models, and design issues and concepts unique to internal combustion engines will be discussed. Students will be required to implement one or more previously developed Fluent learning modules to study the use of CFD in thermal/fluid system design. The final project will incorporate skills developed in the learning modules into the required design of the system or component. The laboratory will include experiments to compliment the lecture material and provide a means for hands on validation of concepts.

### **ME 422 MACHINE DESIGN II**

(3-0) 3 credits. Prerequisites: ME 312, ME 313/313L, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor. This course will explore advanced structural design concepts within an integrated framework of theory, simulation, experiment, and materials. Of particular importance will be the study of modern topics, such as plastic materials and their response to service loads. Structural mechanics and materials response will be brought together in support of machine component design.

### **ME 423 MECHANICAL VIBRATIONS**

(3-0) 3 credits. Prerequisites: ME 312, ME 351/351L, ME 352 or permission of instructor. Study of the oscillatory nature and vibration design of mechanical systems. One, two, multi, and infinite degree of freedom systems are analyzed for their response in both free and forced vibration regimes. Particular emphasis is given to

designing for vibration control. Brief introductions are made to vibration testing and measurement, and human response to vibrations.

### **ME 425 PROBABILISTIC MECHANICAL DESIGN**

(3-0) 3 CREDITS. Prerequisites: ME 322. Basic concepts of probability and statistics are introduced including Gaussian, Exponential, and Weibul distributions. Primary emphasis is placed on treating stresses, strains, deformations, and strength limitations as random variables and computing probability of failure under required loads. Considerable time is devoted to converting data into meaningful engineering parameters for making engineering decisions. Statistical methods applied to topics in mechanical design. (Design Elective)

### **ME 426 MECHANICAL SYSTEMS ANALYSIS LABORATORY**

(0-1) 1 credit. Prerequisites: ME 312, ME 313/313L, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor. Use of experimental methods and modern instrumentation techniques to understand the free and forced oscillations of machines and machine components, as well as the control of these vibrations. Laboratory exercises are designed to reinforce material learned in the companion lecture class ME 423, extend knowledge into new areas, and help to make the connection between theory and practice.

### **ME 427/427L COMPUTER-AIDED DESIGN AND MANUFACTURE**

(2-1) 3 credits. Prerequisites: ME 312, ME 313/313L, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor. Discussion of methods and topics in computer-aided design and manufacture. How to bridge the gap between the design/analysis phase and the actual manufacture phase. Database requirements of CNC machine tools and how they can be constructed.

### **ME 428/428L APPLIED FINITE ELEMENT ANALYSIS**

(2-1) 3 credits. Prerequisites: ME 312, ME 313/313L, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor. Basic mathematical concepts of finite element analysis will be covered. The students will learn finite element modeling using state of the art software, including solid modeling. Modeling techniques for beams, frames, two and three-dimensional solids, and thin walled structures will be covered in the course. This course is cross-listed with BME 528/528L.

### **ME 430 INTRODUCTION TO WIND ENERGY ENGINEERING**

(3-0) 3 credits. Prerequisites: ME 312, ME 313/313L, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor. The course is an introduction to the theory of and the basic concepts of modern wind energy converters. Various types of wind power generators are discussed and in particular horizontal and vertical axis turbine rotors. Other core subjects are; wind energy conversion, the effect of lift and drag, Betz's Momentum Theory, and an introduction to rotor aerodynamics. Concepts of wind, wind prediction, boundary layers, wind loads, and turbulences will be covered. Rotor blades, material selection, airfoils, loads, stresses, failure modes, control systems, and wind energy distribution are also introduced.

### **ME 432/532/432L/532L EXPERIMENTAL STRESS ANALYSIS**

(3-1) 4 credits. Prerequisites: ME 322 or permission of instructor. An introduction to experimental methods for determining stresses inside mechanical components from measuring their deformations, and related topics. Topics: Review of stress/strain analysis, analysis of experimental data, data acquisition, strain gages, introduction photoelasticity, and digital image correlations. Student enrolled in ME 532/532L will be held to a higher standard than those enrolled in ME 432/432L.

### **ME 443 COMPOSITE MATERIALS**

(3-0) 3 credits. Prerequisites: ME 316 or concurrent enrollment in MET 440. This course will cover heterogeneous material systems; basic design concepts and preparation; types of composite materials; advances in filaments, fibers and matrices; physical and mechanical properties; failure modes; thermal and dynamic effects; and application to construction, transportation and communication. This course is cross-listed with MET 443.

### **ME 453/453L CONTROL SYSTEMS**

(3-1) 4 credits. Prerequisites: ME 352 or EE 311/311L. Analysis and design of automatic control and process systems by techniques encountered in modern engineering practice, including both linear and nonlinear systems with either continuous or discrete signals. This course is cross-listed with EE 453/453L.

### **ME 455/455L VEHICLE DYNAMICS**

(2-1) 3 credits. Prerequisites: ME 312, ME 313/313L, ME 316, ME 322, ME 331, ME 351/351L, ME 332 or permission of instructor. Fundamental principles and practices of modern automotive chassis and suspension design, operation and testing are presented in the course. The dynamics of acceleration, braking, ride and handling are covered. Steady-state cornering using the standard bicycle model is covered in detail. Laboratory work involves shock absorber and spring testing and the setup and evaluation of Formula SAE and Baja SAE chassis. Students must complete a chassis design project.

### **ME 460 FUELS AND COMBUSTION**

(3-0) 3 credits. Prerequisites: ME 312, ME 313/313L, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor. This course provides an introductory treatment of fuels and combustion science. The objectives of the course are to develop an understanding of hydrocarbon fuels, combustion reactions and kinetics, flame dynamics, flame stability, and pollutant formation. Coverage includes laminar and turbulent flames, premixed and diffusion flames, and detonations. Fundamental aspects of combustion are applied to analysis of the

combustion process and pollutant formation in internal combustion engines and other combustors.

### **ME 477 MECHANICAL ENGINEERING DESIGN I**

(0-2) 2 credits. Prerequisites: ME 312, ME 313/313L, ME 316, ME 322, ME 331, ME 351/351L, ME 352 all with a minimum grade of "C" or permission of instructor. The first semester of a two course sequence in senior design practice. Integrates concepts from all areas in mechanical engineering into a practical design project. Fundamentals of the design process, specifications, decision making, and preliminary design will be the focus, with the major part of the course being the project.

### **ME 479 MECHANICAL SYSTEMS DESIGN II**

(0-2) 2 credits. Prerequisites: ME 312, ME 313/313L, ME 316, ME 322, ME 331, ME 351/351L, and ME 352 with a minimum grade of "C" and ME 477 or permission of instructor. The second semester continuation of Mechanical Systems Design. Integrates concepts from all areas in mechanical engineering into a practical design project. Detailed design and analysis, manufacturing, and assembly will be the focus.

### **ME 481L ADVANCED PRODUCT DEVELOPMENT LAB I**

(0-1) 1 credit. Corequisites: ME 477. Prerequisites: ME 312, ME 313/313L, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor. Advanced laboratory experience in product development. Students will perform activities in support of preliminary product design and trade studies, including virtual prototyping, computational investigations and proof-of-concept experiments.

### **ME 482L ADVANCED PRODUCT DEVELOPMENT LAB II**

(0-2) 2 credits. Corequisites: ME 479. Prerequisites: ME 312, ME 313/313L, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor. Advanced laboratory experience in product development. Students will

perform activities in support of detailed product design, including virtual prototyping, computational investigations, and testing of components and systems.

### **ME 491 INDEPENDENT STUDY**

1 to 5 credits. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

### **ME 492 TOPICS**

1 to 5 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **ME 400/500 RESEARCH PROBLEMS/PROJECTS**

1 to 3 credits. Prerequisites: ME 312, ME 313/313L, ME 316, ME 322, ME 331, ME 351/351L, ME 352 or permission of instructor. Independent research problems/projects that lead to a research or design paper but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical. Students enrolled in ME 500 will be held to a higher standard than those enrolled in ME 400.

### **ME 555/555L ADVANCED APPLICATIONS IN COMPUTATIONAL MECHANICS**

(1-2) 3 credits. Prerequisites: Senior or higher standing. Introduction to solid modeling techniques using advanced solid modeling software. Use of Computational Fluid Mechanics codes for the solution of complex fluid mechanics and heat transfer problems. Use of finite element codes for the solution of non-linear and transient problems in solid mechanics.

**ME 612 TRANSPORT PHENOMENA:  
MOMENTUM**

(3-0) 3 credits. Introduction to momentum transport. Equations of continuity and motion. Velocity distributions. Boundary layer theory. Turbulent transport compressible flow. This course is cross-listed with CBE 612.

**ME 613 TRANSPORT PHENOMENA:  
HEAT**

(3-0) 3 credits. An in-depth study of the fundamental laws of heat transfer. Major areas considered are: heat conduction, free and forced convection, and radiative heat transfer. Emphasis is placed on the formulation and solution of engineering problems by analytical and numerical methods. This course is cross-listed with CBE 613.

**ME 616 COMPUTATIONS IN TRANSPORT  
PHENOMENA**

(3-0) 3 credits. Various computerized techniques, including finite difference and finite element, will be used to solve transient and steady state heat transfer problems involving conduction and convection. This course is cross-listed with CBE 616.

**ME 618 CONDUCTION HEAT TRANSFER**

(3-0) 3 credits. The study of conduction heat transfer from fundamental physical considerations and methods for analyzing conduction heat transfer including Bessel's equation and related functions, separation of variables, superposition, complex combination, Laplace Transforms, normalization, and numerical method applications.

**ME 619 CONVECTION HEAT TRANSFER**

(3-0) 3 credits. The study of convection heat transfer from fundamental conservation principles including fluid stresses and flux laws, integral and differential equations of the boundary layer, and momentum and heat transfer for both external and internal flow under both laminar and turbulent conditions. Topics studied include the influence of temperature dependent properties, convection at high velocities, and free-convection boundary layers.

**ME 620 RADIATION HEAT TRANSFER**

(3-0) 3 credits. The study of thermal radiation heat transfer including fundamental concepts, radiation heat transfer in enclosures with no attenuating medium, and radiation heat transfer in the presence of an attenuating medium.

**ME 623 ADVANCED MECHANICAL  
VIBRATIONS**

(3-0) 3 credits. Prerequisites: ME 423 or equivalent. Study of the vibration of systems of particles both forced and free. Included is the study of transient vibrations and system natural frequencies. Classical studies of the vibration of continuous systems, free and forced, damped and undamped using computer solutions are emphasized. Introduction to Theoretical and Experiment Modal Analysis. (Design Elective)

**ME 625 SMART STRUCTURES**

(3-0) 3 credits. Topics will include dynamics of flexible structures, distributed sensing and actuation, linear and nonlinear control of flexible structures, electrostatic actuation, piezoelectric sensing and actuation, noise absorption, self-healing structures, introduction to adaptive optics, elastic control, vibration control, and other application areas as necessary.

**ME 673 APPLIED ENGINEERING  
ANALYSIS I**

(3-0) 3 credits. Advanced topics in engineering analysis. Special mathematical concepts will be applied to mechanical engineering problems. Topics will be selected from the following: Fourier series and boundary value problems applied to heat conduction and convection, Laplace transforms and complex variable analysis applied to vibrations and dynamic system analysis, series solutions of differential equations, partial differential equations, general matrix applications to a variety of large systems of equations in engineering, calculus of variation, and Ritz method for various engineering problems. This course is cross-listed with BME 673.

**ME 680 ADVANCED STRENGTH OF MATERIALS**

(3-0) 3 credits. Study of advanced concepts in strength of materials. Topics will be selected from the following: theories of stress and strain, failure criteria, energy methods, torsion, nonsymmetrical beams on elastic foundation, plates, shells, stress concentrations, contact stresses, finite element methods, and plastic behavior of solids. This course is cross-listed with EM 680.

**ME 683 ADVANCED MECHANICAL SYSTEM CONTROL**

(3-0) 3 credits. Prerequisites: Derivation of state equations for continuous and discrete control systems. A study of optimal and adaptive control of mechanical systems. (Manufacturing Elective)

**ME 691 INDEPENDENT STUDY**

1 to 3 credits. Prerequisite: Permission on instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

**ME 692 TOPICS**

1 to 3 credits.  
Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

**ME 713 ADVANCED SOLID MECHANICS I**

(3-0) 3 credits. Presented and discussed. Emphasis is placed on the mathematical description of phenomenological behavior, deformation and flow. Practical solutions from the classical theories of solid mechanics are discussed.  
This course is cross-listed with MES 713.

**ME 715 ADVANCED COMPOSITE MATERIALS**

(3-0) 3 credits. Includes classification and mechanical behavior of composite materials, macro-mechanical behavior of lamina and laminates. Course emphasizes study of advanced composite laminates including failure theories, experimental methods, stresses, strains, and deformations.

**ME 736 ADVANCED FINITE ELEMENT METHODS**

(3-0) 3 credits. Variational and weighted residual approach to finite element equations. Emphasis on two- and three-dimensional problems in solid mechanics. Isoparametric element formulations, higher order elements, numerical integration, imposition of constraints, convergence, and other more advanced topics. Introduction to geometric and material nonlinearities. Introduction to the solution of dynamic problems and time integration. Use of finite element computer programs. This course is cross-listed with BME 736.

**ME 770 CONTINUUM MECHANICS**

(3-0) 3 credits. Introduction to tensor algebra and calculus. Derivation of kinematic, stress, strain, and thermodynamic field equations governing continuous media. Development of constitutive relations for real materials. Applications to problems in fluid and solid mechanics. This course is cross listed with MES 770.

**ME 773 APPLIED ENGINEERING ANALYSIS II**

(3-0) 3 credits. Applications of numerical methods to mechanical engineering problems. Topics will include data processing techniques, curve fitting and interpolation of experimental information, solutions to systems of ordinary differential equations, solutions to partial differential equations, and numerical integration both of known functions and functions described only by experimental data. This course is cross-listed with BME 773.

**ME 781 ROBOTICS**

(3-0) 3 credits. The course covers the following topics as related to modern industrial robots, sensors and actuators, motion trajectories, synthesis, control, computers and languages, available robots, and applications.  
(Manufacturing Elective)

**ME 788 MASTER'S RESEARCH PROBLEMS/PROJECTS**

Credit to be arranged.  
Independent research problems/projects that lead to a research or design paper but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive or intensive. Does not include research courses which are theoretical.

**ME 790 SEMINAR**

(1-0) 1 credit. May not be repeated for credit. A highly focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as Internet and are at the upper division graduate levels.

**ME 791 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

**ME 792 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

**ME 798 THESIS**

Credit to be arranged. A formal treatise

presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

**ME 896 FIELD EXPERIENCE**

(0-3) credits. Applied, monitored, and supervised field-based learning experience for which the student may or may not be paid. Students gain practical experience; they follow a negotiated and/or directed plan of study established by the student, instructor, and field-based supervisor. Due to the presence of a field experience supervisor, a lower level of supervision is provided by the instructor in these courses than is the case with an internship or practicum course.

**ME 898D DISSERTATION**

1 to 12 credits. To be arranged (not to exceed 30). A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

**MEM 110/110L INTRODUCTION TO GEOLOGICAL AND MINING ENGINEERING**

(1-1) 2 credits. An introductory course for incoming freshmen in geological and mining engineering covering fundamental engineering practices in both disciplines. The course will include short field exercises, hands-on practical exercise, group projects, problem solving (using spreadsheets and other current methods), and engineering ethics. When applicable, industry experts will be invited as guest lecturers to discuss current trends and practices in the industry. This course is cross-listed with GEOE 110/110L.

### **MEM 120 INTRODUCTION TO MINING, SUSTAINABLE DEVELOPMENT AND INTRODUCTORY MANAGEMENT**

(2-0) 2 credits. This course presents an introductory overview of current surface and underground mining practices, new and emerging mining technology, mining terminology, and mining economics. Mining engineering faculty members are introduced and career paths available to the mining engineering graduate are discussed. The concept of sustainable development as it relates to minerals venture is introduced, and the interrelationships between mining, the environment, societal needs, and governance is discussed. Also included is an introduction to management concepts, presentation skills, meeting skills, negotiation skills, and basic project management tools.

### **MEM 201L SURVEYING FOR MINERAL ENGINEERS**

(0-2) 2 credits. Prerequisites: Sophomore standing. Principles of surface and underground surveying, including measurements, data collection, calculations, error analysis, topographic mapping, and applications of the Global Positioning System.

### **MEM 202 MATERIALS HANDLING AND TRANSPORTATION**

(2-0) 2 credits. Prerequisites: MEM 120 and PHYS 211. The theory of operation of mining equipment, and its selection and application to materials handling in surface and underground mines. Emphasis is on economics, productivity, reliability, maintenance, and safety.

### **MEM 203 INTRODUCTION TO MINE HEALTH AND SAFETY**

(1-0) 1 credit. Prerequisites: Sophomore standing. Instruction in the safety aspects of mining in accordance with MSHA rules. A study of mine regulations and the recognition of mine hazards along with their prevention and control.

### **MEM 204 SURFACE MINING METHODS AND UNIT OPERATIONS**

(2-0) 2 credits. Prerequisites: MEM 120 or permission of instructor. A study of surface

mining techniques and unit operations applicable to metal mining, coal mining, quarrying and other surface mining operations. Topics include mine design and planning, surface drilling and blasting, the applicability and performance characteristics of earthmoving equipment, and an introduction of mine drainage.

### **MEM 301/301L COMPUTER APPLICATIONS IN MINING**

(1-1) 2 credits. Prerequisites: GE 130 or permission of instructor. Computer hardware and software. Applications in exploration and resource modeling, equipment selection and simulations, mine planning and design, rock stability analysis, and economics and cost estimates. Emphasis on three-dimensional modeling and visualization. Vulcan software and other software applications.

### **MEM 302 MINERAL ECONOMICS AND FINANCE**

(3-0) 3 credits. Prerequisites: Junior standing. An introduction to the concepts of the time value of money and the application of time value of money decision criteria to mineral project evaluation situations. Both before-tax and after-tax investment situations are discussed. A discussion of the financing options available to a company for expansion, new project development or acquisitions.

### **MEM 303 UNDERGROUND MINING METHODS AND EQUIPMENT**

(2-0) 2 credits. Prerequisites: Sophomore or junior standing. A study of underground mining techniques, unit operations, and equipment applicable to coal mining, metal mining, quarrying and tunneling operations. Topics include mining method selection, mine design and planning, drilling and blasting, and novel underground mining methods.

### **MEM 304/304L THEORETICAL AND APPLIED ROCK MECHANICS**

(3-1) 4 credits. Prerequisites: EM 214 or EM 216 or equivalent and junior standing. Principles of rock mechanics and mechanics of materials. Concept of stress, strain and the theory of elasticity. Applications in mining, geological

engineering and tunneling. Emphasis on the design of safe structures in rocks. Laboratory experience for determining the basic physical and mechanical properties of rocks.

### **MEM 305 INTRODUCTION TO EXPLOSIVES ENGINEERING**

(3-0) 3 credits. Prerequisites: Junior standing. An introduction to explosives products; the theory of rock breakage by explosives; and the design of blast patterns for different applications including surface blasting techniques, underground blasting techniques, controlled blasting and specialized techniques. The techniques and equipment used to control and/or monitor airblast, ground vibration and flyrock are studied.

### **MEM 307 MINERAL EXPLORATION AND GEOSTATISTICS**

(3-0) 3 credits. Prerequisites: Junior standing. The application of the theory of geostatistics to qualify the geological concepts of (1) area of influence of a sample, (2) the continuity of the regionalized variable within a deposit, and (3) the lateral changes in the regionalized variable according to the direction. Basic concepts and theory of probability and statistics will be introduced, including probability distributions, sampling distributions, treatment of data, the mean, variance, and correlation. Computer techniques will be extensively used for geostatistical estimation of grade, volume, and variance. This course is cross-listed with ENVE 307.

### **MEM 401/401L THEORETICAL AND APPLIED MINE VENTILATION**

(3-1) 4 credits. Prerequisites: MEM 303, ATM 404, EM 328 and senior standing. Analysis of mine atmosphere and the control of airflow in an underground mine. Basic principles of thermodynamics and air conditions. Emphasis is on solutions of airflow networks and the design principles of mine ventilation systems. Laboratory experience for determining the basic pressure and airflow parameters, ventilation network analysis, and fan characteristics.

### **MEM 405 MINE PERMITTING AND RECLAMATION**

(3-0) 3 credits. Prerequisites: Junior standing. A study of environmental problems associated with both surface and underground mining and the reclamation practices that have been developed or are being evaluated to alleviate these problems. Federal, state and local reclamation regulations are examined for their effects on present and future mining practices and costs. Field trips to mining operations in the Black Hills region or the Powder River Basin will be taken for on-site observation of actual reclamation practices.

### **MEM 410/510 ADVANCED MINERAL ECONOMICS FOR MANAGERS**

(3-0) 3 credits. Prerequisites: MEM 302, or equivalent, or permission of instructor. A discussion of the fundamental factors critical to valuation of mineral properties. The three major approaches to mineral property valuation—the cost approach, the market approach, and the income approach—will be discussed. Additional subjects for discussion will include: selecting discount rates, leveraged cash flow, risk assessment, real asset pricing models and forecasting techniques. Students enrolled in MEM 510 will be held to a higher standard than those enrolled in MEM 410.

### **MEM 415/515 ADVANCED MINING GEOTECHNICAL ENGINEERING**

(3-0) 3 credits. Prerequisites: MEM 304/304L or equivalent, or permission of instructor. This course provides students with a practical understanding of the advanced application of geotechnical engineering principles in mining – from the perspective of planning, design and operations in both soft and hard rock as well as underground and open-cut mining systems. In the course will be a further discussion of theory and methods in geomechanics plus case studies of mining applications. Included will be discussion of new methods of collection and analysis of geotechnical data, geotechnical risk of different mining methods, caving mechanics, dynamic events: seismicity, rock bursts, airblast & outbursts, geotechnical instrumentation and monitoring, and geotechnical risk mitigation.

Students enrolled in MEM 415 will be held to a higher standard than students enrolled in MEM 415.

### **MEM 420/520 ADVANCED TUNNELING AND UNDERGROUND EXCAVATION**

(3-0) 3 credits. Prerequisites: MEM 304/304L or equivalent, or permission of instructor. The course will discuss advanced topics in tunnel excavation and design. These topics will include laboratory and in situ rock characterization and classification. Also to be discussed are mechanical, conventional and cut and cover methods of excavation and tunnel layout in hard and soft rock. Presentations will be on equipment selection and prediction of performance expected of the equipment; and initial ground support and design of permanent lining. Also discussed will be tunnel safety, instrumentation and monitoring and tunnel risk analysis. Students enrolled in MEM 520 will be held to a higher standard than those enrolled in MEM 420.

### **MEM 425/525 ADVANCED ROCK MECHANICS**

(3-0) 3 credits. Prerequisites: MEM 304/304L, or permission of instructor. A discussion of advanced topics in static and dynamic rock mechanics; elasticity theory, failure theories and fracture mechanics applied to rock, stress wave propagation and dynamic elastic constants, rock mass classification methods for support design. Discussed will include advanced analytical, numerical modeling and empirical design methods and probabilistic and deterministic approaches to rock engineering designs. Presented will be excavation design examples for shafts, tunnels, large chambers and mine pillars in coal and metal mines. Also discussed will be seismic loading of structures in rock and the phenomenon of rock burst and its alleviation. Students enrolled in MEM 425 will be held to a higher standard than those enrolled in MEM 425.

### **MEM 433/433L/533/533L COMPUTER APPLICATIONS IN GEOSCIENCE MODELING**

(3-1) 4 credits. Prerequisites: Junior standing. The use of computer techniques in modern

geoscience modeling of mining, geology and environmental problems such as exploration, geological characterization and mining exploitation. Practical application of state-of-the-art Vulcan modeling software will be essential part of the course. Students enrolled in MEM 533/533L will be held to a higher standard than those enrolled in MEM 433/433L.

### **MEM 440/540 ADVANCED MINE VENTILATION AND ENVIRONMENTAL ENGINEERING**

(3-0) 3 credits. Prerequisites: MEM 401/401L, or equivalent, or permission of instructor. Advanced topics in: mine air-quality control; economics of airflow; climate simulation; rock-to-air heat transfer in underground openings; ventilation network analysis; control flow and free splitting networks; controlled recirculation; diffusion and migration of contaminants in mine environment; control of mine fires and explosion; noise in underground environment; mine air conditioning systems; mine lighting; mine rescue apparatus. Students enrolled in MEM 540 will be held to a higher standard than those enrolled in MEM 440.

### **MEM 450/550 ROCK SLOPE ENGINEERING**

(3-0) 3 credits. Prerequisites: MEM 304/304L or CEE 346/346L or equivalent. Modes of slope failure. Economic consequences of instability in mining and construction. Geological factors controlling stability of rock slopes. Shear strength of highly jointed rock mass and discontinuities. Projection methods. Vectorial analysis of 3-D problems by means of the stereographic projection method. Analytical, graphical and computer analysis of planar, wedge and toppling failures. Probabilistic methods. Students enrolled in MEM 550 will be held to a higher standard than those enrolled in MEM 450.

### **MEM 455/555 ROCK SLOPE ENGINEERING II**

(3-0) 3 credits. Prerequisites: MEM 304/304L or CEE 346/346L or equivalent, and MEM 450/550 or CEE 646 or equivalent, or permission of instructor. Advanced topics in rock slope engineering including limiting equilibrium

analysis of plane shear, rotational shear and wedge-type failure; 2-D and 3-D numerical methods; analysis of rockfall; and laboratory and field methods including measurement of structural orientation, determination of strength properties using the direct shear, and instrumentation. Student enrolled in MEM 555 will be held to a higher standard than those enrolled in MEM 455.

#### **MEM 464 MINE DESIGN AND FEASIBILITY STUDY**

(0-4) 4 credits. Pre- or Co-requisites: MEM 302, MEM 304/304L, MEM 401/401L and senior standing. A complete mine feasibility study conducted as a senior design project. Students will have a choice of designing one of the following: a surface or underground coal mine, a quarry, a surface or underground hard rock metal mine, or a sub-surface underground space (tunneling, large excavations, industrial/environmental underground storage site, or underground science laboratory). A comprehensive study of principles and practices involved in developing an ore deposit (surface or underground) starting with drill hole data following through with a complete feasibility study (based on financial returns on investment and sensitivity analysis) covering ore reserve calculations, and selection of mining methods and equipment. Computerized approach will be an integral part of the course: SurvCADD software and Vulcan software are available to use. In addition to a computerized model of the mine, a final written report and presentation in front of the class will be required.

#### **MEM 466 MINE MANAGEMENT**

(2-0) 2 credits. Prerequisites: Senior standing or permission of instructor. The study of critical management issues of fundamental importance to the mining industry: forms of management, organizational structures, project management and mine administration, risk management, and modern management tools. Development of leadership skills. Management of human resources.

#### **MEM 480/580 ADVANCED EXPLOSIVES & BLASTING**

(3-0) 3 credits. Prerequisites: MEM 305, or equivalent, or permission of instructor. A discussion of most recent advances in blasting technology. Most recent developments in new explosives and initiation systems along with new methods of face profiling and blast design concepts will be dealt with in detail. Discussions will include guest speakers and some real time case studies. Electronic initiation systems and their associated technological challenges will be studied in some detail. Students enrolled in MEM 580 will be held to a higher standard than those enrolled in MEM 480.

#### **MEM 491 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Student complete individualized plans of study which include significant one-on-one student/teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting depending on the requirements of the topic.

#### **MEM 492 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may service as instructors.

#### **MES 475/575 ADVANCES IN PROCESSING AND NANOENGINEERING OF POLYMERS**

(2-0) 2 credits. Prerequisites: CHEM 114/114L or MES 604 or permission of instructor. The course will begin with an overview of the basic principles of polymer rheology and structure formation. It will then review recent examples from the scientific literature in which concepts and theories of rheological behavior and structure formation at multiple length scales have been further developed and/or applied to the processing of polymers and composites with advanced functional and multifunctional properties. Special attention will be paid to research related to

processing challenges in the formation of polymer nanocomposites, nanofibers and hierarchical composite structures. As part of this course, students will be expected to develop skills in reviewing and critically assessing the scientific literature, and in developing research strategies based on current state of knowledge. Students enrolled in MES 575 will be held to a higher standard than students enrolled in MES 475. This course is cross-listed with CBE 475/575 and NANO 475/575.

### **MES 601 FUNDAMENTALS OF MATERIALS ENGINEERING**

(4-0) 4 credits. Prerequisites: Admission to M.S./MES or Ph.D./MES program or permission of instructor. The course is taught when the required seven student minimum is reached. The objective of this course is to provide students with the working knowledge required to understand principles governing engineering aspects of materials synthesis and manufacturing. Students are able to analyze the effect of transport phenomena, surface chemistry, solution thermodynamics and kinetics on design, control and process optimization of various materials processes.

### **MES 603 CONDENSED MATTER PHYSICS**

(4-0) 4 credits. Prerequisites: Admission to M.S./MES or MES Ph.D. program or permission of instructor. The objective of this course is to provide students with working knowledge required to understand the principles of condensed matter physics with application to materials science and engineering. The students will be able to analyze basic experiments related to electronic structure of atoms and chemical bonding in solids, diffraction of x-rays and electrons by crystal lattices, lattice dynamics, elastic and thermal properties of solids, electronic band structure, classification of solids, dynamics of electrons in crystals, optical properties of solids, doped semiconductors, p-n junctions and hetero-junctions, dielectric properties of insulators, piezoelectricity, electrostriction, ferroelectricity, and magnetic properties of solids (dia-, para-, and ferro-magnetism).

### **MES 604 CHEMISTRY OF MATERIALS**

(4-0) 4 credits. Prerequisites: Admission to M.S./MES or MES Ph.D. program or permission of instructor. The object of this course is to provide students with the working knowledge required to understand the theoretical chemical basis for chemical and physical properties of crystalline, ceramic, polymeric and metallic materials. Students will be able to analyze macroscopic properties on the basis of underlying chemical concepts.

### **MES 636 PHOTOVOLTAICS**

(3-0) 3 credits. This course will cover modern silicon photovoltaic (PV) devices, including the basic physics, ideal and nonideal models, device parameters and design, and device fabrication. The emphasis will be placed on crystalline and multicrystalline devices, but thin films will also be introduced. PV applications and economics will be also discussed. This course is cross-listed with NANO 636.

### **MES 670 PRINCIPLES OF X-RAY DIFFRACTION**

(3-0) 3 credits. Prerequisites: PHYS 213 and MET 232 or GEOL 212/212L or permission of instructor. This course will cover the principles of crystallography in materials science, theory and production of x-rays, interaction of x-rays with matter, and the principles of x-ray diffraction. The application of x-ray diffraction methods to analytical measurement techniques in materials science and metallurgical engineering will also be covered. This course is cross-listed with GEOL 670.

### **MES 677 PRINTED ELECTRONICS: MATERIALS AND PROCESSES**

(3-0) 3 credits. The principles of interfacial phenomenon, solution thermodynamics and colloid chemistry will be used in illuminated process by which metallic nanoparticulates can be formed and incorporated into inks for use in manufacturing printed electronics by various direct write technologies. Students will learn 1) the methods and science behind the manufacture of a variety of nanoparticles, including gold, silver, copper conducting particles, 2) the methods

of incorporating these particles into inks and printing of these inks for printed electronics applications and 3) the interfacial processes involved in line spreading and curing of the printed traces. This course is cross-listed with NANO 677.

### **MES 691 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

### **MES 692 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **MES 712 INTERFACIAL PHENOMENA**

(3-0) 3 credits. A course in the surface properties of solids and liquids. Areas covered include the thermodynamics of surfaces, material transfer across interfaces, nucleation, surface energies of solids, three-phase contact, wetting phenomena, and adsorption.

### **MES 713 ADVANCED SOLID MECHANICS I**

(3-0) 3 credits. Presented and discussed. Emphasis is placed on the mathematical description of phenomenological behavior, deformation and flow. Practical solutions from the classical theories of solid mechanics are discussed. This course is cross-listed with ME 713.

### **MES 728 HETEROGENEOUS KINETICS**

(3-0) 3 credits. Principles of Absolute Rate Theory are combined with thermodynamics to study the mechanisms of homogeneous and heterogeneous reactions in metallurgical systems. This course is cross-listed with CBE 728.

### **MES 736 ADVANCED PHOTOVOLTAICS**

(3-0) 3 credits. This course builds on the foundations established in MES/NANO 636. It will cover advanced photovoltaic concepts including thin films, compound semiconductors, spectral conversion devices, and organic and polymeric devices. Advanced device designs will be emphasized. Evaluation will include a research paper on a current PV topic. This course is cross-listed with NANO 736.

### **MES 770 CONTINUUM MECHANICS**

(3-0) 3 credits. Introduction to tensor algebra and calculus. Derivation of kinematic, stress, strain, and thermodynamic field equations governing continuous media. Development of constitutive relations for real materials. Applications to problems in fluid and solid mechanics. This course is cross listed with ME 770.

### **MES 788 MASTER'S RESEARCH PROB/PROJECTS**

Credit to be arranged; not to exceed 5 credit hours toward fulfillment of the master of science in materials engineering and science (M.S./MES). Prerequisite: approval of advisor. Independent research problems/projects that lead to a research or design paper but not to a thesis. The plan of study is negotiated by the faculty member and the candidate. Contact between the two may be extensive and intensive. Does not include research courses which are theoretical. Oral defense of the report and research findings are required.

### **MES 790/890 SEMINAR**

(1-0) 1 credit. May not be repeated for degree credit. A highly focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as Internet and are at the upper division graduate levels. Students enrolled in MES 890 will be held to a higher standard than those enrolled in MES 790.

**MES 791 INDEPENDENT STUDY**

1 to 3 credits. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

**MES 792 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. This course is cross-listed with MES 692.

**MES 798 THESIS**

Credit to be arranged; not to exceed 6 credit hours toward fulfillment of the master of science in materials engineering and science (M.S./MES). A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

**MES 898 DISSERTATION**

Credit to be arranged; not to exceed 30 credits toward fulfillment of Ph.D. degree requirements. Open only to doctoral candidates. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

Oral defense of dissertation and research findings are required.

**MET 110/110I INTRODUCTION TO METALLURGICAL ENGINEERING DESIGN**

(1-1) 2 credits. An introductory design course for incoming freshman in metallurgical engineering covering fundamental engineering practices. The course will include group projects, problem solving (using spreadsheets and other current methods), and include engineering ethics.

**MET 220 MINERAL PROCESSING AND RESOURCE RECOVERY**

(3-0) credits. Prerequisites: MATH 123 and CHEM 112. An introductory course in mineral processing highlighting unit operations involved including comminution, sizing, froth flotation, gravity separation, electrostatic separation, magnetic separation, and flocculation. Other topics discussed include remediation of contaminant effluents and the unit operations associated with recycling of post-consumer materials using mineral processing techniques.

**MET 220L MINERAL PROCESSING AND RESOURCE RECOVERY LABORATORY**

(0-1) credit. Pre- or Co-requisites: MET 220. An introductory laboratory course in mineral processing highlighting relevant unit operations.

**MET 231 STRUCTURES AND PROPERTIES OF MATERIALS LAB**

(0-1) 1 credit. Pre- or Co-requisite: MET 232. A laboratory involving quantitative metallography, heat treating practice, mechanical property measurements and metallurgical design of the thermal mechanical treatment of metals.

**MET 232 PROPERTIES OF MATERIALS**

(3-0) 3 credits. Prerequisites: MATH 123 and CHEM 112. A course in engineering materials and their applications. The different technological uses of metals, ceramics, plastics, and composite materials are discussed and explained in terms of their basic atomic structure, and mechanical, thermal, optical, electrical, and magnetic properties. Material selection in engineering design is emphasized.

**MET 310 AQUEOUS EXTRACTION, CONCENTRATION, AND RECYCLING**  
(3-0) 3 credits. Prerequisites: MET 320 or CBE 321, or CHEM 342. Scientific and engineering principles involved in the winning of metals from ores and scrap. Areas covered include the unit operations of comminution, sizing, solid/liquid separations, leaching, ion exchange, solvent extraction, and surface phenomena as related to flocculation, froth floatation, and electrostatic separation.

**MET 310L AQUEOUS EXTRACTION, CONCENTRATION, AND RECYCLING LAB**  
(0-1) 1 credit. Pre- or Co-requisites: MET 310. Laboratory experiments in design of processing equipment and cost estimation, zeta potential, surface tension, leaching kinetics, electrowinning, and solvent extraction.

**MET 320 METALLURGICAL THERMODYNAMICS**  
(4-0) 4 credits. Prerequisites: PHYS 211, CHEM 112, MATH 125. The principles of chemical thermodynamics and their application to metallurgical engineering processes. Topics covered include the zeroth, first and second laws of thermodynamics, the fundamental equations of state for open and closed systems, criterion of equilibrium, heat capacities, reaction equilibrium constants and their dependence upon temperature and pressure, chemical potential, standard and reference states, stability diagrams, and solution thermodynamics.

**MET 321/321L HIGH TEMPERATURE EXTRACTION, CONCENTRATION, AND RECYCLING**  
(3-1) 4 credits. Prerequisites: MET 320. Thermodynamic principles involved in the winning of metals. Areas covered include calcination, oxidation, reduction processes, smelting, high -temperature refining, electrorefining, slags, and slag-metal interactions.

**MET 330 PHYSICS OF METALS**  
(3-0) 3 credits. Prerequisite: MET 232. The fundamental principles of physical metallurgy

with emphasis on the mathematical description of mechanisms that control the structure of materials. Topics covered are structure of metals, x-ray diffraction, elementary theory of metals, dislocations, slip phenomena, grain boundaries, vacancies, annealing, and solid solutions.

**MET 330L PHYSICS OF METALS LAB**  
(0-1) 1 credit. Prerequisites: MET 231 and Pre- or Co-requisite: MET 330. Practical laboratory exercises that involve (1) x-ray diffraction methods, (2) transmission electron microscopy as it applies to dislocations in materials, (3) recovery, recrystallization and grain growth as it applies to annealing of materials, (4) optional and scanning electron microscopy as it applies to the microstructure of materials, and (5) thermomechanical processing of metals with limited regions of solid solubility.

**MET 332 THERMOMECHANICAL TREATMENT**  
(3-0) 3 credits. Prerequisites: MET 232.. Pre- or Co-requisite: MET 330 and MET 320 or ME 211. The relationship between the structure and properties of materials. Topics covered are the iron-carbon system, hardenability of iron base alloys, stainless steels, cast irons, aluminum, copper and magnesium, rubber and copper polymers. Concepts of heat treatment, age hardening, dispersion hardening, and hot and cold working correlated with modification of the structure and physical properties of materials.

**MET 351 ENGINEERING DESIGN I**  
(2-0) 2 credits. Prerequisites: MET 220 and MET 232. Introduction to engineering design. Compare the scientific method with the engineering design method. Define the concept of need as it pertains to the design process. Develop skills associated with the use of modern and classic sources of information. In addition, material selection processes, interaction of materials, and materials processing topics are presented. Focus on the design process, and the design method. The development of interdisciplinary teams is a high priority.

**MET 352 ENGINEERING DESIGN II**

(1-0) 1 credit. Prerequisites: MET 351. A continuation of the design sequence.

**MET 422 TRANSPORT PHENOMENA**

(4-0) 4 credits. Prerequisites: MATH 321. Pre- or Co-requisite in MET 320. The principles of momentum, heat and mass transfer and their application to metallurgical engineering. Topics covered include thermal conductivity, mass diffusion, mechanisms of transport, Fourier's and Fick's Laws, shell balance, boundary conditions, equations of change, unsteady-state transport, mass and heat distributions in turbulent flow, and interphase transport.

**MET 426/526 STEELMAKING**

(3-0) 3 credits. Prerequisites: MET 320 or graduate standing. Chemical reactions and heat and mass transport phenomena associated with the production of steel. Unit operations studied include the blast furnace, the basic oxygen furnace, the electric arc furnace, and selected direct reduction processes. Students enrolled in MET 526 will be held to a higher standard than those enrolled in MET 426.

**MET 430/430L WELDING ENGINEERING AND DESIGN OF WELDED STRUCTURES**

(2-1)3 credits. Prerequisites: MET 232. Introduces the state-of-art in welding processes and technology. Discusses fundamentals of the fabrication welded structures by introducing basics of solidification in welds, metallurgy of welds, fatigue and fracture in welds, joint design and weld defects and inspection. Laboratory exercises will focus on advanced welding processes, characterization, and materials testing methods.

**MET 433 PROCESS CONTROL**

(3-0) 3 credits. Prerequisites: MATH 321 and senior standing. Analysis and design of process control systems for industrial processes, including control tuning and design of multi-variable control scheme. This course is cross-listed with CBE 433.

**MET 440/540 MECHANICAL METALLURGY**

(3-0) 3 credits. Prerequisites: MET 232. Pre- or Co-requisite in ME 216 or EM 321. A course concerned with responses of metals to loads. Areas covered include elastic and plastic deformation under different force systems, dislocation theory, fracture, internal friction, fatigue, creep, residual stresses, and general fundamentals of metal working. Students enrolled in MET 540 will be held to a higher standard than those enrolled in MET 440.

**MET 440L/540L MECHANICAL METALLURGY LABORATORY**

(0-1) 1 credit. Prerequisites: MET 232. Pre- or Co-requisite in MET 440/540. A course designed to expose the student to practical experience on the mechanical behavior of metals and alloys including deformation processing and failure analysis.

**MET 443 COMPOSITE MATERIALS**

(3-0) 3 credits. Prerequisites: ME 316 or concurrent enrollment in MET 440. The course will cover heterogeneous material systems; basic design concepts and preparation; types of composite materials; advances in filaments, fibers and matrices; physical and mechanical properties; failure modes; thermal and dynamic effects; and applications to construction, transportation and communication. This course is cross-listed with ME 443.

**MET 445/545 OXIDATION AND CORROSION OF METALS**

(3-0) 3 credits. Prerequisites: MET 320 or CBE 222 or ME 211 or graduate standing. Initially, the thermodynamics of electrochemical processes are covered; use of the Nernst equation and Pourbaix diagram is presented in this material. Fundamentals of electrode kinetics are then discussed with special emphasis on the derivation of the Butler-Volmer equation and application of the Evan's diagram. Following presentation of these fundamental concepts, phenomena observed in corrosion and oxidation such as uniform attack, pitting, stress corrosion cracking, and corrosion fatigue are discussed. Finally, selection of

materials for site specific applications is covered. Students enrolled in MET 545 will be held to a higher standard than those enrolled in MET 445. This course is cross-listed with CBE 445/545.

**MET 450/550 FORENSIC ENGINEERING**  
(3-0) 3 credits. Prerequisites: MET 231, MET 232, EM 321 or ME 216, or permission of instructor. The principles of physical metallurgy, mechanical metallurgy, manufacturing processes, and service environments will be used to determine the cause(s) for failure of metallic, composite, and polymer engineering components. Analytical techniques and procedures to characterize fractographic features and microstructures will also be reviewed, such as optical metallography, macrophotography, and scanning electron microscopy. Actual failed engineering components from a variety of industrial applications will be used as examples and be evaluated in the course. Fundamental engineering concepts, legal procedures of forensic engineering, failure mechanisms, technical report writing, and remedial recommendations will also be discussed. Students enrolled in MET 550 will be held to a higher standard than those enrolled in MET 450.

**MET 464 ENGINEERING DESIGN III**  
(0-2) 2 credits. Prerequisites: MET 352. A continuation of the design sequence.

**MET 465 ENGINEERING DESIGN IV**  
(0-1) 1 credit. Prerequisites: MET 464. A continuation of the design sequence, which includes a final technical design report and appropriate display material for the School of Mines Design Fair.

**MET 489 COMPOSITES MANUFACTURING**  
(1-0) 1 credit. A background in the concepts of polymers and polymerization as well as an overview of composites concepts, constituent materials, and manufacturing processes provide the groundwork in the first half of the course. A more detailed study of the Vacuum Assisted Resin Transfer molding (VARTM) processing builds

upon this groundwork, including topics such as process materials and parameters, mold design and manufacture, and product design considerations. This course concludes with post-processing topics. In conjunction with the concepts lecture, students spend time in the lab constructing and using a simple mold which will illustrate some of the challenges of molding and finishing a composite product. This course is cross-listed with CBE 489.

**MET 491 INDEPENDENT STUDY**  
1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

**MET 492 TOPICS**  
1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

**MET 601 BIOMATERIALS**  
(3-0) 3 credits. This course will provide students with an overview of the field of biomaterials with the knowledge necessary to conduct biomedical product development and/or biomaterials research. The first portion of the course will provide an introduction to the major classes of materials used in medical devices including metals, polymers, ceramics, composites, and natural materials. Topics covered will include material properties, material processing, testing, corrosion, biocompatibility, tissue responses, etc. The second portion of the course will cover specific biomaterial applications such as dental, orthopedic, cardiovascular, drug delivery, and tissue engineering. The topics of implant cleanliness and sterilization methods will also be discussed. In addition, the topic of national and

international governmental regulations and requirements will be reviewed including examples of investigative devices exemptions and 510k submissions. This course is cross-listed with BME 601.

### **MET 614 ADVANCED METALLURGICAL SIMULATION TECHNIQUES**

(3-0) 3 credits. An advanced course in the simulation of metallurgical processes. Topics covered include numerical solution of partial differential equations, optimization techniques and numerical integration and interpolation. Although the course is intended primarily for metallurgy majors, the coverage is sufficiently broad that non-metallurgy majors are encouraged to enroll.

### **MET 624 ADVANCED CHEMICAL METALLURGY**

(3-0) 3 credits. Prerequisites: MET 320, MET 321 and MET 422. Application of metallurgical thermodynamics and transport phenomena to extractive metallurgical processes.

### **MET 625 STRENGTHENING MECHANISMS IN METALS**

(3-0) 3 credits. Prerequisites: Permission of instructor. Study of the scientific fundamentals leading to the improvement of the mechanical properties of metallic materials. The treatment includes strengthening by strain hardening, grain and twin boundaries, solute atoms, precipitates, dispersed particles and fibers, martensitic transformations, texturing, point defects, and thermomechanical treatments. Enhancement of fracture, fatigue, and creep behavior is also treated.

### **MET 632 THEORY OF DISLOCATIONS**

(3-0) 3 credits. Prerequisites: MET 440 or permission of instructor. A study of defect theory in solids and their role in governing material behavior. Topics covered include the concept, properties, and mutual interaction of dislocations, point defects, stacking faults, dislocation dynamics (motion and multiplication). Application of defect theory to the phenomena of slip, plastic yielding, thermally-activated plastic

flow, microstrain, internal friction, strain hardening, and mechanical twinning.

### **MET 791 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems, and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

### **MET 792 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **MSL 101 LEADERSHIP AND PERSONAL DEVELOPMENT**

(1-0) 1 credit. Corequisites: MSL 101L. Make your first peer group at college one committed to performing well and enjoying the experience. Increase self-confidence through team study and activities in basic drill, physical fitness, rappelling, leadership reaction course, first aid, making presentations and basic marksmanship. Learn fundamental concepts of leadership in a profession in both classroom and outdoor laboratory environments.

### **MSL 101L LEADERSHIP AND PERSONAL DEVELOPMENT LAB**

(0-1) 1 credit. Corequisites: MSL 101. Designed to accompany MSL 101. Provides the students with hands-on experience to supplement and reinforce classroom instruction. Subjects addressed include drill and ceremonies, physical fitness training, marksmanship first aid, rappelling and basic mountaineering skills, voluntary off campus activities reinforce coursework. This course will count for 1 credit hour of physical education credit.

### **MSL 102 INTRODUCTION TO TACTICAL LEADERSHIP**

(1-0) 1 credit. Corequisites: MSL 102L. Learn and apply principles of effective leadership. Reinforce self-confidence through participation in physically and mentally challenging exercise with upper-division ROTC students. Develop communication skill to improve individual performance and group interaction. Relate organizational ethical values to the effectiveness of a leader.

### **MSL 102L INTRODUCTION TO TACTICAL LEADERSHIP LAB**

(0-1) 1 credit. Corequisites: MSL 102. Designed to accompany MSL 102. Provides the students with hands-on experience to supplement and reinforce classroom instruction. Subjects addressed include drill and ceremonies, physical fitness training, marksmanship first aid, rappelling and basic mountaineering skills, voluntary off campus activities reinforce coursework. This course will count for 1 credit hour of physical education credit.

### **MSL 201 INNOVATIVE TEAM LEADERSHIP**

(1-0) 12 credit. Corequisites: MSL 201L. Learn/apply ethics-based leadership skills that develop individual abilities and contribute to the building of effective teams of people. Develop skills in oral presentations, writing concisely, planning events, coordination of group efforts, advanced first aid, land navigation, and basic military tactics. Learn fundamentals of ROTC's leadership assessment program.

### **MSL 201L INNOVATIVE TEAM LEADERSHIP LAB**

(0-1) 1 credit. Corequisites: MSL 201. Students will develop leadership and management skills by being given the opportunity to perform duties in various leadership positions. Emphasis is placed on the development of leadership and managerial skills. Course is supplemented with instruction on the use of a lensatic compass and a topographic map. As well as various survival skills. Voluntary off campus activities reinforce

coursework.

### **MSL 202 FOUNDATIONS OF TACTICAL LEADERSHIP**

(1-0) 1 credit. Corequisites: MSL 202L. Introduction to individual and team aspects of military tactics in small unit operations. Includes use of radio communications, making safety assessments, movement techniques, planning for team safety/security and methods of pre-execution checks. Practical exercises with upper-division ROTC students. Learn techniques for training others as an aspect of continued leadership development.

### **MSL 202L FOUNDATIONS OF TACTICAL LEADERSHIP LAB**

(0-1) 1 credit. Corequisites: MSL 202. Students are provided the opportunity to reinforce classroom leadership and management training with practical experience. Students will also receive training in small unit tactics and use of the m-16 rifle. Voluntary off campus activities reinforce coursework.

### **MSL 290 BASIC SMALL UNIT LEADERSHIP**

(2-0) 2 credits. Concurrent registration in either MSL 101 or MSL 201 is required. Provides the student with practical experience in small unit leadership development, team building, and the technical and tactical skills needed to be a professional officer in the United States Army. Course includes instruction in and practical application of rifle marksmanship, orienteering, mountaineering, weapons proficiency, physical training, and small unit leadership skills. May be repeated for a maximum of 4 credit hours.

**MSL 291 INTERNSHIP IN LEADERSHIP I**  
(2-0) 2 credits. This course is designed for ROTC Cadets who have completed M.S. I and II but are not academically aligned to contract as M.S. III's. The course will expand on their applied leadership skills. Upon approval of the instructor, students will develop training plans, schedules, evaluation outlines and classroom instruction. Students may also do department approved research. The class

may be repeated up to two times, for a maximum of 4 credits, with permission of department head.

### **MSL 294 ROTC SUMMER LEADERSHIP INTERNSHIP**

(0-4) 4 credits. The mission of ROTC Basic Camp is to serve as an alternative for the first two years of on-campus ROTC enrollment. Basic Camp offers students who did not take ROTC courses during their first two years of school the opportunity to enroll in ROTC at the start of their junior year. Basic Camp is a six week training period in which the student undergoes basic military training within a regular Army environment. Instruction consists of both classroom instruction and practical exercises along with considerable field training. All students are closely supervised and carefully evaluated by military officers.

### **MSL 301 ADAPTIVE TEAM LEADERSHIP**

(2-0) 2 credits. Corequisites: MSL 301L. Series of practical opportunities to lead small groups, receive personal assessments and encouragement, and lead again in situations of increasing complexity. Uses small unit tactics and opportunities to plan and conduct training for lower division students both to develop such skills and as vehicles for practicing leadership.

### **MSL 301L ADAPTIVE TEAM LEADERSHIP LAB**

(0-2) 2 credits. Corequisites: MSL 301. Provides the student with practical experience to supplement and reinforce classroom instruction. Subjects include drill and ceremonies, physical training instruction techniques and leadership, which will complement the student's preparation for ROTC advanced camp. Off campus.

### **MSL 302 LEADERSHIP IN CHANGING ENVIRONMENTS**

(2-0) 2 credits. Prerequisites: MSL 301. Continues methodology of MSL 301. Analyze tasks; prepare written or oral guidance for team members to accomplish tasks. Delegate tasks and supervise. Plan for and adapt to the unexpected in organizations under stress. Examine and apply lessons from leadership case studies. Examine

importance of ethical decision making in setting a positive climate that enhances team performance.

### **MSL 302L LEADERSHIP IN CHANGING ENVIRONMENTS LAB**

(0-2) 2 credits. Corequisites: MSL 302. Provides student with additional training in land navigation, drill and ceremonies, physical training, instruction techniques and leadership, which will complement the students' preparation for ROTC advanced camp. Off campus training is required.

### **MSL 394 ADVANCED MILITARY SCIENCE INTERNSHIP**

(0-4) 4 credits. Contracted ROTC Advanced Course Cadets will attend a six-week intensified military training phase at Ft. Lewis, Washington which will provide both classroom and practical experience in the military and leadership skills required by a commissioned officer.

### **MSL 401 DEVELOPING ADAPTIVE LEADERS**

(2-0) 2 credits. Corequisites: MSL 401L. Introduces formal management skills including problem analysis, planning techniques, and the delegation and control of activities, providing an understanding of the command and staff organization used in the modern army and creating a forum for discussing professional and ethical decisions faced by commissioned officers.

### **MSL 401L DEVELOPING ADAPTIVE LEADERS LAB**

(0-2) 2 credits. Corequisites: MSL 401. Provides practical experience supplementing and reinforcing classroom instruction, including drill and ceremonies, physical fitness training, instruction techniques, and operation of the cadet battalion. Off-campus training required.

### **MSL 402 LEADERSHIP IN A COMPLEX WORLD**

(2-0) 2 credits. Corequisites: MSL 412. Provides information for transition to active or reserve commissioned service, developing administrative controls essential in managing a military organization, introducing the management of financial and personal affairs, and allowing time

for discussion and analysis of the ethical decision-making process.

**MSL 402L LEADERSHIP IN A COMPLEX WORLD LAB**

(0-2) 2 credits. Corequisites: MSL 402. Provides practical experience supplementing and reinforcing classroom instruction, including drill and ceremonies, physical fitness training, instructional techniques, small unit leadership and familiarization with duties of commissioned officers. Off-campus training is required.

**MSL 403 THIRD YEAR ADVANCED MILITARY SCIENCE**

(2-0) 2 credits. Prerequisites: MSL 401 and MSL 402. Provides a transition to entering active or reserve commissioned service, including an in-depth study of military decision making, giving experience in planning and conducting squad and platoon level military exercises and leadership.

**MSL 404 THIRD YEAR ADVANCED MILITARY SCIENCE**

(2-0) 2 credits. Prerequisites: MSL 401 and MSL 402. Provides an in-depth study of military decision-making, giving experience in planning and conducting military exercises at squad and platoon level, including an opportunity to develop leadership techniques.

**MSL 411 DEVELOPING SUBORDINATE LEADERS I**

(2-0) 2 credits. Corequisites: MSL 401 Provides practical experience supplementing and reinforcing classroom instruction, including drill and ceremonies, physical fitness training, instruction techniques, and operation of the cadet battalion. Off-campus training required.

**MSL 412 DEVELOPING SUBORDINATE LEADERS II**

(2-0) 2 credits. Corequisites: MSL 402 Provides practical experience supplementing and reinforcing classroom instruction, including drill and ceremonies, physical fitness training, instructional techniques, small unit leadership and familiarization with duties of commissioned

officers. Off-campus training is required.

**MSL 480 ADVANCED SMALL UNIT LEADERSHIP**

(2-0) 2 credits. Corequisites: MSL 301/301L or MSL 401/411 Provides practical experience in small unit leadership development, team building, and officers' technical/tactical skills, including rifle marksmanship, orienteering, mountaineering, weapons proficiency, physical training, and small unit leadership skills. May be repeated for a maximum of 4 credit hours.

**MSL 491 ADVANCED INTERNSHIP IN LEADERSHIP**

(2-0) 2 credits. This course is designed for ROTC Cadets who have completed M.S. IV, but have not completed graduation requirements. The course will allow students to fully develop and conduct training on advanced military subjects. Students may also do department approved research. The class may be repeated two times, for a maximum of 4 credits, with the permission of department head.

**MSL 494 LEADERSHIP DEVELOPMENT AND ASSESS COURSE**

3 to 4 credits. This course is designed for ROTC Cadets who have completed M.S. IV but have not completed graduation requirements. The course will allow students to fully develop and conduct training on advanced military subjects. Students may also do department approved research. The class may be repeated two times, for a maximum of 4 credits, with the permission of department head.

**MUAP 102 CLASS INSTRUCTION-VOICE**

(1-0) 1 credit. One to two semester hours credit for class instruction is given for two one hour class meetings. Adequate preparation through practice is expected of all students. (May be used to fulfill the humanities credit for graduation.)

**MUAP 120 APPLIED MUSIC-WOODWINDS**

1 to 4 credits. One to two hours credit for private lessons is given for half-hour lesson per week. Music majors studying in the major performance area may elect two half-hour lessons per week for

two to four hours of credit. Adequate preparation through practice is expected of all students. (May be used to fulfill the humanities credit for graduation.)

#### **MUAP 121 APPLIED MUSIC-WOODWINDS**

1 to 4 credits. One to two hours credit for private lessons is given for half-hour lesson per week. Music majors studying in the major performance area may elect two half-hour lessons per week for two to four hours of credit. Adequate preparation through practice is expected of all students. (May be used to fulfill the humanities credit for graduation.)

#### **MUAP 130 APPLIED MUSIC-BRASS**

1 to 4 credits. One to two hours credit for private lessons is given for half-hour lesson per week. Music majors studying in the major performance area may elect two half-hour lessons per week for two to four hours of credit. Adequate preparation through practice is expected of all students. (May be used to fulfill the humanities credit for graduation.)

#### **MUAP 131 APPLIED MUSIC-BRASS**

1 to 4 credits. One to two hours credit for private lessons is given for half-hour lesson per week. Music majors studying in the major performance area may elect two half-hour lessons per week for two to four hours of credit. Adequate preparation through practice is expected of all students. (May be used to fulfill the humanities credit for graduation.)

#### **MUAP 200 APPLIED MUSIC-VOICE**

1 to 4 credits. Prerequisites: Permission of instructor. One to 2 semester hours credit for private lessons is given for one half-hour lesson per week. Music majors studying in the major performance area may elect two half-hour lessons per week for 2 to 4 hours of credit. Adequate preparation through practice is expected of all students. (May be used to fulfill the humanities credit for graduation.)

#### **MUAP 201 APPLIED MUSIC-VOICE**

1 to 4 credits. Class voice instruction is open to anyone interested. Emphasis is placed on the

development of the fundamental voice techniques. (May be used to fulfill the humanities credit for graduation.)

#### **MUEN 100 CONCERT CHOIR**

0 to 2 credits. An ensemble performing accompanied and unaccompanied literature for mixed voices. Membership determined by instructor's permission and audition only. (Any combination of PE and MUEN 100/101/121/122 may be allowed toward fulfillment of the physical education credit for graduation. (May not be used to fulfill the humanities credit for graduation.)

#### **MUEN 101 CHORAL ENSEMBLES**

1 to 2 credits. Prerequisites: Permission of instructor. An ensemble performing accompanied and unaccompanied literature for mixed voices. Membership determined by instructor's permission and audition only. School of Mines does not require an audition. (Any combination of P.E. and MUEN 101/121/122 may be allowed toward fulfillment of the physical education credit for graduation. May not be used to fulfill the humanities credit for graduation.)

#### **MUEN 121 SYMPHONIC BAND**

(1-0) 1 credit. Members are selected by audition to perform the finest in original and transcribed literature in concert performances on and off-campus. (Any combination of P.E. and MUEN 101/121/122 may be allowed toward fulfillment of the physical education credit for graduation. May not be used to fulfill the humanities credit for graduation.)

#### **MUEN 122 CONCERT BAND**

(1-0) 1 credit. A joint enterprise open to university students and interested area musicians. Includes rehearsals and performance of band literature culminating in a public performance. (Any combination of P.E. and MUEN-101/121/122 may be allowed toward fulfillment of the physical education credit for graduation. May not be used to fulfill the humanities credits for graduation.)

**MUEN 260 NON-CREDIT MUSIC ENSEMBLE**

No credit. Development of vocal or instrumental skills and aesthetic perception through the study and performance of music. This course cannot count as social science/humanities credit.

**MUS 100 MUSIC APPRECIATION**

(3-0) 3 credits. A non-technical discussion designed to increase the enjoyment and appreciation of music. Fulfills the music requirement in the general education program.

**MUS 110 BASIC MUSIC THEORY I**

2 to 4 credits. An integrated study and application of tonality, melody, harmony, texture and form, from basic notation through modulation. Includes sight singing, ear training, and dictation. Introduction to composition and arranging, i.e.: instrument ranges, transposition, tessitura and preliminary score analysis.

**MUS 217/217L MUSIC IN PERFORMANCE I**

(2-1) 3 credits. Prerequisites: Permission of instructor. This course introduces the functions and techniques of the craft of music through the study of music from both western and non-western cultures. It establishes fundamental performance tools and develops basic systematic processes and skills in musical analysis that through the study, rehearsal, and performance of ensemble music, developing cultural understandings.

**MUS 317/317L MUSIC IN PERFORMANCE II**

(2-1) 3 credits. Prerequisites: Three previous semesters of any combination of MUEN 101/122 or MUS 217/217L and/or permission of instructor. This course builds on concepts introduced in MUS 217/217L to develop advanced understandings of cultural, historical and aesthetic perceptions through in-depth study and performance of ensemble music of both western and non-west cultures.

**NANO 401 INTRODUCTION TO NANOSCIENCE**

(3-0) 3 credits. Prerequisites: PHYS 213/213L, CHEM 114, MATH 321 or permission of

instructor. Introduction to the concepts, motivations, and challenges of nanoscience. Topics include the emergence and background of nanoscience. Properties, applications, and characterization of nanoscale materials and systems will be examined. The course will particularly benefit students considering graduate studies that may involve nanotechnology research. Principles of basic physics, chemistry, and mathematics will be involved.

**NANO 445/545 INTRODUCTION TO NANOMATERIALS**

(3-0) 3 credits. Prerequisites: MET 232, EM 321. This course will introduce the theoretical basis and synthetic processes of nanomaterials. Specifically, this course will focus on the synthesis and fabrication of nanostructures and nanomaterials, and also include content on the nanoscale property measurements. Finally, the course will cover applications of nanomaterials, particularly focusing upon inorganic nanomaterials. Students enrolling in NANO 545 will be held to a higher standard than those enrolled in NANO 445.

**NANO 475/575 ADVANCES IN PROCESSING AND NANOENGINEERING OF POLYMERS**

(2-0) 2 credits. Prerequisites: CHEM 114/114L or MES 604 or permission of instructor. The course will begin with an overview of the basic principles of polymer rheology and structure formation. It will then review recent examples from the scientific literature in which concepts and theories of rheological behavior and structure formation at multiple length scales have been further developed and/or applied to the processing of polymers and composites with advanced functional and multifunctional properties. Special attention will be paid to research related to processing challenges in the formation of polymer nanocomposites, nanofibers and hierarchical composite structures. As part of this course, students will be expected to develop skills in reviewing and critically assessing the scientific literature, and in developing research strategies based on current state of knowledge. Students enrolled in NANO 575 will be held to a higher

standard than students enrolled in NANO 475. This course is cross-listed with CBE 475/575 and MES 475/575.

#### **NANO 504 NANOPHOTONICS**

(3-0) 3 credits. Prerequisites: Introductory quantum mechanics and electricity and magnetism; ability to solve ordinary differential equations and linear systems. The course deals with optical phenomena in materials and structures with subwave-length dimensions. Topics will include the quantum theory of light, laser theory, beam propagation, and the unique properties of nanophotonics structures.

#### **NANO 521 ELECTROMAGNETISM**

(4-0) 4 credits. Prerequisites: PHYS 213 and MATH 321. This is a course in the principles of electricity and magnetism, with applications to dielectric and magnetic materials. Topics include the development of Maxwell's equations, and applications. This course is cross-listed with PHYS 421/521.

#### **NANO 551 CLASSICAL MECHANICS**

(4-0) 4 credits. Prerequisites: PHYS 113 or PHYS 213. Pre- or Co-requisite MATH 321. This is a systematic introduction to classical mechanics emphasizing motion in three dimensions. Topics include central forces, harmonic oscillations, non-inertial reference frames, rigid body motion, and Lagrangian and Hamiltonian Mechanics. This course is cross-listed with PHYS 451/551.

#### **NANO 571 QUANTUM MECHANICS**

(4-0) 4 credits. Prerequisites: MATH 321 or permission of instructor. This is a systematic introduction to quantum mechanics, emphasizing the Schrödinger equation. Topics include simple soluble problems, the hydrogen atom, approximation methods and other aspects of quantum theory. This course is cross-listed with PHYS 471/571.

#### **NANO 604 NANOPHOTONIC MATERIALS**

(3-0) 3 credits. This graduate course will study the analysis and properties of nanostructured photonic materials such as photonic crystals and plasmonic materials.

#### **NANO 636 PHOTOVOLTAICS**

(3-0) 3 credits. This course will cover modern silicon photovoltaic (PV) devices, including the basic physics, ideal and nonideal models, device parameters and design, and device fabrication. The emphasis will be placed on crystalline and multicrystalline devices, but thin films will also be introduced. PV applications and economics will be also discussed. This course is cross-listed with MES 636.

#### **NANO 677 PRINTED ELECTRONICS: MATERIALS AND PROCESSES**

(3-0) 3 credits. The principles of interfacial phenomenon, solution thermodynamics and colloid chemistry will be used in illuminated process by which metallic nanoparticulates can be formed and incorporated into inks for use in manufacturing printed electronics by various direct write technologies. Students will learn 1) the methods and science behind the manufacture of a variety of nanoparticles, including gold, silver, copper conducting particles, 2) the methods of incorporating these particles into inks and printing of these inks for printed electronics applications and 3) the interfacial processes involved in line spreading and curing of the printed traces. This course is cross-listed with MES 677.

#### **NANO 701 NANO MATERIALS**

(3-0) 3 credits. This course will focus on the formation of nanomaterials via gas and liquid phase routes. Theory of homogeneous and heterogeneous nucleation, growth mechanisms and kinetics as well as population balances will be discussed. The second part of the course will cover particle surface functionalization, colloidal properties and stability, processing of nanoparticle suspensions, and chemical and physical fabrication techniques. Application of nanostructures and nanomaterials will be discussed as well.

#### **NANO 702 THEORY AND APPLICATION OF NANOSCALE MATERIALS**

(3-0) 3 credits. Prerequisites: Introductory quantum mechanics, ability to solve ordinary

differential equations and linear systems. The course will survey current research in nanoscience and nanotechnology, providing the essential background and theory at the level accessible to students from varied scientific and engineering backgrounds. Special emphasis will be placed on nano-scaled materials and their practical applications.

#### **NANO 703/703L INSTRUMENTATION AND CHARACTERIZATION OF NANO-MATERIALS**

(3-1) 4 credits. This is an introductory course on instrumentations used in characterization of nano-scaled materials. The course is aimed at entry level graduate students who want to learn characterization of nano-scale materials using state-of-the-art instruments.

#### **NANO 704 CRYSTALLOGRAPHY AND STRUCTURE OF NANOMATERIALS**

(3-0) 3 credits. This graduate course covers crystallographic characteristics and structural properties of nanomaterials. Emphasis is placed on electron and x-ray diffraction signatures of nanoparticle size, shape and configuration.

#### **NANO 705 NANOELECTRONICS**

(3-0) 3 credits. This graduate course covers the electronic properties and applications of nanomaterials with particular emphasis on quantum semiconductor structures.

#### **NANO 706 DIFFRACTION METHODS FOR NANOMATERIALS RESEARCH**

(3-0) 3 credits. This graduate course covers structural, optical, and electronic defects in nano-scaled materials.

#### **NANO 707 DEFECTS IN NANOMATERIALS**

(3-0) 3 credits. This graduate course covers the characterization and identification of structural and electronic defects in nano-scaled materials systems.

#### **NANO 708 NANOMATERIALS FOR PHOTOVOLTACIS**

(3-0) 3 credits. This graduate course covers the engineering of materials and structures on the nanometer length scale for the photovoltaic power generation from radiant sources, especially the sun.

#### **NANO 712/712L ELECTROMAGNETIC PROPERTIES OF HETEROGENEOUS MATERIALS**

(2-1) 3 credits. Focuses on macroscopic electromagnetic properties of heterogeneous materials and their applications. With nanotechnology, it is possible to manufacture materials with totally new properties that cannot be attained by conventional methods. Through the combined use of analysis (such as mixing theory) and numerical methods, the macroscopic material properties will be computed directly from microscopic composition of the material.

#### **NANO 715 POLYMERIC NANOMATERIALS**

(3-0) 3 credits. This course is an introduction of fundamental concepts, synthesis, characterizations, structural and physical properties of polymeric nanomaterials. The contents include, but not limited to, nanofibers, carbon nanotubes, nanocomposites, polymer self-assembly, biopolymers in nanosciences, and nanoparticle coatings.

#### **NANO 717 NANOCHEMISTRY**

(3-0) 3 credits. The course introduces both the fundamentals and frontiers of the rapidly developing interdisciplinary field of nanomaterials from a chemist's point of view. The course covers synthesis and fabrication methods of nanomaterials including "top-down" nanofabrication, "bottom-up" chemical synthesis, and self-assembly. The course discusses the unique properties and the structure-property relationship of nanomaterials.

#### **NANO 721 ELECTRODYNAMICS I**

(3-0) 3 credits. A continuation of PHYS 421. This course treats advanced problems with special emphasis on solutions of the wave equation,

Laplace's equation, and Poisson's equation. Through introduction of the methods of special relativity, the unity of electrical and magnetic phenomena and the covariance of Maxwell's equations are demonstrated. If time permits, topics such as MHD and plasma physics are also introduced. This course is cross-listed with PHYS 721.

### **NANO 736 ADVANCED PHOTOVOLTAICS**

(3-0) 3 credits. This course builds on the foundations established in MES/NANO 636. It will cover advanced photovoltaic concepts including thin films, compound semiconductors, spectral conversion devices, and organic and polymeric devices. Advanced device designs will be emphasized. Evaluation will include a research paper on a current PV topic. This course is cross-listed with MES 736.

### **NANO 743 STATISTICAL MECHANICS**

(3-0) 3 credits. Review fundamentals of thermodynamics, introduce Legendre transforms and develop the concepts of phase equilibria and stability, ensembles, partition functions, and the role of fluctuations. Statistical mechanics of non-interacting ideal systems and phase transformations, mean field theory, renormalization group theory and Monte Carlo calculations applied to the Ising Model. This course is cross-listed with PHYS 743.

### **NANO 751 THEORETICAL MECHANICS**

(3-0) 3 credits. Advanced treatment of classical mechanics, including Lagrange's and Hamilton's equations, rigid-body motion, canonical transformations, calculus of variations, and relativity using vectors, matrices, and tensors. This course is cross-listed with PHYS 751.

### **NANO 771 QUANTUM MECHANICS I**

(3-0) 3 credits. Prerequisites: PHYS 471. Physical basis of quantum mechanics, Schrodinger's equation and its solution, matrix mechanics, operator methods, approximate methods with an introduction to the relativistic wave equation. This course is cross-listed with PHYS 771.

### **NANO 791 INDEPENDENT STUDY**

1 to 3 credits. Prerequisite: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Student complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting depending upon the requirements of the topic.

### **NANO 792 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **NANO 890 SEMINAR**

(1-0) 1 credit. May not be repeated for degree credit. A highly focused, and topical courses. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as Internet and are at the upper division of graduate levels.

### **NANO 898D DISSERTATION**

Credit to be arranged; not to exceed 30 credits toward fulfillment of Ph.D. degree requirements. Open only to doctoral candidates. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

### **PALE 671 ADVANCED FIELD PALEONTOLOGY**

(0-2) 2 credits. A field-oriented course stressing collection and detailed documentation of vertebrate fossils. Taphonomic factors, measured sections, and some geologic maps may be required, as well as detailed field notes.

**PALE 672/672L MICROPALEONTOLOGY**

(2-1) 3 credits. A study of the morphology, ecology, and stratigraphic significance of selected groups of protozoans and invertebrate and plant microfossils with special emphasis on Formaminifera and conodonts. This course is cross-listed with GEOL 672/672L.

**PALE 673/673L COMPARTIVE OSTEOLOGY**

(2-1) 3 credits. A comparison of recent and fossil vertebrate skeletons and dentitions with emphasis on the skeletons and teeth of sharks, bony fish, salamanders, frogs, turtles, alligators, lizards, birds, and mammals to establish a thorough understanding of the diversity of the form and function of the vertebrate skeleton. A major objective is the identification of vertebrates based upon osteology and odontology. This course is cross-listed with GEOL 673/673L.

**PALE 676/676L VERTEBRATE PALEONTOLOGY**

(3-1) 4 credits. An in-depth assessment of the fossil record of vertebrates with special emphasis on current problems in the evolution of vertebrates and the tangible record preserved in the collections of the Museum of Geology. This course is cross-listed with GEOL 676/676L.

**PALE 678/678L VERTEBRATE BIOSTRATIGRAPHY**

(3-1) 4 credits. Prerequisite: GEOL/PALE 676/676L. The principles and practices for establishing the distribution of vertebrate fossils in the rock record. This course will include a brief history of biostratigraphy, methodology, and the content and assessment of vertebrate ages, particularly of Mesozoic and Cenozoic mammals. This course is cross-listed with GEOL 678/678L.

**PALE 691 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher

involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic. A description of the work to be performed must be filed in the Department of Geology and Geological Engineering. This course is cross-listed with GEOL 691.

**PALE 692 TOPICS**

1 to 3 credits. Includes Current Topics, Advanced Topics, and Special Topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A description of the work to be performed must be filed in the geology and geological engineering office. This course is cross-listed with GEOL 692.

**PALE 790 SEMINAR**

(1-0) 1 credit. May be repeated once for degree credit. Preparation A highly focused, and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as Internet and are at the upper division graduate levels. This presentation normally will directly precede the final oral defense of the thesis. This course is cross-listed with GEOL 790.

**PALE 798 THESIS**

Credit to be arranged; not to exceed 6 credits toward fulfillment of M.S. degree requirements. Open only to students pursuing the M.S. thesis option. A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

**PE 100 ACTIVITY COURSES**

(1-0) 1 credit. Activities stressing individual physical fitness and lifetime activities according to student needs and interests. The same activity course cannot be counted toward graduation

credit.

**PE 103 NUTRITION FOR EVERYDAY LIVING**

(1-0) 1 credit. This course will teach nutritional components of healthy diet, impact on body composition, and overall health. Course includes lecture and activity. This course can only be taken one time for credit.

**PE 105 WELLNESS AND PHYSICAL FITNESS**

(1-0) 1 credit. For men and women. An activity course with lecture instructing students in many different aspects of personal wellness and physical fitness with practical application. This course can only be taken one time for credit.

**PE 113 VARSITY SPORTS I**

(1-0) 1 credit. This course is an introduction/conditioning course offered fall semester. A student must be a member of a varsity sports team that is sponsored by the School of Mines to be enrolled in this course. This course can only be taken four times for credit, however it may only be used two times to fulfill physical education graduation requirements.

**PE 118 BEGINNING AND INTERMEDIATE SWIMMING (MEN AND WOMEN)**

(1-0) 1 credit. This course will provide instruction in basic skills and fundamental strokes of swimming. After developing basic skills, the fundamental strokes are perfected along with elementary forms of rescue. This course can only be taken one time for credit.

**PE 160 MODIFIED PHYSICAL EDUCATION ACTIVITY**

(1-0) 1 credit. This course is designed to adapt a variety of activities to the special needs and interests of students who qualify under the Americans with Disabilities Act. The course will seek to adapt physical fitness and sports activities for the special needs student within the limitations of current staffing and facilities. Course can be repeated once for additional credit.

**PHIL 100 INTRODUCTION TO PHILOSOPHY**

(3-0) 3 credits. Introduces competing philosophical views of reality, perception, learning, and values, emphasizing their relevance to the contemporary world.

**PHIL 200 INTRODUCTION TO LOGIC**

(3-0) 3 credits. Introduces the formal study of argumentation, including forms of logic, inductive and deductive reasoning, proofs, refutations, and fallacies.

**PHIL 220 INTRODUCTION TO ETHICS**

(3-0) 3 credits. Examines the major currents and components of ethical theory from classical times to the present, investigating problems arising from specific theories, as well as critically analyzing the validity of these theories for current ethical concerns.

**PHIL 233 PHILOSOPHY AND LITERATURE**

(3-0) 3 credits. Examination of selected topics from the Western World's literary tradition and analysis of their contributions in the areas of philosophy of life, philosophy of religion, and the concepts of duty and human nature. Study and discussion of topics in relation to their significance for the individual.

**PHYS 111 INTRODUCTION TO PHYSICS I**

(3-0) 3 credits. Prerequisites: MATH 102 or MATH 123 or permission of instructor. This is the first course in a two semester algebra-level sequence, covering fundamental concepts of physics. This sequence is appropriate for pre-professional majors requiring two semesters of physics. Topics include classical mechanics, thermodynamics, and waves. The School of Mines covers classical mechanics only. May not be used for credit toward an engineering or science degree (except interdisciplinary science, geology (paleontology emphasis), and associate of arts).

**PHYS 111L INTRODUCTION TO PHYSICS I LAB**

(0-1)1 credit. Pre- or Co-requisites: PHYS 111. This laboratory accompanies PHYS 111. May not be used for credit toward an engineering or science degree (except interdisciplinary science, geology (paleontology emphasis), and associate of arts).

**PHYS 113 INTRODUCTION TO PHYSICS II**

(3-0) 3 credits. Prerequisites: PHYS 111. This course is the second course in a two semester algebra-level sequence, covering fundamental concepts of physics. Topics include electricity and magnetism, sound, light, optics, and some modern physics concepts. The School of Mines course covers electricity and magnetism only. May not be used for credit toward an engineering or science degree (except interdisciplinary science, geology – paleontology emphasis, and associate of arts).

**PHYS 113L INTRODUCTION TO PHYSICS II LAB**

(0-1) 1 credit. Pre- or Co-requisites: PHYS 113. This laboratory accompanies PHYS 113. May not be used for credit toward an engineering or science degree (except interdisciplinary science, geology - paleontology emphasis, and associate of arts).

**PHYS 183 ELEMENTS OF MODERN ASTRONOMY**

(3-0) 3 credits. This course presents a broad view of astronomy in a straightforward and descriptive manner without complex mathematics. It introduces students to basic concepts and the historic and modern foundations of the science of astronomy. Students will gain some insight into the basic physics underlying conclusions drawn from observational and theoretical astronomy, astrophysics, and cosmology. The course provides descriptions of a wide variety of objects found in the universe, from gas and dust particles of stars, planets, and galactic clusters.

**PHYS 211 UNIVERSITY PHYSICS I**

(3-0) 3 credits. Prerequisites: MATH 123. This is the first course in a two semester calculus-level

sequence, covering fundamental concepts of physics. This is the preferred sequence for students majoring in physical science or engineering. Topics include classical mechanics and thermodynamics. The School of Mines course covers classical mechanics only.

**PHYS 213 UNIVERSITY PHYSICS II**

(3-0) 3 credits. Prerequisites: PHYS 211. This course is the second course in a two semester calculus-level sequence, covering fundamental concepts of physics. This is the preferred sequence for students majoring in physical science or engineering. Topics include electricity and magnetism, sound, light, and optics. The School of Mines course covers electricity and magnetism only.

**PHYS 213L UNIVERSITY PHYSICS II LABORATORY**

(0-1) 1 credit. Pre- or Co-requisites: PHYS 213. This laboratory accompanies PHYS 213. Introduction to physical phenomena and measurements. Recording and processing data, determining uncertainties, reporting results. The experiments supplement the work in PHYS 211 and PHYS 213.

**PHYS 275 RELATIVITY**

(3-0) 3 credits. Prerequisites: PHYS 111 or PHYS 211 and a working knowledge of elementary algebra and trigonometry. Michelson-Morley experiment, inertial reference frames, the principle of relativity, space-time coordinates of an event, Lorentz Transformations, clock paradox, momentum-energy 4-vector, equivalence of energy and rest mass, the principle of equivalence, curved space-time and qualitative features of general relativity and cosmology, relevance of relativity to space travel.

**PHYS 291 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students

negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **PHYS 292 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **PHYS 312 EXPERIMENTAL PHYSICS DESIGN I**

### **PHYS 314 EXPERIMENTAL PHYSICS DESIGN II**

(0-2) 2 credits each. Prerequisites: CENG 244/244L or permission of instructor. This course is structured to acquaint the student with the experimental design methods. The experiments are chosen to cover as many areas as possible in keeping with the backgrounds of faculty and abilities of the students.

### **PHYS 341 THERMODYNAMICS**

(2-0) 2 credits. Prerequisites: PHYS 213 and MATH 225 or permission of instructor. This is an intermediate level thermodynamics course dealing with systems from a macroscopic perspective. Topics include the first and second laws of thermodynamics, phase diagrams, and equilibria.

### **PHYS 343 STATISTICAL PHYSICS**

(2-0) 2 credits. Prerequisites: PHYS 213 and MATH 225 or permission of instructor. This course provides a systematic introduction to the use of statistical principles applied to the study of thermodynamic systems.

### **PHYS 361 OPTICS**

(3-0) 3 credits. Prerequisites: PHYS 113 or PHYS 213 and MATH 225 or permission of instructor. This is an intermediate level study of geometrical and physical optics. Topics include analysis of refraction phenomena, thick lenses, wave nature of light, interference, diffraction, and polarization.

### **PHYS 386/386L OBSERVATIONAL ASTRONOMY**

(2-1)3 credits. Prerequisites: PHYS 183. This course is designed to help students expand their knowledge of astronomy through interactive seminars and observing sessions. The focus of this course will be developing observational and data collection skills using state of the art telescopes. Background knowledge will be fostered through instructor-supervised seminars led by the students. Students will use current web-based and advanced amateur/professional publications to lead the seminar sessions. Advanced observing sessions will be held off-campus at the Badlands Observatory in Quinn, SD. Observing sessions will incorporate advanced 18 and 26 inch telescopes provided by the instructors; also with CCD cameras and software for data collection and image manipulation. Observing sessions will also involve students in ongoing searches for near-earth asteroids.

### **PHYS 391 INDEPENDENT STUDY**

1 to 4 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **PHYS 392 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **PHYS 412 ADVANCED DESIGN PROJECTS I PHYS 414 ADVANCED DESIGN PROJECTS II**

(0-2) 2 credits each. The student designs and carries out original projects. The aim is to involve the student in project design and the application of

knowledge to a realistic problem. Students will be significantly engaged in the research efforts of the department.

### **PHYS 421/521 ELECTROMAGNETISM**

(4-0) 4 credits. Prerequisites: PHYS 213 and MATH 321. This is a course in the principles of electricity and magnetism, with applications to dielectric and magnetic materials. Topics include the development of Maxwell's equations, and applications. Students enrolled in PHYS 521 will be held to a higher standard than those enrolled in PHYS 421. This course is cross-listed with NANO 521.

### **PHYS 433/533 NUCLEAR AND ELEMENTARY PARTICLE PHYSICS**

(3-0) 3 credits. Prerequisites: PHYS 471 or permission of instructor. This course covers fundamental topics in nuclear physics and elementary particles. Topics include radioactivity, nuclear spectra and structure, nuclear models, elementary particle theories and high energy physics. Students enrolled in PHYS 533 will be held to a higher standard than those enrolled in PHYS 433.

### **PHYS 439/539 SOLID STATE PHYSICS**

(3-0) 3 credits. Prerequisites: MATH 321 or permission of instructor. This course looks at solid materials from a microscopic level. Topics include basic crystal structure; mechanical and thermal properties; and electronic processes with reference to electrical properties of metals, semiconductors, and insulators. Students enrolled in PHYS 539 will be held to a higher standard than those enrolled in PHYS 439.

### **PHYS 445/545 STATISTICAL MECHANICS**

(4-0) 4 credits. Prerequisites: PHYS 451 and MATH 321 or permission of instructor. This course provides a systematic introduction to the use of statistical principles applied to the study of thermodynamic systems. Student enrolled in PHYS 545 will be held to a higher standard than those enrolled in PHYS 445.

### **PHYS 451/551 CLASSICAL MECHANICS**

(4-0) 4 credits. Prerequisites: MATH 321. This is

a systematic introduction to classical mechanics emphasizing motion in three dimensions. Topics include central forces, harmonic oscillations, non-inertial reference frames, rigid body motion, and Lagrangian and Hamiltonian Mechanics.

Students enrolled in PHYS 551 will be held to a higher standard than those enrolled in PHYS 451. This course is cross-listed with NANO 551.

### **PHYS 471/571 QUANTUM MECHANICS**

(4-0) 4 credits. Prerequisites: MATH 321 or permission of instructor. This is a systematic introduction to quantum mechanics, emphasizing the Schrödinger equation. Topics include simple soluble problems, the hydrogen atom, approximation methods and other aspects of quantum theory. Students enrolled in PHYS 571 will be held to a higher standard than those enrolled in PHYS 471. This course is cross-listed with NANO 571.

### **PHYS 481/581 MATHEMATICAL PHYSICS I**

PHYS 481 (4-0) 4 credits. PHYS 581 (3-0) 3 credits. Prerequisites: Permission of instructor. The first of a two semester sequence covering mathematical methods essential to the study of Physics. The topics include differential and integral Vector Calculus, theory and applications of complex variables, ordinary differential equations and applications of series and transform methods in their solutions. Students enrolled in PHYS 581 will be held to a higher standard than those enrolled in PHYS 481.

### **PHYS 491 INDEPENDENT STUDY**

1 to 4 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **PHYS 492 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a

particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **PHYS 590 SEMINAR**

1 credit. A highly focused and topical course. The format includes student presentations and discussions of reports based on literature, practices, problems, and research. Seminars may be conducted over electronic media such as Internet and are at the upper division graduate levels.

### **PHYS 683 MATHEMATICAL PHYSICS II**

(3-0) 3 credits. Prerequisites: PHYS 581. A continuation of PHYS 581. The topics of emphasis are Partial differential equations, boundary value problems, special functions, Green's Functions, and linear algebra. Additional topics of interest will be chosen; possible topics include differential forms and geometry, tensors in physics, group theory, distributions, statistical methods, integral equations, difference equations, numerical methods, variation techniques etc.

### **PHYS 691 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

### **PHYS 692 TOPICS**

1 to 3 credits. Includes Current Topics, Advanced Topics, and Special Topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **PHYS 721 ELECTRODYNAMICS I**

(3-0) 3 credits. Prerequisites: PHYS 421 or equivalent. This is the first course of a two semester sequence in Electrodynamics. Topics in

the sequence include boundary value problems, Maxwell's equations, multi-pole expansions and gauge transformations. Additional topics will be chosen from such areas as the relativistic formulation of electro-magnetic theory, Lagrangian formulations of classical fields, plane and spherical waves, wave guides, multipole radiation, radiation from moving charges, plasma physics, magneto-hydrodynamics, relativistic (synchrotron) radiation, and radiation in collisions and other applications of interest. This course is cross-listed with NANO 721.

### **PHYS 723 ELECTRODYNAMICS II**

(3-0) 3 credits. Prerequisites: PHYS 721. This course is the second course in a two semester sequence and covers advanced topics in Electrodynamics.

### **PHYS 739 CONDENSED MATTER PHYSICS I**

(3-0) 3 credits. Prerequisites: PHYS 439 or equivalent. Topics include crystal structure and the reciprocal lattice, quantum theory of electrons and phonons, x-ray diffraction, crystal binding energies, and energy band theory. Additional topics may be chosen from the properties of metals, semiconductors, and insulators.

### **PHYS 743 STATISTICAL MECHANICS**

(3-0) 3 credits. Prerequisites: PHYS 443 (USD Course) or equivalent. This is a one semester course in classical and quantum statistical mechanics. Topics include ensembles, partition functions, identical particles, Fermi-Dirac and Bose-Einstein statistics. Other topics will be chosen from mean field theory, phase transformations, renormalization group theory, Monte Carlo techniques and other topics of interest. This course is cross-listed with NANO 743.

### **PHYS 749 CONDENSED MATTER PHYSICS II**

(3-0) 3 credits. Prerequisites: PHYS 739. This course is the second course in a two semester sequence and covers advanced topics in condensed matter physics.

**PHYS 751 THEORETICAL MECHANICS**  
(3-0) 3 credits. Prerequisites: PHYS 451 or equivalent. This is a one semester course in classical mechanics. Topics include Newtonian Mechanics, Hamilton's Principle, non-Inertial Frames of Reference, Lagrangian Mechanics. Other topics will be chosen from such areas of study as Rigid Body Motion, Chaos theory, Hamilton-Jacobi theory, Perturbation Theory, Quaternion applications to rotations, Lagrangian/Hamiltonian formulations for Continuous systems and fields, and other topics of interest. This course is cross-listed with NANO 751.

**PHYS 771 QUANTUM MECHANICS I**  
(3-0) 3 credits. Prerequisites: PHYS 471 or equivalent. This is the first course of a two semester sequence in quantum physics. Topics include the Schrodinger equation and its solutions, matrix mechanics, operator methods, the harmonic oscillator, the hydrogen atom, spin and angular momentum. NANO 771.

**PHYS 773 QUANTUM MECHANICS II**  
(3-0) 3 credits. Prerequisites: PHYS 771. This is the second course in a two semester sequence. Additional topics include perturbation methods. Applications will be chosen from such topics as scattering theory, second quantization, theory of identical particles, relativistic quantum mechanics, creation and annihilation operators and other topics of interest.

**PHYS 775 GENERAL RELATIVITY**  
(3-0) 3 credits. Prerequisites: PHYS 421, PHYS 451 or equivalent. This course includes study of Minkowski Space, tensor algebra and calculus, non-Euclidean Geometry, and the Einstein Field Equations. Applications will be chosen from such topics as the Schwarzschild, Kerr, and Reissner-Nordstrom solutions, gravitational waves, Post-Newtonian Formalisms, 3+1 formalism, and other topics of interest.

**PHYS 779 GROUP THEORY**  
(3-0) 3 credits. Prerequisites: PHYS 471 or equivalent. Topics may include symmetry transformations, continuous groups, finite groups,

applications to valence theory, Lorentz group, and fundamental particles

**PHYS 781 NUCLEAR AND PARTICLE PHYSICS**  
(3-0) 3 credits. Prerequisites: PHYS 771 or equivalent. This is a one-semester course in nuclear and elementary particle physics. Nuclear physics topics may include nuclear structure (nuclear form factors, multipole moments, liquid and shell models); nuclear decay; nuclear reactions; and other topics of interest. Elementary particle physics topics may include the role of symmetry in particle physics, Quantum Electrodynamics and Quantum Chromodynamics; the Standard Model of Particle Physics; Strong and Weak interactions; Accelerator and Experimental Particle Physics; and other selected topics beyond the Standard Model.

**PHYS 783 QUANTUM FIELD THEORY**  
(3-0) 3 credits. Prerequisites: PHYS 771 or equivalent. This course is the study of relativistic quantum field theory and its application to the standard model. The course covers quantization of relativistic fields; perturbative theory and Feynman diagram; S-matrix; introduction to gauge theories and the standard model; and other topics of interest.

**PHYS 785 ASTROPHYSICS AND COSMOLOGY**  
(3-0) 3 credits. Prerequisites: PHYS 771 or equivalent. This course introduces the broad base of fundamental topics in astrophysics and cosmology. Topics include observational properties of stars; stellar physics, stellar atmospheres; distance scales; galactic structures; interstellar medium, normal and peculiar galaxies and high energy astrophysics; cosmological observations and Friedmann models; the early universe at different epochs; the origin of dark matter and formation of galaxies and large scale structure.

**PHYS 791 INDEPENDENT STUDY**  
1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and

special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meetings depending upon the requirements of the topic.

### **PHYS 792 TOPICS**

1 to 3 credits. Includes Current Topics, Advanced Topics, and Special Topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors.

### **PHYS 798 THESIS**

(1- 9 credits) A formal treatise presenting the results of study submitted in partial fulfillment of the requirements for the applicable degree. The process requires extensive and intensive one-on-one interaction between the candidate and professor with more limited interaction between and among the candidate and other members of the committee.

### **POLS 100 AMERICAN GOVERNMENT**

(3-0) 3 credits. A study of the basic principles of the American system of government with emphasis on problems relating to governmental structure and policies.

### **POLS 250 WORLD POLITICS**

(3-0) 3 credits. A study of international relations including the sources of power and conflict, and the methods by which states compete and cooperate with each other. Additional international actors and contemporary issues will be addressed.

### **POLS 350 INTERNATIONAL RELATIONS**

(3-0) 3 credits. Prerequisites: Junior or senior standing or permission of instructor. How nations/states behave and why they behave as they do in their relations with each other.

### **POLS 407 ENVIRONMENTAL LAW AND POLICY**

(3-0) 3 credits. Prerequisites: Junior or senior standing or permission of instructor. An

examination of the political issues involved with environmental and ecological concerns such as land use, population, air and water pollution, energy, and public policy.

### **POLS 492 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in political science. Course content is not wholly included in the regular curriculum. A maximum of 6 credits will be allowed for degree credit.

### **PSYC 101 GENERAL PSYCHOLOGY**

(3-0) 3 credits. This course is an introductory survey of the field of psychology with consideration of the biological bases of behavior, sensory and perceptual processes, learning and memory, human growth and development, social behavior and normal and abnormal behavior.

### **PSYC 319 TEAMS AND TEAMING**

(1-0) 1 credit. The basic processes necessary for individuals to effectively work together are presented with an emphasis including values such as trust, the importance of conflict, interpersonal communications and dynamics of commitment.

### **PSYC 323 HUMAN DEVELOPMENT THROUGHOUT THE LIFESPAN**

(4-0) 4 credits. Prerequisites: PSYC 101 or permission of instructor. Focus will be upon physiological/biological, intellectual, emotional, social, and psychological development. Includes the normal sequence of development as well as developmental irregularities.

### **PSYC 331 INDUSTRIAL AND ORGANIZATION PSYCHOLOGY**

(3-0) 3 credits. Prerequisites: PSYC 101 and junior standing or permission of instructor. This course covers the application of psychological principles to such problems as employee selection, supervision, job satisfaction, and work efficiency.

### **PSYC 391 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems,

readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **PSYC 392 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. May be repeated twice with different topics for a maximum of 6 credits.

### **PSYC 451 PSYCHOLOGY OF ABNORMAL BEHAVIOR**

(3-0) 3 credits. Prerequisites: PSYC 101 or permission of instructor. This course is a comprehensive survey of abnormal personality and behavior. It includes an examination of the origin, symptoms and treatment of psychological disorders.

### **PSYC 461 THEORIES OF PERSONALITY**

(3-0) 3 credits. Prerequisites: PSYC 101 or permission of instructor. Students will learn about the role of philosophy and science and their contributions to the development of personality theory. Students will examine, in depth, the theoretical contributions made in the areas of psychoanalytic, behavioristic, and humanistic personality theories. The students will be able to articulate their own beliefs concerning the development of human personality.

### **SOC 100 INTRODUCTION TO SOCIOLOGY**

(3-0) 3 credits. Comprehensive study of society, with analysis of group life, and other forces shaping human behavior.

### **SOC 150 SOCIAL PROBLEMS**

(3-0) 3 credits. A study of present day problems in contemporary societies, such as racism, sexism, ageism, alcoholism, drug addiction, physical and

mental health, war and environmental issues-their significance and current policies and action.

### **SOC 250 COURTSHIP AND MARRIAGE**

(3-0) 3 credits. Courtship and marriage period given special emphasis, as are problems of mate selection, marital adjustments, reproduction, child-parent relations, divorce and later years of marriage.

### **SOC 351 CRIMINOLOGY**

(3-0) 3 credits. Prerequisites: SOC 100 or 150. Focuses on theories of crime, juvenile delinquency and justice, law, systems of criminal behavior, victimization, and corrections.

### **SOC 391 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

### **SOC 392 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as instructors. A maximum of 6 credits of special topics will be allowed for degree credit.

### **SOC 411 LICIT AND ILLICIT DRUGS**

(3-0) 3 credits. Prerequisites: SOC 100, SOC 150 or PSYC 101. A survey of the use, abuse, and addictive properties of psychoactive drugs other than alcohol; approaches to prevention, treatment, and identification of use. Will apply toward certification for chemical dependency counseling.

### **SOC 420 ALCOHOL USE AND ABUSE**

(3-0) 3 credits. Prerequisites: SOC 100, 150 or PSYC 101. A survey of the use, abuse, and addictive nature of beverage alcohol, some of the

problems associated with excessive use of alcohol, and approaches to prevention and treatment. Will apply toward certification for chemical dependency counseling.

#### **SOC 491 INDEPENDENT STUDY**

1 to 3 credits. Prerequisites: Permission of instructor. Includes directed study, problems, readings, directed readings, special problems and special projects. Students complete individualized plans of study which include significant one-on-one student-teacher involvement. The faculty member and students negotiate the details of the study plans. Meeting frequency depends on the requirements of the topic.

#### **SOC 492 TOPICS**

1 to 3 credits. Includes current topics, advanced topics and special topics. A course devoted to a particular issue in a specified field. Course content is not wholly included in the regular curriculum. Guest artists or experts may serve as

instructors. A maximum of 6 credits of special topics will be allowed for degree credit.

#### **SPAN 101 INTRODUCTORY SPANISH I SPAN 102 INTRODUCTORY SPANISH II**

(4-0) 4 credits each. Prerequisite for SPAN 102 is SPAN 101 or permission of instructor. Introduces the fundamental elements of Spanish sentence structure and vocabulary. Promotes speaking, listening and writing within a cultural context. Class work may be supplemented with required aural/oral practice outside of class.

#### **SPCM 101 FUNDAMENTALS OF SPEECH**

(3-0) 3 credits. Introduces the study of speech fundamentals and critical thinking through frequent public speaking practice, including setting, purpose, audience, and subject. This course cannot count as social science/humanities credit.

## **GOVERNANCE**

### **2011-12 ACADEMIC YEAR (As of July 2011)**

The South Dakota School of Mines and Technology is one of six universities operating under the authority assigned by the Constitution of the State of South Dakota to the nine member Board of Regents. The mission of the university is established by the Legislature of the State of South Dakota with programs and organization approved by the Board of Regents. The president is delegated to administer the operation of the university. The traditional collegial process of shared governance for the formation of policies and oversight includes representative organizations to provide recommendations to the president for implementation as appropriate.

### **Councils**

#### **Executive Council**

The Executive Council is the principal administrative unit at the university. The council members are the president, assistant to the president, provost and vice president for academic affairs, vice president for finance and administration, vice president for university relations, vice president for student affairs and dean of students, vice president for research, director of athletics, SDSM&T Foundation president, and director of the Alumni Association.

#### **University Cabinet**

The University Cabinet advises the president concerning the development of policy, the governance of the university, strategic planning, and the fiscal operation of the university. The University Cabinet consists of: the president, assistant to the president, provost and vice president for academic affairs, vice president for finance and administration, vice president for university relations, vice president for student affairs and dean of students, vice president for research, director of athletics, SDSM&T Foundation president, chair of the faculty senate, director of the Alumni Association, dean of graduate education, chair of the exempt employees council, chair of the career service council, president of the student association, and the director of facility services.

#### **Career Service Council**

The Career Service Act employees elect the Career Service Council members.

#### **Exempt Employees Council**

The Exempt Employees Advisory Council is elected by the administrative employees who are exempt from the Career Service Act of the state of South Dakota.

#### **Faculty Senate**

The Faculty Senate consists of nine voting members, two non-voting (ex-officio) members and is chaired by the chair of the Faculty Senate. The ex-officio members are the vice president for research and the provost and vice president for academic affairs. All faculty members may vote in the election of representatives from their discipline and each is eligible for election as a discipline representative.

#### **Student Association**

The Senate of the Student Association is the elected representative council for the formation of recommendations on behalf of enrolled students, including the fees charged to students and the operation of student activities funded through student fees.

### **Executive Council**

**WHARTON, ROBERT A.** (2008) President. B.A., M.A., Humboldt State University; Ph.D., Virginia Polytechnic Institute.

**HENDERSON, TIMOTHY G.** (1981) Vice President, Finance and Administration. B.S., University of South Dakota.

**HOFFART, HEATHER C.** (2010) Executive Assistant to the President. B.A., Arizona State University.

**HORN, CHRISTY A.** (2011) Vice President for University Relations. B.A., M.A., Ball State University.

**HRNCIR, DUANE C.** (2006) Provost/Vice President, Academic Affairs. B.S., University of Alabama; M.S., University of Massachusetts; Ph.D., Texas A&M University.

**KAISER, RICHARD** (2009) Director of Athletics. B.A., University of Northern Colorado; M.A., South Dakota State University; Ed.D., Brigham Young University.

**MAHON, PATRICIA G.** (2000) Vice President, Student Affairs and Dean of Students. B.S., M.S., Montana State University-Billings; Ph.D., Kansas State University.

**VACANT.** President, South Dakota School of Mines and Technology Foundation.

**VOTTERO, TIMOTHY J.** (1998) Director, Alumni Association. B.S., South Dakota School of Mines and Technology.

**WHITE, RONALD J.** (2009) Vice President, Research. B.S., University of Southwestern Louisiana; Ph.D., University of Wisconsin-Madison.

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## Directories

<http://sdmines.sdsmt.edu/sdsmt/directory>

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**Departments** <http://sdmines.sdsmt.edu/sdsmt/directory/department>

**Faculty** <http://sdmines.sdsmt.edu/sdsmt/directory/personnel/faculty>

**Personnel** <http://sdmines.sdsmt.edu/sdsmt/directory/personnel/all>

