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** *Credits: (3-0) 3*
- **ENGL 279 Technical Communications I** *Credits: (3-0) 3*
- **ENGL 289 Technical Communications II** *Credits: (3-0) 3*
- **OR**
- **ENGL 101 Composition I** *Credits: (3-0) 3*
- **ENGL 201 Composition II** *Credits: (3-0) 3*
- **SPCM 101 Fundamentals of Speech** *Credits: (3-0) 3*

**Note(s):**
Students who intend to continue at or return to Mines for a B.S. degree should take the first sequence—ENGL 101, ENGL 279, ENGL 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. Courses offered at Mines include the following:

- ART 111/111A Drawing | Credits: (3-0) 3
- ART 112/112A Drawing II | Credits: (3-0) 3
- ARTH 211 History of World Art | Credits: (3-0) 3
- ENGL 210 Introduction to Literature | Credits: (3-0) 3
- ENGL 212 World Literature II | Credits: (3-0) 3
- ENGL 221 British Literature | Credits: (3-0) 3
- ENGL 222 British Literature II | Credits: (3-0) 3
- ENGL 241 American Literature I | Credits: (3-0) 3
- ENGL 242 American Literature II | Credits: (3-0) 3
- ENGL 250 Science Fiction | Credits: (3-0) 3
- GER 101 Introductory German I | Credits: (4-0) 4 AND GER 102 Introductory German II | Credits: (4-0) 4
- HIST 121 Western Civilization I | Credits: (3-0) 3
- HIST 122 Western Civilization II | Credits: (3-0) 3
- HUM 100 Introduction to Humanities | Credits: (3-0) 3
- HUM 200 Connections: Humanities & Technology | Credits: (3-0) 3
- MUS 100 Music Appreciation | Credits: (3-0) 3
- PHIL 100 Introduction to Philosophy | Credits: (3-0) 3
- PHIL 200 Introduction to Logic | Credits: (3-0) 3
- PHIL 220 Introduction to Ethics | Credits: (3-0) 3
- PHIL 233 Philosophy and Literature | Credits: (3-0) 3
- SPAN 101 Introductory Spanish I | Credits: (4-0) 4 AND SPAN 102 Introductory Spanish II | Credits: (4-0) 4

Note(s):

ART and ARTH are considered the same prefix.

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. Courses offered at Mines include the following:

- ANTH 210 Cultural Anthropology | Credits: (3-0) 3
- GEOG 101 Introduction to Geography Credits: (3-0) 3
- GEOG 200 Introduction to Human Geography Credits: (3-0) 3
- GEOG 210 World Regional Geography Credits: (3-0) 3
- GEOG 212 Geography of North America Credits: (3-0) 3
- HIST 151 United States History I Credits: (3-0) 3
- HIST 152 United States History II Credits: (3-0) 3
- POLS 100 American Government Credits: (3-0) 3
- POLS 250 World Politics Credits: (3-0) 3
- PSYC 101 General Psychology Credits: (3-0) 3
- SOC 100 Introduction to Sociology Credits: (3-0) 3
- SOC 150 Social Problems Credits: (3-0) 3
- SOC 250 Courtship and Marriage Credits: (3-0) 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 Credits: (3-0) 3

E. Natural Sciences

A minimum of 6 semester hours in the natural sciences is required including one semester hour of laboratory. Courses in biology, chemistry, earth science, geology, and physics may be used. The following courses are offered at Mines:

- BIOL 151 General Biology I Credits: (3-0) 3 AND
  BIOL 151L General Biology I Lab Credits: (0-1) 1

- BIOL 153 General Biology II Credits: (3-0) 3 AND
  BIOL 153L General Biology II Lab Credits: (0-1) 1

- CHEM 106 Chemistry Survey Credits: (3-0) 3 AND
  CHEM 106L Chemistry Survey Lab Credits: (0-1) 1

- CHEM 108 Organic and Biochemistry Credits: (4-0) 4 AND
  CHEM 108L Organic and Biochemistry Lab Credits: (0-1) 1

- CHEM 112 General Chemistry I Credits: (3-0) 3 AND
  CHEM 112L General Chemistry I Lab Credits: (0-1) 1

- CHEM 114 General Chemistry II Credits: (3-0) 3 AND
  CHEM 114L General Chemistry II Lab Credits: (0-1) 1

- GEOL 201 Physical Geology Credits: (3-0) 3 AND
  GEOL 201L Physical Geology Laboratory Credits: (0-1) 1

- PHYS 111 Introduction to Physics I Credits: (3-0) 3 AND
  PHYS 111L Introduction to Physics I Laboratory Credits: (0-1) 1

- PHYS 113 Introduction to Physics II Credits: (3-0) 3 AND
  PHYS 113L Introduction to Physics II Laboratory Credits: (0-1) 1

- PHYS 211/211-A University Physics I/Recitation Credits: (3-0) 3
Electives

Total semester hours required to graduate is 60. 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 45 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 15 credits from School of Mines. In addition, 8 of the last 15 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.

Contact Information

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Faculty

Professors Bang, Boyles, Fong, and Sinden; Associate Professors DeVeaux, Heglund, Sani, and Zhu; Assistant Professors Kunza and Smirnova; Senior Lecturer Meyer; Lecturers Filipova and Coble; Instructors Christofferson, K. Gilcrease, and Marshall.

Staff

Department Senior Secretary, Tara Huber; Chemical and Instrumentation Specialist, Margaret Smallbrook.

Applied Biological Sciences

The Department of Chemistry and Applied Biological Sciences offers a Bachelor of Science in Applied Biological Sciences.

Applied Biological Sciences (ABS) graduates are rigorously trained in the biological sciences, with a strong background in the foundation areas of biology, chemistry, mathematics, and physics. The Department of Chemistry and Applied Biological Sciences offers both fundamental and advanced courses in biology and chemistry. In the area of biology, course offerings include anatomy, physiology, microbiology, genetics, biochemistry, microbial genetics, cell and molecular biology, pathogenesis, and industrial microbiology. The Bachelor of Science in Applied Biological Sciences requires 120 semester credits.

The department prepares students for meaningful and productive careers in one of the diverse areas within the biological sciences, including medicine, microbial and molecular biology, biomedical sciences, biotechnology, or biomedical engineering. The ABS major has a wide range of options to uniquely prepare graduates for these cross-disciplinary and technology-oriented professional career paths. Students can select courses
from an extensive list of electives to suit their particular interests and career aspirations.

- Students wishing to pursue careers or graduate study in medicine, pharmaceutical science, biomedical technology, medical and patent law, academic research can choose a premedical or molecular emphasis, rich in courses in microbiology and cell and molecular biology.
- Students wishing to prepare for graduate study in biomedical engineering or pursue career fields such as bioprocessing or bioenergy can choose a biomedical engineering emphasis, which provides an opportunity to meld biology with world-class engineering courses available at SDSM&T. This emphasis involves academic preparation in various engineering disciplines, including civil, materials and metallurgical, or mechanical engineering.
- ABS graduates will also be well-positioned, with further certification, to fill the demand for highly-trained middle and high school science teachers.

Our department develops in its students a requisite fundamental knowledge base in both biology and chemistry. We then integrate these basics into an understanding of, and appreciation for, the applied biological sciences leading to the ABS BS. This is accomplished through our traditional course offerings and optional hands-on research experience in individual faculty labs, preparing students for graduate study or the workplace. The Department of Chemistry and Applied Biological Sciences prides itself in the 2011 opening of a new wing which houses state-of-the-art laboratory facilities and instrumentation available for cutting-edge research. Students find opportunities to work with faculty who hold high caliber, peer-reviewed, externally funded research grants awarded by federal agencies, including the Air Force Research Laboratory, Office of Naval Research, Army Research Office, United States Department of Agriculture, the National Science Foundation, National Institutes of Health, and other agencies. This affords the student opportunities to conduct independent research and present their research at local or national meetings.

For students interested in graduate studies, the faculty of the Department of Chemistry and Applied Biological Sciences participate in several SDSM&T graduate programs including the M.S. and Ph.D. in Materials Engineering and Science and Ph.D. in Nanoscience and Nanotechnology. Students opting for a graduate degree in these disciplines have the opportunity to perform cutting-edge research with a dissertation in fundamental, depth areas of chemistry while augmenting their chemistry background with coursework specific to their respective graduate program in which they are enrolled.

The program also offers a Minor in Applied Biological Sciences.

Applied Biological Sciences Curriculum/Checklist

The following curriculum shows one embodiment of a path toward the ABS degree. The sequence of courses taken will depend on the academic preparation and career objectives of incoming students. Students should consult with an Applied Biological Sciences advisor for a more personalized course of study based on career goals within the applied biological sciences. It is important to note that certain courses have prerequisite requirements. Judicious selection of electives from the approved list will allow students specialized training in an applied biological sciences area, including microbiology, molecular biology, molecular genetics, pre-professional studies, or biomedical engineering.

**Freshman Year**

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**First Semester**

- **BIOL 111 Introduction to Chemistry and Applied Biological Sciences** Credits: (1-0) 1
- **BIOL 151 General Biology I** Credits: (3-0) 3
- **BIOL 151L General Biology I Lab** Credits: (0-1) 1
- **CHEM 112 General Chemistry I** Credits: (3-0) 3
- **CHEM 112L General Chemistry I Lab** Credits: (0-1) 1
- **ENGL 101 Composition I** Credits: (3-0) 3
- **MATH 123 Calculus I** Credits: (4-0) 4

**Total: 16**

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**Second Semester**

- **BIOL 153 General Biology II** Credits: (3-0) 3
- **BIOL 153L General Biology II Lab** Credits: (0-1) 1
- **CHEM 114 General Chemistry II** Credits: (3-0) 3
- **CHEM 114L General Chemistry II Lab** Credits: (0-1) 1
- **MATH 125 Calculus II** Credits: (4-0) 4
- General Education Goal 3 or 4 Elective(s) Credits: 3

Total: 15

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**Sophomore Year**

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**First Semester**

- **CHEM 326 Organic Chemistry I** Credits: (3-0) 3
- **CHEM 326L Organic Chemistry I Lab** Credits: (0-2) 2
- **PHYS 111 Introduction to Physics I** Credits: (3-0) 3
- OR
- **PHYS 211/211-A University Physics I/Recitation** Credits: (3-0) 3
- **PHYS 111L Introduction to Physics I Laboratory** Credits: (0-1) 1
- General Education Goal 3 or 4 Elective(s) Credits: 3
- General Education Goal 3 or 4 Elective(s) Credits: 3
- OR
- ABS Program Elective Credits: 3

Total: 14

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**Second Semester**

- **CHEM 328 Organic Chemistry II** Credits: (3-0) 3
- **CHEM 328L Organic Chemistry II Lab** Credits: (0-2) 2
- **ENGL 279 Technical Communications I** Credits: (3-0) 3
- **PHYS 113 Introduction to Physics II** Credits: (3-0) 3
- OR
- **PHYS 213/213-A University Physics II/Recitation** Credits: (3-0) 3
- **PHYS 213L University Physics II Laboratory** Credits: (0-1) 1
- General Education Goal 3 or 4 Elective(s) Credits: 3
- OR
- ABS Program Elective Credits: 3

Total: 15

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**Junior Year**
First Semester

- **BME 408/508 Biomedical Engineering** Credits: (3-0) 3
- **BIOL 331 Microbiology** Credits: (3-0) 3
- **BIOL 331L Microbiology Lab** Credits: (0-1) 1
- **ENGL 289 Technical Communications II** Credits: (3-0) 3
- ABS Program Elective Credits: 3
- Free Elective Credits: 3

Total: 16

Second Semester

- **BIOL 371 Genetics** Credits: (3-0) 3
- **BIOL 371L Genetics Lab** Credits: (0-1) 1
- **MATH 321 Differential Equations** Credits: (3-0) 3
- OR
- **MATH 381 Introduction to Probability and Statistics** Credits: (3-0) 3
- ABS Program Elective Credits: 3
- Free Elective Credits: 3

Total: 13

Senior Year

First Semester

- **BIOL 480/580 Bioinformatics** Credits: (3-0) 3
- **CHEM 464/564 Biochemistry I** Credits: (3-0) 3
- **CHEM 464L Biochemistry I Lab** Credits: (0-1) 1
- Free Elective Credits: 3
- **BIOL 498 Undergraduate Research/Scholarship** Credits: 1 to 12
- OR
- ABS Program Elective Credits: 3

Total: 16

Second Semester
- CHEM 465/565 Biochemistry II Credits: (3-0) 3
- CHEM 465L Biochemistry Laboratory II Credits: (0-1) 1
- ABS Program Elective Credits: 3
- ABS Program Elective Credits: 3
- Free Elective Credits: 3
- BIOL 498 Undergraduate Research/Scholarship Credits: 1 to 12
- OR
- Approved Major Elective Credits: 2

Total: 15

120 credits required for graduation

ABS Program Electives

- AES 403/503 Biogeochemistry Credits: (3-0) 3
- BIOL 221 Human Anatomy Credits: (3-0) 3
- BIOL 221L Human Anatomy Lab Credits: (0-1) 1
- BIOL 311 Principles of Ecology Credits: (3-0) 3
- BIOL 326 Biomedical Physiology Credits: (3-0) 3
- BIOL 326L Biomedical Physiology Lab Credits: (0-1) 1
- BIOL 383 Bioethics Credits: (3-0) 3
- BIOL 406/506 Global Environmental Change Credits: (3-0) 3
- BIOL 423 Pathogenesis Credits: (3-0) 3
- BIOL 423L Pathogenesis Lab Credits: (0-1) 1
- BIOL 431 Industrial Microbiology Credits: (3-0) 3
- BIOL 444 DNA Structure and Function Credits: (3-0) 3
- BIOL 446 Molecular Cell Biology Credits: (3-0) 3
- BIOL 478/578 Microbial Genetics Credits: (3-0) 3
- BIOL 491 Independent Study Credits: 1 to 4
- BIOL 492 Topics Credits: 1 to 5
- BIOL 498 Undergraduate Research/Scholarship Credits: 1 to 12
- CHEM 252 Systematic Inorganic Chemistry Credits: (3-0) 3
- CHEM 332 Analytical Chemistry Credits: (3-0) 3
- CHEM 332L Analytical Chemistry Lab Credits: (0-1) 1
- CHEM 342 Physical Chemistry I Credits: 2 to 3
- CHEM 342L Physical Chemistry I Lab Credits: (0-1) 1
- CHEM 344 Physical Chemistry II Credits: 2 to 3
- CHEM 344L Physical Chemistry II Lab Credits: (0-1) 1
- CHEM 420/520 Organic Chemistry III Credits: (3-0) 3
- CHEM 421/521 Spectroscopic Analysis Credits: (3-0) 3
- CHEM 426/526 Polymer Chemistry Credits: (3-0) 3
- CHEM 434 Instrumental Analysis Credits: (3-0) 3
- CHEM 434L Instrumental Analysis Lab Credits: (0-2) 2
- CHEM 452/552 Inorganic Chemistry Credits: (3-0) 3
- CHEM 452L/552L Inorganic Chemistry Lab Credits: (0-1) 1
- CHEM 482/582 Environmental Chemistry Credits: (3-0) 3
- EM 215 Statics and Dynamics Credits: 4
- IENG 321/321L Ergonomics/Human Factors Engineering/Lab Credits: (2-1) 3
- IENG 431/531 Industrial Hygiene Credits: (3-0) 3
- MATH 225 Calculus III Credits: (4-0) 4
• MATH 321 Differential Equations Credits: (3-0) 3
• MATH 381 Introduction to Probability and Statistics Credits: (3-0) 3
• ME 211 Introduction to Thermodynamics Credits: (3-0) 3
• ME 216 Introduction to Solid Mechanics Credits: (3-0) 3
• ME 316 Solid Mechanics Credits: (3-0) 3
• ME 331 Thermo Fluid Dynamics Credits: (3-0) 3
• MET 320 Metallurgical Thermodynamics Credits: (4-0) 4
• MET 422 Transport Phenomena Credits: (4-0) 4
• NANO 401 Introduction to Nanoscience Credits: (3-0) 3

Curriculum Notes

The following shows the basic course requirements for the ABS B.S. Advisors will work with individual students to tailor an individualized curriculum based on their areas of interest and academic preparedness.

General Education Requirements: 21 credits of General Education Requirements as determined by the SD Board of Regents.

Math Requirement: 11 credits (MATH 123, 125, and 321 or 381)

Physics Requirement: 7 credits (100 or 200 level PHYS courses)


Biology Requirement: 26 credits (BIOL 110, 151, 151L, 153, 153L, 331, 331L, 371, 371L, 343, 480)

ABS Program Electives: 13 credits

Free Electives: 13 credits

Total 120 credits required for the ABS B.S.
Applied and Computational Mathematics B.S.

Contact Information

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Faculty

Professors Braman, Corwin, Johnson, Logar, McGough, and Teets; Associate Professors Kowalski and Riley; Assistant Professors Caudle, Dahl, Deschamp, Fleming and Garlick-Grieve; Instructors Bienert, Grieve, Leonard, and Richard; Emeritus Professors Carda, Grimm and Opp.

Applied and Computational Mathematics Major

Students majoring in mathematics will use the accompanying applied and computational mathematics curriculum. The curriculum includes 55 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 selecting courses from: MATH 353, MATH 381, MATH 382, MATH 447/547, 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 15 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.

**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.

**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.sdsmt.edu/MCS](http://www.sdsmt.edu/MCS).

**Freshman Year**

**First Semester**

- **ENGL 101 Composition** | Credits: (3-0) 3
- **MATH 110 Survey of Computer Science and Mathematics** | Credits: (1-0) 1
- **MATH 123 Calculus** | Credits: (4-0) 4
- **CSC 150/150L Computer Science I/Lab** | Credits: (2-1) 3
Second Semester

- MATH 125 Calculus II Credits: (4-0) 4
- Science Elective/Science Lab Credits: 4
- CSC 250 Computer Science II Credits: (4-0) 4
- Humanities/Social Science Elective(s) Credits: 3

Total: 15

Sophomore Year

First Semester

- ENGL 279 Technical Communications I Credits: (3-0) 3
- MATH 225 Calculus III Credits: (4-0) 4
- MATH 321 Differential Equations Credits: (3-0) 3
- PHYS 211/211-A University Physics I/Recitation Credits: (3-0) 3
- Humanities/Social Science Elective(s) Credits: 3

Total: 16

Second Semester

- MATH 315 Linear Algebra Credits: (3-0) 3
- CSC 251 Finite Structures Credits: (4-0) 4
- ENGL 289 Technical Communications II Credits: (3-0) 3
- PHYS 213/213-A University Physics II/Recitation Credits: (3-0) 3
- Humanities/Social Science Elective(s) Credits: 3

Total: 16

Junior Year
First Semester

- **MATH 413 Abstract Algebra I** Credits: (3-0) 3
- **MATH 381 Introduction to Probability and Statistics** Credits: (3-0) 3
- **MATH 452/552 Advanced Studies in Mathematics** Credits: (3-0) 3
- **MATH 373 Introduction to Numerical Analysis** Credits: (3-0) 3
- **3** Elective/Emphasis Credits: 3

Total: 15

Second Semester

- **MATH 382 Probability Theory and Statistics II** Credits: (3-0) 3
- **MATH 443/543 Data Analysis** Credits: (3-0) 3
- **MATH 421 Complex Analysis** Credits: (3-0) 3
- **3** Elective/Emphasis Credits: 6

Total: 15

Senior Year

First Semester

- **MATH 423 Advanced Calculus I** Credits: (4-0) 4
- **MATH 432 Partial Differential Equations** Credits: (3-0) 3
- **MATH 498 Undergraduate Research/Scholarship** Credits: (1-0) 1
- **3** Elective/Emphasis Credits: 5
- **4**PE Physical Education Credits: 1

Total: 14

Second Semester

- **MATH 424 Advanced Calculus II** Credits: (4-0) 4
- **MATH 451/551 Math Modeling** Credits: (3-0) 3
- **MATH 402 Communicating Mathematics** Credits: (1-0) 1
- **3** Elective/Emphasis Credits: 5
- **4**PE Physical Education Credits: 1
120 credits required for graduation

Curriculum Notes

1 The science requirement for this major consists of PHYS 211/211-A, PHYS 213/213-A, 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.

2 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 15 semester hours of electives in humanities and social sciences. At least three credits of humanities/social sciences must be at the 300 level or above.

3 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.

4 MUEN 101, MUEN 121, MUEN 122 can be used to substitute for one or two of the required two physical education credits.

5 CHEM 106, CHEM 108, CSC 105, MATH 021, MATH 101, MATH 102, MATH 120, PHYS 111, and PHYS 113 may not be counted towards the degree in Applied and Computational Mathematics.
Contact Information

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Faculty

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Director and Emeritus Faculty

Professor and Composites and Polymer Engineering Laboratory Director Salem and Emeritus Professors Bauer and Munro.

Staff

Chemical and Biological Engineering Administrative Assistant, Lila Baskerville. Chemical and Biological Engineering Program Assistant, Lori Litzen. 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. With emphasis in advanced materials, biochemical engineering, energy technology, environmental engineering, and petroleum engineering you can personalize your education. An accelerated Master of Science (B.S. + M.S.) degree program is also available for qualified undergraduate students.

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 responsible and economical.

Examples of such processes include:

- Alternative and renewable energy
- 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, leadership skills, 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 energy industries, state and federal government and academia. Recent graduates from SDSM&T have gone to work in ChE positions at companies like ADM, Baker Hughes, Dakota Gasification, Dow Chemical, Dow Corning, Cargill, Caterpillar, Freeport-McMoRan Copper and Gold, Halliburton, Lafarge, Lyondell-Basell, 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) and pull down Events & Resources/Career/Career FAQ's then click on “What exactly does a chemical engineer do?” and 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.

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 graduates 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 SDSM&T 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.
   a. Students will demonstrate their ability to solve technical problems through the application of engineering principles.
   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
   a. Students will be able to articulate the concept of critical thinking and practice it at a beginner’s level.
   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.
   a. Students will be able to write memoranda and reports that effectively communicate technical information to technical and non-technical audiences.
   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.
   a. Students will be able to work effectively with others.
   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.
   a. Students will be able to solve complex problems by formulating and solving numerical solutions.
   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.
   a. Students will have positive experiences of learning material on their own.
   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://www.sdsmt.edu/CBE/](http://www.sdsmt.edu/CBE/) 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, leadership skills and communication skills.

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

The chemical engineering faculty at 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 these developments have and continue to come 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 into the curriculum sophisticated process software. In addition, 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** | Credits: (4-0) 4
- **CHEM 112 General Chemistry I** | Credits: (3-0) 3
- **CHEM 112L General Chemistry I Lab** Credits: (0-1) 1
- **CHEM 111/111L Introduction to Chemical Process Modeling/Lab** Credits: (1-1) 2
- **ENGL 101 Composition I** | Credits: (3-0) 3
- Humanities or Social Sciences Elective(s) | Credits: 3

Total: 16

**Second Semester**

- **MATH 125 Calculus II** Credits: (4-0) 4
- **CHEM 114 General Chemistry II** Credits: (3-0) 3
- **CHEM 114L General Chemistry II Lab** Credits: (0-1) 1
- **PHYS 211/211-A University Physics I/Recitation** Credits: (3-0) 3
- **CBE 117L Programming for Chemical and Biological Engineering** Credits: (0-1) 1
- Humanities or Social Sciences Elective(s) | Credits: 6

Total: 18
Sophomore Year

First Semester

- CBE 217 Chemical Engineering Material Balances Credits: (3-0) 3
- MATH 321 Differential Equations Credits: (3-0) 3
- Biology Elective Credits: 3
- CHEM 326 Organic Chemistry I Credits: (3-0) 3
- CHEM 220L Experimental Organic Chemistry IA Credits: (0-1) 1
- PHYS 213/213-A University Physics II/Recitation Credits: (3-0) 3

Total: 16

Second Semester

- CBE 218 Chemical Engineering Fluid Mechanics Credits: (3-0) 3
- CBE 222 Chemical Engineering Process Thermodynamics Credits: (3-0) 3
- CBE 250 Computer Applications in Chemical Engineering Credits: (2-0) 2
- CHEM 328 Organic Chemistry II Credits: (3-0) 3
- MATH 225 Calculus III Credits: (4-0) 4
- ENGL 279 Technical Communications I Credits: (3-0) 3

Total: 18

Junior Year

First Semester

- CBE 317 Chemical Engineering Heat Transfer Credits: (3-0) 3
- CBE 321 Chemical Engineering Equilibrium Thermodynamics Credits: (3-0) 3
- CBE 333 Process Measurements and Control Credits: (1-0) 1
- CBE 333L Chemical Engineering Process Control Lab Credits: (0-1) 1
- CBE 361L Chemical Engineering Fluid Laboratory Credits: (0-1) 1
- CHEM 230 Analytical Chemistry for Engineers Credits: (2-0) 2
- CHEM 332L Analytical Chemistry Lab Credits: (0-1) 1
- CHEM 342 Physical Chemistry I Credits: 2 to 3 (ChE’s take 2 credit hours)
- ENGL 289 Technical Communications II Credits: (3-0) 3

Total: 17
Second Semester

- CBE 318 Chemical Engineering Mass Transfer Credits: (3-0) 3
- CBE 343 Chemical Kinetics and Reactor Design Credits: (3-0) 3
- CBE 362L Chemical Engineering Heat Transfer Laboratory Credits: (0-1) 1
- CBE 364 Chemical Process Design, Economics, and Safety Credits: (0-2) 2
- CHEM 344 Physical Chemistry II Credits: 2 to 3 (ChE’s take 2 credit hours)
- CHEM 344L Physical Chemistry II Lab Credits: (0-1) 1
- Engineering Elective Credits: 3
- Humanities or Social Sciences Elective Credits: 3

Total: 18

Senior Year

First Semester

- CBE 417 Chemical Engineering Equilibrium Separations Credits: (2-0) 2
- CBE 463 Process Design for Chemical Engineering Credits: (0-2) 2
- CBE 465 Advanced Process and Equipment Design Credits: (0-2) 2
- Chemical Engineering Elective Credits: 3
- Department Approved Elective Credits: 3

Total: 12

Second Semester

- CBE 433 Process Control Credits: (3-0) 3
- CBE 461L Chemical Engineering Mass Transfer and Reaction Engineering Laboratory Credits: (0-1) 1
- CBE 466 Capstone Design for Chemical Engineering Credits: (0-2) 2
- CBE 487 Global and Contemporary Issues in Chemical Engineering Credits: 1-0) 1
- Chemical Engineering Elective Credits: 3
- Chemical Engineering Lab Elective Credits: 1
- Department Approved Elective Credits: 4

Total: 15

130 credits required for graduation
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.

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: advanced materials (nano materials, polymers, ceramics, materials processing, corrosion, or solid state/semi-conductors), biochemical engineering, energy technology, environmental engineering, or petroleum engineering.

BIOL Elective (3 cr hr):

Select from

- BIOL 341 Microbial Processes in Engineering and Natural Sciences Credits: (3-0) 3 (preferred)
- BIOL 371 Genetics Credits: (3-0) 3 OR
- Other approved by advisor.

CHE Elective (6 cr hr):

Select 6 credits from

- CBE 424/524 Molecular Modeling and Simulation Credits: (3-0) 3
- CBE 434 Design of Separation Processes Credits: (1-0) 1
- CBE 434L Design of Separation Processes Laboratory Credits: (0-1) 1
- CBE 444/444 Reactor Design Credits: (3-0) 3
- CBE 444/445 Oxidation and Corrosion of Metals Credits: (3-0) 3
- CBE 450/450 Systems Analysis Applied to Chemical Engineering Credits: 2 to 3
- CBE 455/455 Pollution Phenomena and Process Design Credits: (3-0) 3
- CBE 474/474 Polymer Technology Credits: 2 to 3
- CBE 474L/474L Experimental Polymer Technology Credits: (0-1) 1
- CBE 475/475 Advances in Processing and Nanoengineering of Polymers Credits: (2-0) 2
- CBE 476/476 Organosilicon Polymer Chemistry and Technology Credits: (1-0) 1
- CBE 484/484 Fundamentals of Biochemical Engineering Credits: (3-0) 3
- CBE 484L/484L Biochemical Engineering Laboratory Credits: (0-1) 1
- CBE 485/485 Renewable and Sustainable Energy Credits: (3-0) 3
- CBE 485L/485L Renewable and Sustainable Energy Lab Credits: (0-1) 1
- CBE 488/488 Applied Design of Experiments for the Chemical Industry Credits: (2-0) 2
- CBE 489/489 Composites Manufacturing Credits: (1-0) 1
- CBE 491 Independent Study Credits: 1 to 3
- CBE 492 Topics Credits: 1 to 3
- CBE 498 Undergraduate Research/Scholarship Credits: Credit to be arranged. OR
- Others approved by advisor.
CHE Lab Elective (1 cr hr):

Select 1 credit from

- CBE 434L Design of Separation Processes Laboratory Credits: (0-1) 1
- CBE 474L/574L Experimental Polymer Technology Credits: (0-1) 1
- CBE 484L/584L Biochemical Engineering Laboratory Credits: (0-1) 1
- CBE 485L/585L Renewable and Sustainable Energy Lab Credits: (0-1) 1
- CBE 498 Undergraduate Research/Scholarship Credits: Credit to be arranged. 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 (7 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:

- CP 297/397/497 Cooperative Education Credits: 1 to 3
- Up to three (3) credits of advanced military science Credits: 1 to 3
- Up to six (6) credits of cooperative education Credits: 1 to 6
- Up to three (3) credits 300 level or above Humanities, Social Science or Business Credits: 1 to 3
- and
- Physical Education (PE) or Music Ensemble (MUEN) Credits: 1

Contact Information
Dr. Richard Sinden (Department Head)
Department of Chemistry and Applied Biological Sciences
Chemistry/Chemical Engineering 2219
(605) 394-1678
E-mail: Richard.Sinden@sdsmt.edu

Faculty
Professor Bang, Boyles, Fong, and Sinden; Associate Professors DeVeaux, Heglund, Sani, and Zhu; Assistant Professors Kunza and Smirnova; Senior Lecturer Meyer; Lecturers Coble and Filipova; Instructors Christofferson, K. Gilgrease, and Marshall.

Staff
Department of Chemistry and Applied Biological Sciences Senior Secretary, Tara Huber; Chemical and Instrumentation Specialist, Margaret Smallbrock.

Chemistry
The Department of Chemistry and Applied Biological Sciences offers a Bachelor of Science in Chemistry.

The Bachelor of Science in Chemistry degree fulfills the recommendations of the Committee on Professional Training of the American Chemical Society (ACS), the world’s largest scientific society. Graduates with the Bachelor of Science in Chemistry are certified by ACS as having completed coursework recommended by ACS. The coursework within the department offers a broad-based and rigorous education which emphasizes a molecular approach to chemical phenomena, an approach central to the heart of any chemical field. The department offers foundation and in-depth coursework in the five major sub-disciplines of Chemistry: Analytical, Biochemistry, Inorganic, Organic, and Physical Chemistry. The Bachelor of Science in Chemistry degree requires 120 semester credits.

The department prepares students for careers in the chemical sciences by affording the intellectual, technical, and communications opportunities conducive to the development of future generations of scientists. The Department of Chemistry and Applied Biological Sciences prides itself in the 2011 opening of a new wing which houses state-of-the-art laboratory facilities and instrumentation available for cutting edge research. Students find opportunities to work with faculty who hold high caliber, peer-reviewed, externally-funded research grants awarded by federal agencies including the Air Force Research Laboratory, Office of Naval Research, Army Research Office, United States Department of Agriculture, the National Science Foundation, and many other agencies. This affords students opportunities to present their research at local or national biannual meetings of the American Chemical Society.

For students interested in graduate studies, the faculty of the Department of Chemistry and Applied Biological Sciences participate in several SDSM&T graduate programs including the M.S. and Ph.D. in Biomedical Engineering, M.S. and Ph.D. in Chemical and Biological Engineering, M.S. and Ph.D. Materials Engineering and Science, and Ph.D. in Nanoscience and Nanoengineering. Students opting for a graduate degree in these disciplines have the opportunity to perform cutting-edge research with a dissertation in fundamental and in-depth areas of chemistry while augmenting their chemistry background with coursework specific to their respective graduate program of enrollment.

As chemistry is pervasive in the economy of the United States, graduates of the department find diverse employment opportunities in government, private, and academic sectors, and are highly sought after by employers. Additionally, the Bachelor of Science in Chemistry degree is an excellent choice as a pre-professional degree option for those students seeking further study in medicine, dentistry, pharmacy, veterinary medicine, materials science, environmental science, patent or environmental law, and education.

Advisors work closely with their assigned students in order to ensure each student completes all degree requirements in a timely manner, meets prerequisites for further education (such as medical or other professional schools), and is knowledgeable about post-graduation options and employment opportunities.

The department also offers a minor in chemistry to SDSM&T students.

Chemistry Curriculum/Checklist
The following shows the preferred curriculum for the Chemistry B.S. degree. The sequence of courses taken will depend on the academic preparation of incoming students. Students should consult with a Chemistry advisor for their individualized course of study. It is important to note that certain courses have prerequisite requirements. Moreover, as certain courses are taught every two years, curricula are shown for the junior and senior years for both even and odd year cycles.

Freshman Year
First Semester

- **CHEM 112 General Chemistry I** Credits: (3-0) 3
- **CHEM 112L General Chemistry I Lab** Credits: (0-1) 1
- **ENGL 101 Composition I** Credits: (3-0) 3
- **MATH 123 Calculus I** Credits: (4-0) 4
- **General Education Goal 3 or 4 Elective(s)** Credits: 3
- **CHEM 111 Introduction to Chemistry and Applied Biological Sciences** Credits: (1-0) 1
- **CHEM 290 Seminar** Credits: (0.5-0) 0.5

Total: 16.5

Second Semester

- **CHEM 114 General Chemistry II** Credits: (3-0) 3
- **CHEM 114L General Chemistry II Lab** Credits: (0-1) 1
- **MATH 125 Calculus II** Credits: (4-0) 4
- **PHYS 211/211-A University Physics I/Recitation** Credits: (3-0) 3
- **General Education Goal 3 or 4 Elective(s)** Credits: 3
- **General Education Goal 3 or 4 Elective(s)** Credits: 3
- **CHEM 490 Seminar** Credits: (0.5-0) 0.5

Total: 17.5

Sophomore Year

First Semester

- **CHEM 252 Systematic Inorganic Chemistry** Credits: (3-0) 3
- **CHEM 332 Analytical Chemistry** Credits: (3-0) 3
- **CHEM 332L Analytical Chemistry Lab** Credits: (0-1) 1
- **CHEM 326 Organic Chemistry I** Credits: (3-0) 3
- **CHEM 326L Organic Chemistry I Lab** Credits: (0-2) 2
- **MATH 321 Differential Equations** Credits: (3-0) 3
- **CHEM 290 Seminar** Credits: (0.5-0) 0.5

Total: 15.5

Second Semester
- **CHEM 328 Organic Chemistry II** Credits: (3-0) 3
- **CHEM 328L Organic Chemistry II Lab** Credits: (0-2) 2
- **ENGL 279 Technical Communications I** Credits: (3-0) 3
- **PHYS 213/213-A University Physics II/Recitation** Credits: (3-0) 3
- **PHYS 213L University Physics II Laboratory** Credits: (0-1) 1
- General Education Goal 3 or 4 Elective(s) Credits: 3
- **CHEM 290 Seminar** Credits: (0.5-0) 0.5

Total: 15.5

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**Junior Year**

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**First Semester - Odd Years**

- **CHEM 342 Physical Chemistry I** Credits: 2 to 3
- **CHEM 342L Physical Chemistry I Lab** Credits: (0-1) 1
- **ENGL 289 Technical Communications II** Credits: (3-0) 3
- **CHEM 420/520 Organic Chemistry III** Credits: (3-0) 3
- OR
- 1 Elective(s) Credits: 3
- 1 Elective(s) Credits: 6
- **CHEM 490 Seminar** Credits: (0.5-0) 0.5

Total: 16.5

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**Second Semester - Odd Years**

- **CHEM 344 Physical Chemistry II** Credits: 2 to 3
- **CHEM 344L Physical Chemistry II Lab** Credits: (0-1) 1
- **CHEM 452/552 Inorganic Chemistry** Credits: (3-0) 3
- **CHEM 452L/552L Inorganic Chemistry Lab** Credits: (0-1) 1
- **CHEM 421/521 Spectroscopic Analysis** Credits: (3-0) 3
- OR
- 1 Elective(s) Credits: 3
- 1 Elective(s) Credits: 2
- **CHEM 490 Seminar** Credits: (0.5-0) 0.5

Total: 13.5

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**First Semester - Even Years**
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CHEM 342</td>
<td>Physical Chemistry I</td>
<td>2 to 3</td>
</tr>
<tr>
<td>CHEM 342L</td>
<td>Physical Chemistry I Lab</td>
<td>(0-1) 1</td>
</tr>
<tr>
<td>ENGL 289</td>
<td>Technical Communications II</td>
<td>(3-0) 3</td>
</tr>
<tr>
<td>CHEM 482</td>
<td>Environmental Chemistry</td>
<td>(3-0) 3</td>
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<tr>
<td></td>
<td>Elective(s)</td>
<td>6</td>
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<tr>
<td>CHEM 490</td>
<td>Seminar</td>
<td>(0.5-0) 0.5</td>
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**Total: 16.5**

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**Second Semester - Even Years**

<table>
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<tr>
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<tr>
<td>CHEM 344</td>
<td>Physical Chemistry II</td>
<td>2 to 3</td>
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<tr>
<td>CHEM 344L</td>
<td>Physical Chemistry II Lab</td>
<td>(0-1) 1</td>
</tr>
<tr>
<td>CHEM 370</td>
<td>Chemical Literature</td>
<td>(1-0) 1</td>
</tr>
<tr>
<td>CHEM 434</td>
<td>Instrumental Analysis</td>
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</tr>
<tr>
<td>CHEM 434L</td>
<td>Instrumental Analysis Lab</td>
<td>(0-2) 2</td>
</tr>
<tr>
<td></td>
<td>Elective(s)</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 490</td>
<td>Seminar</td>
<td>(0.5-0) 0.5</td>
</tr>
</tbody>
</table>

**Total: 13.5**

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**Senior Year**

**First Semester - Odd Years**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CHEM 464</td>
<td>Biochemistry I</td>
<td>(3-0) 3</td>
</tr>
<tr>
<td>^2^ CHEM 420/520</td>
<td>Organic Chemistry III</td>
<td>(3-0) 3</td>
</tr>
<tr>
<td>OR</td>
<td>Elective</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Elective(s)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Elective(s)</td>
<td>6</td>
</tr>
<tr>
<td>CHEM 490</td>
<td>Seminar</td>
<td>(0.5-0) 0.5</td>
</tr>
</tbody>
</table>

**Total: 12.5**

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**Second Semester - Odd Years**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 452</td>
<td>Inorganic Chemistry</td>
<td>(3-0) 3</td>
</tr>
<tr>
<td>CHEM 452L</td>
<td>Inorganic Chemistry Lab</td>
<td>(0-1) 1</td>
</tr>
<tr>
<td>^2^ CHEM 421/521</td>
<td>Spectroscopic Analysis</td>
<td>(3-0) 3</td>
</tr>
<tr>
<td>OR</td>
<td>Elective</td>
<td>3</td>
</tr>
</tbody>
</table>

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[^2]: Indicates that another course with similar credit hours is an option.
Elective(s) Credits: 2
2. CHEM 465/565 Biochemistry II Credits: (3-0) 3
OR
1. Elective(s) Credits: 3
   CHEM 490 Seminar Credits: (0.5-0) 0.5

Total: 12.5

First Semester - Even Years

- CHEM 482/582 Environmental Chemistry Credits: (3-0) 3
- CHEM 464/564 Biochemistry I Credits: (3-0) 3
- Elective Credits: 6
- CHEM 490 Seminar Credits: (0.5-0) 0.5

Total: 12.5

Second Semester - Even Years

- CHEM 370 Chemical Literature Credits: (1-0) 1
- CHEM 434 Instrumental Analysis Credits: (3-0) 3
- CHEM 434L Instrumental Analysis Lab Credits: (0-2) 2
- CHEM 465/565 Biochemistry II Credits: (3-0) 3
OR
- Elective(s) Credits: 3
- CHEM 490 Seminar Credits: (0.5-0) 0.5

Total: 12.5

120 credits required for graduation

Curriculum Notes

1. Twenty-three (23) elective credits are required. These electives can be used to tailor a degree to meet requirements for pursuit of an advanced degree.

2. Three credits of advanced chemistry electives are required. Take any one of the following courses:

   CHEM 420/520 Organic Chemistry III
   CHEM 421/521 Spectroscopic Analysis
   CHEM 426/526 Polymer Chemistry
Contact Information

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Lois Arneson-Meyer
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Civil/Mechanical 121
(605) 394-2446
E-mail: Lois.Arneson-Meyer@sdsmt.edu

Faculty

Professors Bang, Fontaine, Gribb, and Kenner; Associate Professor Stone; Assistant Professors Arneson-Meyer, Benning, Cetin, Gadhamshetty, Nam, Robinson, and Shearer.

Civil and Environmental Engineering at the School of Mines

Civil and environmental engineers are problem solvers, meeting the needs for environmental stewardship, renewable energy, sustainable design solutions, and community planning for a better tomorrow. Civil and environmental engineers serve the public by designing a wide variety of infrastructure systems such as dams and waterways, harbors, bridges, buildings, water supply and wastewater systems, highways and airports, tunnels and pipelines, and renewable energy facilities.

Students interested in a career in civil or environmental engineering follow a curriculum that culminates in a bachelor of science degree in civil engineering that is accredited by the Engineering Accreditation Commission of ABET, [http://www.abet.org](http://www.abet.org).

The mission of the CEE Department is to provide our students with the fundamental knowledge and skills required to address the needs of society through design, research and construction, and to instill them with the desire for professionalism, leadership, and lifelong learning.

The goal of the BSCE program with regard to undergraduate education is to produce graduates, who, within a few years of graduation, will
demonstrate the following Civil Engineering Program Objectives:

1. Engage in the professional practice of civil engineering through work in the public or private sector,
2. Actively participate in professional and/or civic organizations,
3. Pursue opportunities to assume leadership roles in their professional and/or service activities, and
4. Seek to continue their educations through advanced studies in civil or environmental engineering or a related professional discipline, continuing education and/or professional development activities.

The undergraduate curriculum provides a comprehensive education for students who wish to pursue a professional career directly after graduation. The B.S. program in civil engineering also serves as a preparation for graduate study in any of the specialized branches of civil and environmental engineering, construction management or other professional degrees such as business, medicine, or law.

Curriculum

The civil and environmental engineering curriculum begins with students gaining fundamental understanding of humanities, social sciences, mathematics, and basic sciences. Student interested in environmental engineering may follow a curriculum specifically tailored to this important sub-disciplinary area, and may also pursue a minor in environmental engineering or sustainable engineering. In the senior year, a capstone design course allows students to work in multi-disciplinary teams to develop alternative solutions, incorporate sustainable design principles, perform feasibility and economic analyses, and create detailed designs. The capstone design experience culminates with a formal final written report and a presentation to the faculty and the students’ peers.

At the time of graduation, students completing the BSCE program will be able to demonstrate the following Civil Engineering Program Outcomes:

a. An ability to apply knowledge of mathematics, science, and engineering;
b. An ability to design and conduct experiments, as well as to analyze and interpret data;
c. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
d. An ability to function on multi-disciplinary teams;
e. An ability to identify, formulate, and solve engineering problems;
f. An understanding of professional and ethical responsibility;
g. An ability to communicate effectively;
h. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
i. A recognition of the need for, and an ability to engage in life-long learning;
j. A knowledge of contemporary issues; and
k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Graduate programs in civil engineering or construction management afford opportunities for motivated students to pursue advanced studies. An accelerated Master of Science (BS/MS) degree program is available for qualified seniors enrolled in engineering B.S. programs at the South Dakota School of Mines and Technology. The accelerated master's degree program allows B.S. engineering students to take up to nine (9) graduate-level credits to simultaneously meet undergraduate and graduate degree program requirements. For more information about the accelerated master's degree program, see the Civil and Environmental Engineering M.S. section of the catalog or contact CENE Graduate Coordinator Dr. Sangchul Bang (Sangchul.Bang@sdsmt.edu).

Department Approved Electives

The undergraduate curriculum includes 12 credit hours of Department Approved Electives that students may use to gain knowledge and skills in a specialized area to meet their individual career goals. Students may participate in undergraduate research or scholarship, which may include international design projects, design activities associated with 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. Soonkie Nam (Soonkie.Nam@sdsmt.edu).

Department Approved Electives include the following which are described in more detail on the department web page: cee.sdsmt.edu

- At least 9 credits of CEE 400 level coursework 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 3 credit hours of 300 or 400 level courses in engineering, science, math or computer science not applied to another CEE graduation requirement.

Professionalism
Students are encouraged to participate in the student chapter of the American Society of Civil Engineers (ASCE), Engineers and Scientists Abroad (ESA), the Center of Excellence for Advanced Manufacturing and Production (CAMP) that involves designing, building, testing, and competing in a variety of engineering challenges), or any other of the many student organizations on campus. During the senior year, students are strongly encouraged to take the Fundamentals of Engineering (F.E.) examination. Passing the F.E. examination is the first step toward registration as a Professional Engineer (P.E.). 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 P.E. for at least four years.

Civil Engineering Curriculum/Checklist

Students pursuing a traditional civil engineering education will follow the curriculum below. The BSCE curriculum for the environmental engineering emphasis is shown separately.

Civil Engineering, B.S. - Environmental Engineering Emphasis

Students are responsible for checking with their advisors for any program modifications that may occur after the publication of this catalog. Curriculum flowcharts and other advising information are available on the departmental web page: cee.sdsmt.edu.

Freshman Year

First Semester

- ENGL 101 Composition I Credits: (3-0) 3
- CHEM 112 General Chemistry I Credits: (3-0) 3
- CHEM 112L General Chemistry I Lab Credits: (0-1) 1
- 2 MATH 123 Calculus I Credits: (4-0) 4
- CEE 130/130L Introduction to Civil and Environmental Engineering/Lab Credits: (1-1) 2
- 1 Humanities or Social Sciences Elective(s) Credits: 3

Total: 16

Second Semester

- CHEM 114 General Chemistry II Credits: (3-0) 3
- PHYS 211/211-A University Physics I/Recitation Credits: (3-0) 3
- MATH 125 Calculus II Credits: (4-0) 4
- CEE 117/117L Introduction to CADD/Lab Credits: (1-1) 2
- 2 EM 214 Statics Credits: (3-0) 3
- 1 Humanities or Social Sciences Elective(s) Credits: 3

Total: 18

Sophomore Year
First Semester

- **MATH 225 Calculus III** Credits: (4-0) 4
- **CEE 206/206L Engineering Surveys I/Lab** Credits: (2-1) 3
- ¹ Humanities or Social Sciences Elective(s) Credits: 3
- **ENGL 279 Technical Communications I** Credits: (3-0) 3
- ² **EM 331 Fluid Mechanics** Credits: (3-0) 3

Total: 16

Second Semester

- ² **CEE 326 Environmental Engineering I** Credits: (3-0) 3
- **CEE 284 Applied Numerical Methods** Credits: (3-0) 3
- **MATH 321 Differential Equations** Credits: (3-0) 3
- **ME 221 Dynamics of Mechanisms** Credits: (3-0) 3
- OR
- **ME 211 Introduction to Thermodynamics** Credits: (3-0) 3
- ² **EM 321 Mechanics of Materials** Credits: (3-0) 3
- ¹ Humanities or Social Sciences Elective(s) Credits: 3

Total: 18

Junior Year

First Semester

- **ENGL 289 Technical Communications II** Credits: (3-0) 3
- **CEE 316/316L Engineering and Construction Materials/Lab** Credits: (2-1) 3
- ² **CEE 336/336L Hydraulic Systems Design/Lab** Credits: (2-1) 3
- ² **CEE 346/346L Geotechnical Engineering/Lab** Credits: (2-1) 3
- ² **CEE 353 Structural Theory** Credits: (3-0) 3

Total: 15

Second Semester

- **CEE 325 Introduction to Sustainable Design** Credits: (3-0) 3
- **GEOE 221/221L Geology for Engineers/Lab** Credits: (2-1) 3
Three of the following four courses

- CEE 327/327L Environmental Engineering II/Lab Credits: (2-1) 3
- CEE 337 Engineering Hydrology Credits: (3-0) 3
- CEE 347 Geotechnical Engineering II Credits: (3-0) 3
- CEE 456/556 Concrete Theory & Design Credits: (3-0) 3

Total: 15

Senior Year

First Semester

- CEE Department Approved Elective(s) Credits: 6
- IENG 302 Engineering Economics Credits: (3-0) 3
- CEE 463 Concepts of Professional Practice Credits: (2-0) 2
- ³Science Elective Credits: 3
- ¹Humanities or Social Sciences Elective Credit: 3

Total: 17

Second Semester

- CEE 474/574 Construction Engineering and Management Credits: (3-0) 3
- CEE Department Approved Elective(s) Credits: 6
- ⁴ CEE 489 Capstone Design Project Credits: (0-3) 3
- ³Math/Science Elective Credits: 3

Total: 15

130 credits required for graduation

Curriculum Notes

¹ Consult the section of the catalog addressing graduation requirements for a description of the combinations of lower level (1 xx/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).

2 Students must earn a “C” or better in the following courses to advance in the program: MATH 123, EM 214, EM 321, EM 331, CEE 326, CEE 336/336L, CEE 346/346L, CEE 353.

3 Mathematics/science elective may be chosen from physics, chemistry, biology, geology, mathematics, or atmospheric and environmental science. See departmental webpage for list.

4 Prerequisites for CEE 489 are: CEE 326, CEE 336/336L, and CEE 346/346L all with a “C” or better.

Contact Information

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Faculty

Professors Bang, Fontaine, Gribb, Hansen and Kenner; Associate Professor Stone; Assistant Professors Arneson-Meyer, Benning, Cetin, Gadhamshetty, Nam, Robinson, and Shearer.

Environmental Engineering Emphasis, BS Civil Engineering at School of Mines

Environmental engineering is an important emphasis area in the broad field of civil engineering. Environmental engineers design systems and solve pressing global problems in all areas related to the environment and public health: sustainable design of drinking water treatment and distribution, wastewater treatment, and solid and hazardous waste disposal systems; development of air quality monitoring and pollution prevention programs; design of site remediation and mining reclamation programs; and development of ecosystem protection and restoration efforts, among others.

Students interested in a career in environmental engineering at the School of Mines follow a curriculum with an emphasis in environmental engineering that culminates in a bachelor of science degree in civil engineering that is accredited by the Engineering Accreditation Commission of ABET, www.abet.org.

The mission of the CEE Department is to provide our students with the fundamental knowledge and skills required to address the needs of society through design, research and construction, and to instill them with the desire for professionalism, leadership, and lifelong learning.

The goal of the BSCE program with regard to undergraduate education is to produce graduates, who, within a few years of graduation, will demonstrate the following Civil Engineering Program Objectives:

1. Engage in the professional practice of civil engineering through work in the public or private sector,
2. Actively participate in professional and/or civic organizations,
3. Pursue opportunities to assume leadership roles in their professional and/or service activities, and
4. Seek to continue their educations through advanced studies in civil or environmental engineering or a related professional discipline, continuing education and/or professional development activities.

The undergraduate curriculum provides a comprehensive education for students who wish to pursue a professional career directly after graduation. The B.S. program in civil engineering also serves as preparation for graduate study in any of the specialized branches of environmental or civil engineering, construction management or other professional degrees such as medicine or law.

Curriculum

The curriculum for the BSCE with environmental engineering emphasis includes courses in the liberal arts, higher mathematics, basic sciences, engineering sciences, and engineering design. Civil and environmental engineers often work on interdisciplinary teams to solve complex system design problems, so a broad background in engineering fundamentals and the natural sciences is essential. Students will take courses in environmental, geotechnical, water resources, construction, and sustainable engineering, as well as related chemical engineering courses, to
prepare them for a career and/or additional studies.

In the senior year, a capstone design course allows students to work in multi-disciplinary teams to develop alternative solutions, incorporate sustainable design principles, perform feasibility and economic analyses, and create detailed designs. The capstone design experience culminates with a formal final written report and a presentation to the faculty and the students’ peers. Minors in environmental engineering and sustainable engineering are also available.

At the time of graduation, students completing the BSCE program will be able to demonstrate the following Civil Engineering Program Outcomes:

a. An ability to apply knowledge of mathematics, science, and engineering;
b. An ability to design and conduct experiments, as well as to analyze and interpret data;
c. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
d. An ability to function on multi-disciplinary teams;
e. An ability to identify, formulate, and solve engineering problems;
f. An understanding of professional and ethical responsibility;
g. An ability to communicate effectively;
h. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
i. A recognition of the need for, and an ability to engage in life-long learning;
j. A knowledge of contemporary issues; and
k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Graduate programs in civil and environmental engineering or construction engineering and management afford opportunities for motivated students to pursue advanced studies. An accelerated Master of Science (BS/MS) degree program is available for qualified seniors enrolled in engineering B.S. programs at the South Dakota School of Mines. The accelerated master’s degree program allows B.S. engineering students to take up to nine (9) graduate-level credits to simultaneously meet undergraduate and graduate degree program requirements. For more information about the accelerated master’s degree program, see the Civil and Environmental Engineering M.S. section of the catalog or contact the CENE Graduate Coordinator Dr. Sangchul Bang, Sangchul.Bang@sdsmt.edu.

Department Approved Electives

The curriculum for the BSCE with environmental engineering emphasis includes 15 credit hours of Department Approved Electives that students may use to gain knowledge and skills to meet their individual career goals. Students may participate in undergraduate research or scholarship, which may include international design projects, design activities associated with 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. Soonkie Nam (Soonkie.Nam@sdsmt.edu).

Department Approved Electives include the following and a list can also be found on the departmental web page: cee.sdsmt.edu

- At least 9 credits of CEE 400 level coursework 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 3 credit hours of 300 or 400 level courses in engineering, science, math or computer science not applied to another CEE graduation requirement.

Professionalism

Students are encouraged to participate in the student chapter of the American Society of Civil Engineers (ASCE), Engineers and Scientists Abroad (ESA), the Center of Excellence for Advanced Manufacturing and Production (CAMP) that involves designing, building, testing, and competing in a variety of engineering challenges), or any other of the many student organizations on campus. During the senior year, students are strongly encouraged to take the Fundamentals of Engineering (F.E.) examination. Passing the F.E. examination is the first step toward registration as a Professional Engineer (P.E.). 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 P.E. for at least four years.

BSCE Environmental Engineering Emphasis Curriculum/Checklist

Freshman Year
First Semester

- **ENGL 101 Composition I** Credits: (3-0) 3
- **CHEM 112 General Chemistry I** Credits: (3-0) 3
- **CHEM 112L General Chemistry I Lab** Credits: (0-1) 1
- **MATH 123 Calculus I** Credits: (4-0) 4
- **CEE 130/130L Introduction to Civil and Environmental Engineering/Lab** Credits: (1-1) 2
- *Humanities or Social Science Elective** Credits: 3

Total: 16

Second Semester

- **CHEM 114 General Chemistry II** Credits: (3-0) 3
- **CHEM 114L General Chemistry II Lab** Credits: (0-1) 1
- **MATH 125 Calculus II** Credits: (4-0) 4
- **PHYS 211/211-A University Physics I/Recitation** Credits: (3-0) 3
- **EM 214 Statics** Credits: (3-0) 3
- *Humanities or Social Science Elective(s)** Credits: 3

Total: 17

Sophomore Year

First Semester

- **ENGL 279 Technical Communications I** Credits: (3-0) 3
- **MATH 225 Calculus III** Credits: (4-0) 4
- **CHEM 230 Analytical Chemistry for Engineers** Credits: (2-0) 2
- **EM 331 Fluid Mechanics** Credits: (3-0) 3
- **CBE 217 Chemical Engineering Material Balances** Credits: (3-0) 3
- *Humanities or Social Science Elective** Credits: 3

Total: 18

Second Semester
• CEE 326 Environmental Engineering | Credits: (3-0) 3
• MATH 321 Differential Equations Credits: (3-0) 3
• CBE 222 Chemical Engineering Process Thermodynamics Credits: (3-0) 3
• CEE 284 Applied Numerical Methods Credits: (3-0) 3
• 2 EM 321 Mechanics of Materials Credits: (3-0) 3
• 1 Humanities or Social Science Elective(s) Credits: 3

Total: 18

Junior Year

First Semester

• ENGL 289 Technical Communications II Credits: (3-0) 3
• CBE 317 Chemical Engineering Heat Transfer Credits: (3-0) 3
• CEE 316/316L Engineering and Construction Materials/Lab Credits: (2-1) 3
• CEE 336/336L Hydraulic Systems Design/Lab Credits: (2-1) 3
• CEE 346/346L Geotechnical Engineering/Lab Credits: (2-1) 3

Total: 15

Second Semester

• CEE 325 Introduction to Sustainable Design Credits: (3-0) 3
• CEE 327/327L Environmental Engineering II/Lab Credits: (2-1) 3
• CEE 337 Engineering Hydrology Credits: (3-0) 3
• CBE 318 Chemical Engineering Mass Transfer Credits: (3-0) 3
• GEOE 221/221L Geology for Engineers/Lab Credits: (2-1) 3
• OR
• GEOL 201 Physical Geology Credits: (3-0) 3

Total: 15

Senior Year

First Semester

• IENG 301 Basic Engineering Economics Credits: (2-0) 2
• CEE 463 Concepts of Professional Practice Credits: (2-0) 2
• 3 CEE Department Approved Elective(s)  Credits: 6
• CEE 464 Civil Engineering Capstone Design I  Credits: (0-1) 1
• 4 CEE Department Approved Elective  Credits: 3

Total: 15

Second Semester

• CEE 474/574 Construction Engineering and Management  Credits: (3-0) 3
• CEE 465 Civil Engineering Capstone Design II  Credits: (0-2) 2
• CEE Department Approved Elective(s)  Credits: 9
• Humanities or Social Science Elective  Credits: 3

Total: 16

130 credits required for graduation

Curriculum Notes

1 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).

2 Students must earn a “C” or better in the following courses to advance in the program: MATH 123, EM 214, EM 321, EM 331, CEE 326, CEE 336/336L, and CEE 346/346L.

3 Environmental Engineering Minor electives are listed on the CEE web page: cee.sdsmt.edu.

4 Recommend BIOL 341 for environmental engineering minor.
Contact Information

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Department of Electrical and Computer Engineering  
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Faculty

Professors Corwin, Logar, Sohraby and Weiss; Associate Professors Pyeatt, McGough, Tolle, and Montoya; Assistant Professors Zhao and Hoover; Instructors Linde and Batchelder; Professors Emeritus Batchelder, Cox, McNeil, Meiners, Opp, and Oliver.

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 a number of 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, computer vision, robotics, 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, assume leadership roles, 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 and applied 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 and ethically in diverse environments.
4. Graduates will be prepared to demonstrate leadership in outreach, innovation and invention.

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 (IEEE), 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.

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** | Credits: (4-0) 4
- **CHEM 112 General Chemistry** | Credits: (3-0) 3
- **CHEM 112L General Chemistry Lab** | Credits: (0-1) 1
- **CENG 244/244L Introduction to Digital Systems/Lab** | Credits: (3-1) 4
- Humanities or Social Sciences Elective(s) **Credits:** 3

**Total:** 15

### Second Semester

- [ENGL 101] Composition I **Credits:** (3-0) 3
- [MATH 125] Calculus II **Credits:** (4-0) 4
- [PHYS 211/211-A] University Physics I/Recitation **Credits:** (3-0) 3
- Humanities or Social Sciences Elective(s) **Credits:** 3
- [CSC 150/150L] Computer Science I/Lab **Credits:** (2-1) 3

**Total:** 16

### Sophomore Year

### First Semester

- [EE 220/220L] Circuits I/Lab **Credits:** (3-1) 4
- [MATH 321] Differential Equations **Credits:** (3-0) 3
- [PHYS 213/213-A] University Physics II/Recitation **Credits:** (3-0) 3
- [PHYS 213L] University Physics II Laboratory **Credits:** (0-1) 1
- [CENG 264L] Electromechanical Systems Product Development and Design Lab **Credits:** (0-2) 2
- [CSC 250] Computer Science II **Credits:** (4-0) 4

**Total:** 17

### Second Semester

- [CSC 251] Finite Structures **Credits:** (4-0) 4
- [ENGL 279] Technical Communications I **Credits:** (3-0) 3
- [EE 221/221L] Circuits II/Lab **Credits:** (3-1) 4
- Humanities or Social Sciences Elective(s) **Credits:** 3
- [CENG 351/351L] Mechatronics and Measurement Systems **Credits:** (3-1) 4

**Total:** 18

### Junior Year
First Semester

- Approved Basic Sciences Electives Credits: 3
- ENGL 289 Technical Communications II Credits: (3-0) 3
- EE 320/320L Electronics I/Lab Credits: (3-1) 4
- MATH 225 Calculus III Credits: (4-0) 4
- EE 312/312L Signals/Lab Credits: (3-0.5) 3.5

Total: 17.5

Second Semester

- EE 311/311L Systems/Lab Credits: (3-0.5) 3.5
- CENG 447/447L/547/547L Embedded Systems Credits: (3-1) 4
- CENG 342/342L Digital Systems/Lab Credits: (3-1) 4
- MATH 381 Introduction to Probability and Statistics Credits: (3-0) 3
- EM 216 Statics and Dynamics Credits: (4-0) 4

Total: 18.5

Senior Year

First Semester

- CENG 464 Computer Engineering Design I Credits: (0-2) 2
- CENG Senior Elective(s) Credits: 4
- CENG 448/448L/548/548L Real-Time Operating Systems Credits: (3-1) 4
- CSC 300 Data Structures Credits: (4-0) 4

Total: 14

Second Semester

- CENG 465 Computer Engineering Design II Credits: (0-2) 2
- CENG Senior Elective(s) Credits: 7
- IENG 301 Basic Engineering Economics Credits: (2-0) 2
- Humanities or Social Sciences Elective Credits: 3
130 credits required for graduation

Curriculum Notes

1 Approved basic science courses must be at 300-level or higher with prefixes MATH, PHYS, CHEM.

CENG Senior Electives

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.

- **CENG 314/314L Assembly Language/Lab** Credits: (2-1) 3
- **CENG 414/514 Introduction to Computer Vision** Credits: (3-0) 3
- **CENG 415/415L/515/515L Introduction to Robotics/Lab** Credits: (2-1) 3
- **CENG 420/420L Design of Digital Signal Processing Systems** Credits: (3-1) 4
- **CENG 421/421L Communication Systems/Lab** Credits: (3-1) 4
- **CENG 444/444L VLSI Design/Lab** Credits: (3-1) 4
- **CENG 444/444L/544/544L Computer Networks/Lab** Credits: (3-1) 4
- (credit for only one of CENG 444/444L/544/544L or CSC 463/563 may be used)
- **CENG 446/446L Advanced Computer Architectures/Lab** Credits: (3-1) 4
- (credit for only one of CENG 446/446L or CSC 440/440L may be used)
- **CENG 452/452L Robotic Control Systems/Lab** Credits: (2.5-0.5) 3
- **EE 322/322L Electronics II/Lab** Credits: (3-1) 4
- **EE 432/432L/532/532L Power Electronics/Lab** Credits: (3-1) 4
- **EE 453/453L/553/553L Control Systems/Lab** Credits: (3-1) 4
- **EE 456/456L/556/556L Digital Control Systems/Lab** Credits: (3-1) 4
- **EE 481/481L/581/581L Microwave Engineering/Lab** Credits: (3-1) 4
- **CSC 410/510 Parallel Computing** Credits: (3-0) 3
- **CSC 416/416L/516/516L Introduction to Autonomous Systems/Lab** Credits: (2.5-0.5) 3
- **CSC 421/521 Graphical User Interfaces with Object-Oriented Programming** Credits: (3-0) 3
- **CSC 433/533 Computer Graphics** Credits: (3-0) 3
- **CSC 442/542 Introduction to Digital Image Processing and Computer Vision** Credits: (3-0) 3
- **CSC 447/547 Artificial Intelligence** Credits: (3-0) 3
- **CSC 448/548 Machine Learning** Credits: (3-0) 3
- **CSC 449/549 Pattern Recognition** Credits: (3-0) 3
- **CSC 461 Programming Languages** Credits: (3-0) 3
- **CSC 464 Senior Design I** Credits: (2-0) 2
- **CSC 470 Software Engineering** Credits: (3-0) 3
Computer Science B.S.
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www.sdsmt.edu/MCS

Faculty

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

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 15 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.

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 4 computer science elective courses from the following list: CSC 410/510, CSC 412/512, CSC 414/514, CSC 415/515L/515L, CSC 426/526, CSC 433/533, CSC 441/541, CSC 442/542, CSC 445/545, CSC 447/547, CSC 449/549, CSC 476/476L/576/576L, and CENG 444/444L/444L/544L. A 3-credit Co-op (CP 497) 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** Credits: (3-0) 3
- **MATH 123 Calculus I** Credits: (4-0) 4
- **CSC 150/150L Computer Science I/Lab** Credits: (2-1) 3
- 1Humanities or Social Sciences Elective(s) Credits: 3
- **CSC 110 Survey of Computer Science and Mathematics** Credits: (1-0) 1

Total: 14

**Second Semester**

- **MATH 125 Calculus II** Credits: (4-0) 4
- 1Humanities or Social Sciences Elective(s) Credits: 3
- **CSC 250 Computer Science II** Credits: (4-0) 4
- **CSC 251 Finite Structures** Credits: (4-0) 4

Total: 15

**Sophomore Year**

**First Semester**

- **CSC 300 Data Structures** Credits: (4-0) 4
- **MATH 225 Calculus III** Credits: (4-0) 4
- **CSC 314/314L Assembly Language/Lab** Credits: (2-1) 3
- 1Humanities or Social Science Elective(s) Credits: 3

Total: 14

**Second Semester**

- **ENGL 279 Technical Communications** Credits: (3-0) 3
- **CSC 317 Computer Organization and Architecture** Credits: (3-0) 3
- **MATH 315 Linear Algebra** Credits: (3-0) 3
- 1Humanities or Social Sciences Elective(s) Credits: 3
- 1Science Elective Credits: 3
- 1Science Elective Lab Credits: 1

Total: 16

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**Junior Year**

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**First Semester**

- **ENGL 289 Technical Communications II** Credits: (3-0) 3
- **PHYS 211/211-A University Physics I/Recitation** Credits: (3-0) 3
- **CSC 372 Analysis of Algorithms** Credits: (3-0) 3
- **CSC 484 Database Management Systems** Credits: (3-0) 3
- 1Science Elective Credits: 3
- 1Science Elective Lab Credits: 1

Total: 15

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**Second Semester**

- **CSC 461 Programming Languages** Credits: (3-0) 3
- **CSC 470 Software Engineering** Credits: (3-0) 3
- 1Elective or CSC Elective Credits: 9

Total: 15

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**Senior Year**

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**First Semester**

- **CSC 464 Senior Design I** Credits: (2-0) 2
- **MATH 381 Introduction to Probability and Statistics** Credits: (3-0) 3
- **CSC 421/521 Graphical User Interfaces with Object-Oriented Programming** Credits: (3-0) 3
- 1Humanities or Social Sciences Elective(s) Credits: 3
- 1Elective or CSC Elective Credits: 4
Second Semester

- **CSC 456 /456L Operating Systems/Lab** Credits: (3-1) 4
- **CSC 465 Senior Design II** Credits: (2-0) 2
- 1'Elective or CSC Elective  Credits: 6
- 1'Elective or MATH Elective  Credits: 3

Total: 15

120 credits required for graduation

Curriculum Notes

- **CSC 464 /CSC 465** 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 465. The overall results of this exam will be used to assess the computer science program.
- **CHEM 106 , CHEM 108 , CSC 105 , MATH 021 , MATH 101 , MATH 102 , MATH 120 , PHYS 111 , and PHYS 113** may not be counted towards the Computer Science degree.

1 Elective courses must be chosen to satisfy all of the following requirements.

- Fifteen 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 4 computer science elective courses from the following list: CSC 410/510 , CSC 412/512 , CSC 414/514 , CSC 415/415L/515/515L , CSC 426/526 , CSC 433/533 , CSC 441/541 , CSC 442/542 , CSC 445/545 , CSC 447/547 , CSC 449/549 , CSC 476/476L/576/576L , and CENG 444/444L/544/544L . A 3-credit Co-op (CP 497) 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 211/211-A and two more lecture courses from among BIOL 151 , BIOL 153 , CHEM 112 , CHEM 114 , GEOL 201 , or PHYS 213/213-A; plus two labs that accompany the science courses taken, i.e., either BIOL 151L , BIOL 153L , CHEM 112L , CHEM 114L , GEOL 201L , or PHYS 213L . Students must complete science classes from at least two different disciplines.
- The math elective includes any course from the following list: MATH 321 , MATH 381 , MATH 382 , MATH 413 , MATH 421 , MATH 423 , or MATH 443/543 .

Contact Information

Dr. Kazem Sohraby  
Department of Electrical and Computer Engineering  
Electrical Engineering/Physics 311  
(605) 394-1219  
E-mail: Kazem.Sohraby@sdsmt.edu
Faculty

Steven P. Miller Endowed Chair and Professor Whites; Professor Sohraby; Associate Professors Montoya, Tolle, and Anagnostou; Assistant Professors Zhao, Zhang, and Hoover; Instructors Linde and Rausch; Professors Emeritus Batchelder, Cox, McNeil, Meiners, Opp, Simonson and Oliver.

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 and control systems, and properties of materials. Electrical engineering students are required to select a number of 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, assume leadership roles, 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 and applied 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 and ethically in diverse environments.
4. Graduates will be prepared to demonstrate leadership in outreach, innovation and invention.

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 (IEEE), 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
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.

Undergraduate students with strong interest and background in Electrical Engineering may choose to apply for the accelerated BS/MS in Electrical Engineering at the beginning of their junior year.

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.

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

Freshman Year

First Semester

- MATH 123 Calculus I Credits: (4-0) 4
- CHEM 112 General Chemistry I Credits: (3-0) 3
- CHEM 112L General Chemistry I Lab Credits: (0-1) 1
- CENG 244/244L Introduction to Digital Systems/Lab Credits: (3-1) 4
- Humanities or Social Sciences Elective(s) Credits: 3

Total: 15

Second Semester

- ENGL 101 Composition I Credits: (3-0) 3
- MATH 125 Calculus II Credits: (4-0) 4
- PHYS 211/211A University Physics I/Recitation Credits: (3-0) 3
- Humanities or Social Sciences Elective(s) Credits: 3
- CSC 150/150L Computer Science I/Lab Credits: (2-1) 3

Total: 16

Sophomore Year

First Semester
- **EE 220/220L Circuits I/Lab** Credits: (3-1) 4
- **MATH 321 Differential Equations** Credits: (3-0) 3
- **ENGL 279 Technical Communications I** Credits: (3-0) 3
- **PHYS 213/213-A University Physics II/Recitation** Credits: (3-0) 3
- **PHYS 213L University Physics II Laboratory** Credits: (0-1) 1
- Humanities or Social Sciences Elective(s) Credits: 3

Total: 17

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**Second Semester**

- **EM 216 Statics and Dynamics** Credits: (4-0) 4
- **EE 221/221L Circuits II/Lab** Credits: (3-1) 4
- **MATH 225 Calculus III** Credits: (4-0) 4
- **EE 351/351L Mechatronics and Measurement Sys/Lab** Credits: (3-1) 4
- **EE 264L Electromechanical Systems Product Development and Design Lab** Credits: (0-2) 2

Total: 18

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**Junior Year**

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**First Semester**

- **ENGL 289 Technical Communications II** Credits: (3-0) 3
- **EE 312/312L Signals/Lab** Credits: (3-0.5) 3.5
- **EE 320/320L Electronics I/Lab** Credits: (3-1) 4
- **EE 381 Electric and Magnetic Fields** Credits: (3-0) 3
- **EE 330/330L Energy Systems/Lab** Credits: (3-1) 4

Total: 17.5

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**Second Semester**

- **EE 311/311L Systems/Lab** Credits: (3-0.5) 3.5
- **EE 322/322L Electronics II/Lab** Credits: (3-1) 4
- **EE 382/382L Applied Electromagnetics/Lab** Credits: (2.5-0.5) 3
- ^Approved Math Elective Credits: 3
- **PHYS 439/539 Solid State Physics** Credits: 3 or 4

Total: 16.5
Senior Year

First Semester

- IENG 301 Basic Engineering Economics Credits: (2-0) 2
- EE 464 Senior Design I Credits: (0-2) 2
- EE Electrical Engineering Senior Elective(s) Credits: 8
- Free Elective Credits: 3

Total: 15

Second Semester

- EE 465 Senior Design II Credits: (0-2) 2
- EE Electrical Engineering Senior Elective Credits: 3
- Technical Elective Credits: 3
- Humanities or Social Sciences Elective(s) Credits: 3

Choose 4 Credits From Either:

- CENG 447/447L/547/547L Embedded Systems Credits: (3-1) 4
- OR
- ME 211 Introduction to Thermodynamics Credits: (3-0) 3
  with Free Elective Credits: 1

Total: 15

130 credits required for graduation

Curriculum Notes

1 Students must choose to take 4 credits from either CENG 447/447L/547/547L Credits: (3-1) 4 or ME 211 Credits: (3-0) 3 plus one credit free elective.

2 MATH 381 is the approved elective.

3 Eleven electrical engineering senior elective credits required.
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.

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.

EE Senior Electives

- EE 421/421L/521/521L Communication Systems/Lab Credits: (3-1) 4
- EE 431/431L/531/531L Power Systems/Lab Credits: (3-1) 4
- EE 432/432L/532/532L Power Electronics/Lab Credits: (3-1) 4
- EE 451 Control Systems Credits: 4
- EE 435/535 Power Transmission and Distribution Credits: (3-0) 3
- EE 437 Electronic Motor Drives Credits: (3-0) 3
- EE 439/539 Grid-Connected Power Electronics Devices Credits: (3-0) 3
- EE 447 Advanced Power Systems Credits: (3-0) 3
- EE 448/548 Power Generation Credits: (3-0) 3
- EE 449 Power Conversion Credits: (3-0) 3
- EE 452/452L/552/552L Robotic Control Systems/Lab Credits: (2.5-0.5) 3
- EE 453/453L/553/553L Control Systems/Lab Credits: (3-1) 4
- EE 456/456L/556/556L Digital Control Systems/Lab Credits: (3-1) 4
- EE 481/481L/581/581L Microwave Engineering/Lab Credits: (3-1) 4
- EE 483/483L/583/583L Antennas for Wireless Communications/Lab Credits: (3-1) 4
- CENG 342/342L Digital Systems/Lab Credits: (3-1) 4
- CENG 414/514 Introduction to Computer Vision Credits: (3-0) 3
- CENG 415/415L/515/515L Introduction to Robotics/Lab Credits: (2-1) 3
- CENG 420/420L Design of Digital Signal Processing Systems Credits: (3-1) 4
- CENG 440/440L VLSI Design/Lab Credits: (3-1) 4
- CENG 444/444L/544/544L Computer Networks/Lab Credits: (3-1) 4
- (credit for only one of CENG 444/444L/544/544L or CSC 463/563 may be used)
- CENG 446/446L Advanced Computer Architectures/Lab Credits: (3-1) 4
- (credit for only one of CENG 446/446L or CSC 440/440L may be used)
- CENG 447/447L/547/547L Embedded Systems Credits: (3-1) 4
- CENG 448/448L/548/548L Real-Time Operating Systems Credits: (3-1) 4

Contact Information

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Civil/Mechanical 122
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E-mail: Molly.Gribb@sdsmt.edu

NOTE: The B.S. in Environmental Engineering degree program is not open to new students. Students wishing to pursue environmental engineering studies are directed to the Civil Engineering, B.S. - Environmental Engineering Emphasis

degree and the
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.

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, cleanup 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.

Cooperative Education Program

Students may participate in the Cooperative Education Internship Program, but credits earned are not applicable for degree credit.

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. Additional advising information is available on the departmental web page: cee.sdsmt.edu.

Freshman Year
First Semester

- **ENGL 101 Composition I** | Credits: (3-0) 3
- **CHEM 112 General Chemistry I** | Credits: (3-0) 3
- **CHEM 112L General Chemistry I Lab** | Credits: (0-1) 1
- **MATH 123 Calculus I** | Credits: (4-0) 4

Total: 16

Second Semester

- **CHEM 114 General Chemistry II** | Credits: (3-0) 3
- **CHEM 114L General Chemistry II Lab** | Credits: (0-1) 1
- **MATH 125 Calculus II** | Credits: (4-0) 4
- **PHYS 211/211-A University Physics I/Recitation** | Credits: (3-0) 3
- **GEOE 221/221L Geology for Engineers/Lab** | Credits: (2-1) 3
- 1 General Education Goal 3 or 4 Elective | Credits: 3

Total: 17

Sophomore Year

First Semester

- **MATH 225 Calculus III** | Credits: (4-0) 4
- **CHEM 230 Analytical Chemistry for Engineers** | Credits: (2-0) 2
- **CEE 284 Applied Numerical Methods** | Credits: (3-0) 3
- **CHEM 332L Analytical Chemistry Lab** | Credits: (0-1) 1
- 1 General Education Goal 3 or 4 Elective | Credits: 3

Total: 16

Second Semester

- **EM 216 Statics and Dynamics** | Credits: (4-0) 4
- **CBE 222 Chemical Engineering Process Thermodynamics** | Credits: (3-0) 3
- **ENGL 279 Technical Communications I** | Credits: (3-0) 3
<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 321 Differential Equations</td>
<td>(3-0) 3</td>
</tr>
<tr>
<td>Total: 16</td>
<td></td>
</tr>
</tbody>
</table>

**Junior Year**

**First Semester**

- ENGL 289 Technical Communications II **Credits:** (3-0) 3
- BIOL 341 Microbial Processes in Engineering and Natural Sciences **Credits:** (3-0) 3
- Science Elective **Credits:** 3
- IENG 301 Basic Engineering Economics **Credits:** (2-0) 2

Total: 17

**Second Semester**

- EM 331 Fluid Mechanics **Credits:** (3-0) 3

Total: 16.5

**Senior Year**

**First Semester**

Total: 17

**Second Semester**

- AES 405/505 Air Quality **Credits:** (3-0) 3

Total: 14.5
130 credits are required for graduation

Curriculum Notes

1 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.

2 A combination of **EM 214 / EM 321**, **EM 214 / EM 215**, or **EM 214 / ME 221** may replace **EM 216**.

3 **ME 211** or **MET 320** may replace **CBE 222**.

4 **CBE 218**, **EM 331**, or **ME 331** will also satisfy fluid mechanics requirements.

6 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.

5 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.

6 **ME 211** or **MET 320** may replace **CBE 222**.
Contact Information

Dr. Laurie Anderson
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Mineral Industries 303
(605) 394-2461
E-mail: Laurie.Anderson@sdsmt.edu

Faculty

Professors Davis and Stetler; Associate Professor Sawyer; Assistant Professor Katzenstein; Professor Emeritus Rahn.

Supporting Faculty

Professors Duke, Paterson, Price and Uzunlar; Associate Professor Masterlark; Assistant Professor Oner; Adjunct Faculty M. Anderson, Iles, Long, Roggenthen, and Stamm.

Geological Engineering

Geological engineering is the development and conservation of natural resources in ways useful to humankind. It encompasses diverse fields such as groundwater resources, subsurface contamination, slope stability, environmental site design, and mineral and petroleum exploration and production. Instruction in geological engineering provides training at both the undergraduate and graduate levels through the Ph.D.
Geological Engineering Program Educational 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:
   - groundwater
   - environmental site planning and natural hazards
   - geo-mechanics and geo-technics
   - 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 statistics, 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 Tech Geological Association as well as to become student members of the Association of Engineering Geologists (AEG), National Ground Water Association, the Society for Mining, Metallurgy, and Exploration (SME), and/or 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 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 | Credits: (3-0) 3
- MATH 123 Calculus I Credits: (4-0) 4
- ENGL 101 Composition I Credits: (3-0) 3
- GEOE 110L Introduction to Geological and Mining Engineering/Lab Credits: (0-1) 1
- General Education Goal 3 and Goal 4 Elective(s) Credits: 6

Total: 17

Second Semester

- CHEM 112L General Chemistry I Lab Credits: (0-1) 1
- CHEM 114 General Chemistry II Credits: (3-0) 3
- MATH 125 Calculus II Credits: (4-0) 4
- PHYS 211/211-A University Physics I/Recitation Credits: (3-0) 3
- GEOE 221/221L Geology for Engineers/Lab Credits: (2-1) 3
- CEE 117/117L Introduction to CADD/Lab Credits: (1-1) 2

Total: 16

Sophomore Year

First Semester

- EM 214 Statics Credits: (3-0) 3
- MATH 225 Calculus III Credits: (4-0) 4
- MEM 201L Surveying for Mineral Engineers Credits: (0-2) 2
- PHYS 213/213-A University Physics II/Recitation Credits: (3-0) 3
- General Education Goal 3 Elective(s) Credits: 3

Total: 15

Second Semester

- ENGL 279 Technical Communications I Credits: (3-0) 3
- EM 321 Mechanics of Materials Credits: (3-0) 3
- GEOL 212/212L Mineralogy and Crystallography/Lab Credits: (2-1) 3
- MATH 321 Differential Equations Credits: (3-0) 3
- Gen. Ed. Goal 4 Electives Credits: 3

Total: 15
Junior Year

First Semester

- ENGL 289 Technical Communications II Credits: (3-0) 3
- GEOL 331/331L Stratigraphy and Sedimentation/Lab Credits: (2-1) 3
- GEOL 341/341L Igneous and Metamorphic Petrology/Lab Credits: (2-1) 3
- CEE 346/346L Geotechnical Engineering/Lab Credits: (2-1) 3
- MET 320 Metallurgical Thermodynamics Credits: (4-0) 4

Total: 16

Second Semester

- GEOL 322/322L Structural Geology/Lab Credits: (2-1) 3
- 3 GEOE 324/324L Engineering Geophysics I/Lab Credits: (2-1) 3
- EM 331 Fluid Mechanics Credits: (3-0) 3
- GEOL 416/416L/516/516L Introduction to GIS/Lab Credits: (2-1) 3
- MEM 302 Mineral Economics and Finance Credits: (3-0) 3

Total: 15

Summer

- 3 GEOE 410 Engineering Field Geology Credits: 6
- (SDSM&T students must take GEOE 410 for 6 credits.)

Total: 6

Senior Year

First Semester

- 3 GEOE 466/466L/566/566L Engineering and Environmental Geology/Lab Credits: (2-1) 3
- 3 GEOE 475/475L Groundwater/Lab Credits: (2-1) 3
- 3 GEOE 464 Geological Engineering Design Project I Credits: (0-3) 3
- 1 Approved Elective(s) Credits: 3
Second Semester

- **MEM 304/304L Theoretical and Applied Rock Mechanics/Lab** Credits: (2-1) 3
- **3 Professional Elective(s)** Credits: 3
- **3 GEOE 465 Geological Engineering Design Project II** Credits: (0-3) 3
- **3 GEOE 461 Petroleum Drilling and Production Engineering** Credits: (3-0) 3
- Upper Level Humanities or Social Sciences Elective(s) Credits: 3

Total: 15

130 credits required for graduation

Curriculum Notes

- 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.

1Approved Elective. Must be a course approved by the Department of Geology and Geological Engineering.

2Professional Electives. Students may choose two of the courses listed below

- **GEOE 451/451L Economic Geology/Lab** Credits: (2-1) 3
- **GEOE 482/482L/582/582L Applied Geomorphology/Lab** Credits: (3-0) 3
- **CEE 337 Engineering Hydrology** Credits: (3-0) 3
- **CEE 347 Geotechnical Engineering II** Credits: (3-0) 3
- **CEE 437/437L/537/537L Watershed and Floodplain Modeling/Lab** Credits: (2-1) 3
- **CEE 447/547 Foundation Engineering** Credits: (3-0) 3
- **CEE 474/574 Construction Engineering and Management** Credits: (3-0) 3
- **ME 351/351L Mechatronics and Measurement Systems/Lab** Credits: (3-1) 4
- **MEM 301/301L Computer Applications in Mining/Lab** Credits: (1-1) 2
- **MEM 305 Introduction to Explosives Engineering** Credits: (3-0) 3
- **MEM 307 Mineral Exploration and Geostatistics** Credits: (3-0) 3
- **MEM 405 Mine Permitting and Reclamation** Credits: (3-0) 3
- **MEM 450/550 Rock Slope Engineering** Credits: (3-0) 3

3A grade of “C” or better is required in these courses for graduation with a Geological Engineering B.S.
Contact Information

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Faculty

Professors Anderson, Duke, Paterson, Price and Uzunlar; Associate Professor Masterlark; Assistant Professors Belanger, Oner and
Supporting Faculty

Professors Davis and Stetler; Associate Professor Sawyer; Assistant Professor Katzenstein; Professor Emeritus Rahn; Adjunct Faculty M. Anderson, Bapst, Benton, Iles, Long, McCormick, Roggenthen, and Stamm.

Geology Program (includes Paleontology)

Students majoring in GEOL will earn a BS degree in Geology, which contains five career foci including environmental geology, geospatial technology, mineral resources, paleontology, and petroleum geology. Geologists study geologic process shaping Earth today and through its history to find natural resources, protect the environment, and mitigate geologic hazards. The GEOL program provides a strong background in the basic sciences and geosciences with an emphasis on technical training, research opportunities, and a broad range of field experiences. Courses use the magnificent geologic setting of the Black Hills and adjacent Badlands, and the extensive fossil and mineral specimens in the Museum of Geology. The GEOL degree includes both a geology field mapping course and a two-semester senior research experience. GEOL students train for careers in the geosciences including in environmental applications, mineral and petroleum exploration, paleontological surveying, governmental agencies, museums, academic fields, teaching, and entrepreneurship.

Choosing a career focus

Many different career opportunities are open to students in the geosciences. Students complete a core of geology courses to solidly prepare them for 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 five career paths or select electives from two or more career paths, depending on their interests.

GEOL focus areas include:

- **Environmental Geology**: protection and management of natural resources. Graduates may work for environmental firms, or could do environmental work for petroleum and mineral companies. Many government agencies also hire graduates with these skills.
- **Geospatial Technology**: managing spatial data using GIS, GPS, and remote sensing. 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.
- **Mineral Resources**: exploration and development of mineral resources. Graduates may explore for and assist with extracting these resources.
- **Paleontology**: study of ancient organisms and environments. Graduates in this focus area will often attend graduate school to develop research and teaching careers, but career opportunities also are available in museums, governmental agencies, or with consulting firms that survey and preserve fossil resources.
- **Petroleum Geology**: exploration and development of both conventional and unconventional petroleum systems. Graduates may become employed in oil and gas exploration and extraction, including work in established fields, coal bed methane, or oil shale provinces.

Students are strongly encouraged to consult with their advisor in selecting a career path and electives.

Recommended Electives

Environmental Geology

Recommended electives for environmental geology include:

- **Free electives**
- **AES 201 Introduction to Atmospheric Sciences** Credits: (3-0) 3
- **AES 403/503 Biogeochemistry** Credits: (3-0) 3
- **AES 406/506 Global Environmental Change** Credits: (3-0) 3
- **BIOL 311 Principles of Ecology** Credits: (3-0) 3
- **BIOL 331 Microbiology** Credits: (3-0) 3
- **POLI 407 Environmental Law & Policy** Credits: (3-0) 3
Geology electives
- GEOE 324/324L Engineering Geophysics I/Lab Credits: (2-1) 3
- GEOE 466/466L/566/566L Engineering and Environmental Geology/Lab Credits: (2-1) 3
- GEOE 475/475L Groundwater/Lab Credits: (2-1) 3
- GEOE 482/482L/582/582L Applied Geomorphology/Lab Credits: (3-0) 3
- GEOL 351 Earth Resources and the Environment Credits: (3-0) 3
- GEOL 361 Oceanography I Credits: (3-0) 3
- GEOL 403/503 Regional Field Geology Credits: (3-0) 3
- GEOL 420/520 Introduction to Remote Sensing Credits: (3-0) 3

Geospatial Technology

Recommended electives for geospatial technology include:

- Free electives
- CSC 111/111L Introduction to Computer Programming/Lab Credits: (2-0) 2
- CSC 150/150L Computer Science I/Lab Credits: (2-1) 3
- CSC 250 Computer Science II Credits: (4-0) 4
- CEE 437/437L/537/537L Watershed and Floodplain Modeling/Lab Credits: (2-1) 3
- MEM 201L Surveying for Mineral Engineers Credits: (0-2) 2
- MEM 301/301L Computer Applications in Mining/Lab Credits: (1-1) 2
- Geology electives
- GEOL 417/517 Geospatial Databases Credits: (3-0) 3
- GEOL 419/519 Advanced Geospatial Analysis Credits: (3-0) 3
- GEOL 420/520 Introduction to Remote Sensing Credits: (3-0) 3

Geology majors can simultaneously satisfy elective requirements for the Geology B.S. and a Minor in Geospatial Technology by taking GEOL 417/517, GEOL 419/519, GEOL 420/520, MEM 201L and MATH 381. Students considering the geospatial minor should take GEOL 416/416L/516/516L Intro to GIS by their junior year.

Mineral Resources

Recommended electives for resource geology include:

- Free electives
- MEM 120 Introduction to Mining, Sustainable Development and Introductory Management Credits: (2-0) 2
- MEM 201L Surveying for Mineral Engineers Credits: (0-2) 2
- MEM 204 Surface Mining Methods and Unit Operations Credits: (2-0) 2
- MEM 301/301L Computer Applications in Mining/Lab Credits: (1-1) 2
- MEM 307 Mineral Exploration and Geostatistics Credits: (3-0) 3
- MET 220 Mineral Processing and Resource Recovery Credits: (3-0) 3
- POLS 407 Environmental Law & Policy Credits: (3-0) 3
- Geology electives
  * GEOE 451/451L Economic Geology/Lab Credits: (2-1) 3
  * GEOE 466/466L/566/566L Engineering and Environmental Geology/Lab Credits: (2-1) 3
  * GEOL 351 Earth Resources and the Environment Credits: (3-0) 3
  * GEOL 403/503 Regional Field Geology Credits: (0-1) 1
  * GEOL 420/520 Introduction to Remote Sensing Credits: (3-0) 3
  * GEOL 442/442L/542/542L Optical Petrology/Lab Credits: (2-1) 3

Paleontology
Recommended electives for paleontology include:

- Free electives
- **AES 403/503 Biogeochemistry** Credits: (3-0) 3
- **AES 406/506 Global Environmental Change** Credits: (3-0) 3
- **BIOL 121 Basic Anatomy** Credits: (3-0) 3
- **BIOL 121L Basic Anatomy Lab** Credits: (0-1) 1
- **BIOL 151 General Biology I** Credits: (3-0) 3
- **BIOL 123 Basic Physiology** Credits: (3-0) 3
- **BIOL 153 General Biology II** Credits: (3-0) 3
- **BIOL 311 Principles of Ecology** Credits: (3-0) 3
- Geology electives
- **GEOL 361 Oceanography I** Credits: (3-0) 3
- **GEOL 372 Dinosaurs** Credits: (3-0) 3
- **GEOL 403/503 Regional Field Geology** Credits: (0-1) 1
- **GEOL 471/571 Field Paleontology** Credits: (0-2) 2
- **GEOL 472/472L/572/572L Museum Collections Management/Lab** Credits: (2-1) 3
- **GEOL 473/473L/573/573L Museum Exhibit Design/Lab** Credits: (1-2) 3
- **GEOL 474/574 Paleontological Resource Management** Credits: (3-0) 3

**Petroleum Geology**

Recommended electives for petroleum geology include:

- Free electives
- **POLS 407 Environmental Law & Policy** Credits: (3-0) 3
- Geology electives
- * **GEOE 324/324L Engineering Geophysics I/Lab** Credits: (2-1) 3
- **GEOE 461 Petroleum Drilling and Production Engineering** Credits: (3-0) 3
- * **GEOE 351 Earth Resources and the Environment** Credits: (3-0) 3
- **GEOL 403/503 Regional Field Geology** Credits: (0-1) 1
- **GEOL 420/520 Introduction to Remote Sensing** Credits: (3-0) 3
- * **GEOL 442/442L/542/542L Optical Petrology/Lab** Credits: (2-1) 3
- * **GEOL 476/576 Petroleum Geology** Credits: (3-0) 3

**Professional Development**

The senior year culminates in an individual research project (GEOL 464, GEOL 465) 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 AAPG Student Chapter, Tech Geological Association, the Society of Economic Geologists and the Paleontology Club. Students interested in paleontology and mineralogy may have opportunities to volunteer or work on collections, archives, educational outreach and/or research projects through the Museum of Geology. Internships in industry and government are commonly available and highly recommended.

**Advanced Degrees**

The 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 in medicine or law.
Graduate programs, both master’s and doctoral, are available and involve additional specialization in geology or paleontology and incorporate original research leading to the completion and defense of a thesis or dissertation. Completion of graduate degrees leads to higher-level professional employment including college-level instruction.

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 212/212L, GEOL 341/341L, GEOL 322/322L, and GEOL 410 form a critical sequence that must be taken in the order listed.

Freshman Year

First Semester

- CHEM 112 General Chemistry I Credits: (3-0) 3
- CHEM 112L General Chemistry I Lab Credits: (0-1) 1
- ENGL 101 Composition I Credits: (3-0) 3
- GEOL 201 Physical Geology Credits: (3-0) 3
- GEOL 201L Physical Geology Laboratory Credits: (0-1) 1
- GEOL 110 Explorations in Geology Credits: (2-0) 2

Total: 13

Note: Some students may need preparatory math in the first semester, such as MATH 102 or MATH 120.

Second Semester

- CHEM 114 General Chemistry II Credits: (3-0) 3
- CHEM 114L General Chemistry II Lab Credits: (0-1) 1
- MATH 123 Calculus I Credits: (4-0) 4
- 1Gen. Ed. Goal 3 and Goal 4 Electives Credits: 6

Total: 14

Sophomore Year

First Semester

- MATH 125 Calculus II Credits: (4-0) 4
- PHYS 211/211-A University Physics I/Recitation Credits: (3-0) 3
- 2GEOL 323 Search for Our Past Credits: (3-0) 3
- Free Electives  **Credits: 3**
- ^1 Gen Ed Goal 3 and Goal 4 Electives  **Credits: 3**

**Total: 16**

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**Second Semester**

- **PHYS 213/213-A University Physics II/Recitation**  Credits: (3-0) 3
- **ENGL 279 Technical Communications I**  Credits: (3-0) 3
- **GEOL 212/212L Mineralogy and Crystallography/Lab**  Credits: (2-1) 3
- ^1 Gen Ed Goal 3 and Goal 4 Electives  **Credits: 3**

One of: 3-4 Credits

- **3 MATH 225 Calculus III**  Credits: (4-0) 4
- **3 MATH 381 Introduction to Probability and Statistics**  Credits: (3-0) 3

**Total: 16**

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**Junior Year**

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**First Semester**

- **1 ENGL 289 Technical Communications II**  Credits: (3-0) 3
- **2 GEOL 331/331L Stratigraphy and Sedimentation/Lab**  Credits: (2-1) 3
- **2 GEOL 341/341L Igneous and Metamorphic Petrology/Lab**  Credits: (2-1) 3
- **2 GEOL 416/416L/516/516L Introduction to GIS/Lab**  Credits: (2-1) 3
- ^4 Geology Electives  **Credits: 3**

**Total: 15**

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**Second Semester**

- **2 GEOL 322/322L Structural Geology/Lab**  Credits: (2-1) 3
- ^2 GEOL 451/451L Invertebrate Paleontology/Lab**  Credits: (2-1) 3
- ^4 Geology Electives  **Credits: 3**
- **Free Electives  **Credits: 3**

One of: 3 Credits
•  GEOL 482/482L/582/582L Applied Geomorphology/Lab Credits: (3-0) 3

Total: 15

Summer

•  GEOL 410 Field Geology Credits: (0-6) 6

Total: 6

Senior Year

First Semester

•  GEOL 464 Senior Research I Credits: (0-1) 1
•  4 Geology Electives Credits: 6
•  Free Elective(s) Credits: 3
•  Humanities/Social Science electives Credits: 3

Total: 13

Second Semester

•  GEOL 465 Senior Research II Credits: (0-3) 3
•  Geology Electives Credits: 6
•  Free electives Credits: 3-4

Total: 12-13

120 credits required for graduation

Curriculum Notes
* Course offered in alternate years.

Students must take at least one of these two courses. If both are taken, the second may serve as a geology elective.

\(^1\) 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.

\(^2\) A grade of “C” or better is required in these courses for graduation with a Geology B.S.

\(^3\) Students should consult an advisor when choosing math courses.

\(^4\) Geology electives must have a GEOL or GEOE prefix. At least 9 credits must be taken from 400-level courses. Substitutions must be approved by the department head.

\(^5\) Under exceptional circumstances, a student may petition the department head to substitute geology electives for senior research.

Contact Information

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Faculty

Professor Kellogg; Ervin Pietz Professor Kerk; Associate Professors Matejck, Karlin and Jensen; Assistant Professor Piper; and Instructor Jensen.

Industrial Engineering and Engineering Management

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.

Curriculum

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.

Accreditation

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](http://www.abet.org).

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 | Credits: (4-0) 4
- **CHEM 112** General Chemistry | Credits: (3-0) 3
- Humanities or Social Sciences Elective(s) Credits: 3
- **ENGL 101** Composition | Credits: (3-0) 3
- **CHEM 112L** General Chemistry | Lab Credits: (0-1) 1
- **ME 110/110L** Introduction to Mechanical Engineering/Lab Credits: (3-0) 3 OR
• CEE 117/117L Introduction to CADD/Lab Credits: (1-1) 2

Total: 16

Second Semester

• MATH 125 Calculus II Credits: (4-0) 4
• PHYS 211/211-A University Physics I/Recitation Credits: (3-0) 3
• PSYC 101 General Psychology Credits: (3-0) 3
• IENG 241L Introduction to Quality Methods and Teaming Credits: (0-2) 2
• Humanities or Social Sciences Elective(s) Credits: 3

Total: 15

Sophomore Year

First Semester

• Engineering Fundamentals Elective Credits: 3
• ENGL 279 Technical Communications I Credits: (3-0) 3
• MATH 225 Calculus III Credits: (4-0) 4
• IENG 381 Introduction to Probability and Statistics Credits: (3-0) 3
• PHYS 213/213-A University Physics II/Recitation Credits: (3-0) 3
• PHYS 213L University Physics II Laboratory Credits: (0-1) 1

Total: 17

Second Semester

• IENG 382 Probability Theory and Statistics II Credits: (3-0) 3
• MATH 321 Differential Equations Credits: (3-0) 3
• IENG 215 Cost Estimating for Engineers I Credits: (1-0) 1 AND
• IENG 216 Cost Estimating for Engineers II Credits: (1-0) 1 AND
• IENG 217 Cost Estimating for Engineers III Credits: (1-0) 1
• Engineering Fundamentals Elective Credits: 3
• IENG 302 Engineering Economics Credits: (3-0) 3
• Humanities or Social Sciences Elective(s) Credits: 3

Total: 18
Junior Year

First Semester

- ENGL 289 Technical Communications II Credits: (3-0) 3
- IENG 311/311L Work Methods and Measurements/Lab Credits: (2-1) 3
- IENG 486 Statistical Quality and Process Control Credits: (3-0) 3
- IENG 352 Creativity and Innovation Credits: (1-0) 1
- IENG 354 Marketing Technology Innovations Credits: (1-0) 1
- IENG 362 Stochastic Models Credits: (3-0) 3
- Professional Breadth Elective Credits: 3

Total: 17

Second Semester

- IENG 355 Financing Technology Innovations Credits: (1-0) 1
- IENG 441 Simulation Credits: (3-0) 3
- MATH 353 Linear Optimization Credits: (3-0) 3
- IENG 321/321L Ergonomics/Human Factors Engineering/Lab Credits: (2-1) 3
- Engineering Fundamentals Elective Credits: 3
- Professional Breadth Elective Credits: 4

Total: 17

Senior Year

First Semester

- IENG 425 Production and Operation Management Credits: (3-0) 3
- IENG 331 Safety Engineering Credits: (3-0) 3
- IENG 471 Facilities Planning Credits: (3-0) 3
- IENG 464 Senior Design Project I Credits: (0-2) 2
- IENG 462 Industrial and Engineering Management Profession Credits: (1-0) 1
- Professional Breadth Elective Credits: 3

Total: 15
Second Semester

- IENG 366 Engineering Management Credits: (3-0) 3
- IENG 465 Senior Design Project II Credits: (0-3) 3
- IENG 475/475L Computer-Controlled Manufacturing Systems and Robotics Credits: (2-1) 3
- Humanities or Social Sciences Elective(s) Credits: 3
- Department Elective Credits: 3

Total: 15

130 credits required for graduation

Curriculum Notes

1IENG 341 (Industrial Hygiene) may be substituted during a second semester.

Elective courses must be chosen to satisfy all of the following requirements.

1. Fifteen 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.

Department Electives (6 credits)

Human Engineering (3 credits)

- IENG 331 Safety Engineering Credits: (3-0) 3
- IENG 431/531 Industrial Hygiene Credits: (3-0) 3

Department Breadth (3 credits)

- IENG 353 Commercialization of New Technology Credits: (1-0) 1
- IENG 356 Technology Start Ups Credits: (1-0) 1
- IENG 451/451L Operational Strategies/Lab Credits: (2-1) 3
- IENG 452 Introduction to Six Sigma Credits: (1-0) 1
- IENG 466/566 Project Planning and Control Credits: (3-0) 3
- IENG 492 Topics Credits: 1 to 3

Engineering Fundamentals (11 credits)
Graphics (2 credits)

- ME 110/110L Introduction to Mechanical Engineering/Lab Credits: (3-0) 3
- CEE 117/117L Introduction to CADD/Lab Credits: (1-1) 2

Fundamentals (9 credits from at least two different areas)

Materials

- MET 231 Structures and Properties of Materials Lab Credits: (0-1) 1
- MET 232 Properties of Materials Credits: (3-0) 3

Circuits

- EE 301/301L Introduction to Circuits, Machines, and Systems/Lab Credits: (3-1) 4 OR
- EE 220/220L Circuits I/Lab Credits: (3-1) 4

Statics/Dynamics

- EM 214 Statics Credits: (3-0) 3 OR
- EM 216 Statics and Dynamics Credits: (4-0) 4
- OR
- EM 214 Statics
  
  Credits: 3 AND

- EM 215 Dynamics Credits: (3-0) 3
- OR
- EM 214 Statics
  
  Credits: 3 AND

- ME 221 Dynamics of Mechanisms Credits: (3-0) 3

Thermodynamics

- CBE 222 Chemical Engineering Process Thermodynamics Credits: (3-0) 3
- ENVE 320 OR
- MET 320 Metallurgical Thermodynamics Credits: (4-0) 4
- ME 211 Introduction to Thermodynamics Credits: (3-0) 3
Fluid Mechanics

- EM 327
- EM 328 Applied Fluid Mechanics Credits: (3-0) 3 OR
- EM 331 Fluid Mechanics Credits: (3-0) 3 OR
- ME 331 Thermo Fluid Dynamics Credits: (3-0) 3

Mechanics

- ME 216 Introduction to Solid Mechanics Credits: (3-0) 3 OR
- EM 321 Mechanics of Materials Credits: (3-0) 3

Professional Breadth (12 credits)

- Courses in Department Electives beyond 6-credit requirement
- Courses in Engineering Fundamentals beyond 11 credit requirement

Engineering Breadth

- CENG 244/244L Introduction to Digital Systems/Lab Credits: (3-1) 4
- GEOE 221/221L Geology for Engineers/Lab Credits: (2-1) 3
- CP 297/397/497 Cooperative Education Credits: 1 to 3
- CSC 150/150L Computer Science I/Lab Credits: (2-1) 3
- CSC 250 Computer Science II Credits: (4-0) 4
- CBE 217 Chemical Engineering Material Balances Credits: (3-0) 3 OR
- CBE 317 Chemical Engineering Heat Transfer Credits: (3-0) 3
- CBE 318 Chemical Engineering Mass Transfer Credits: (3-0) 3 OR
- ENVE 318
- MEM 203 Introduction to Mine Health and Safety Credits: (1-0) 1

Mathematics and Science Breadth

- MATH 315 Linear Algebra Credits: (3-0) 3
- MATH 373 Introduction to Numerical Analysis Credits: (3-0) 3
- MATH 423 Advanced Calculus I Credits: (4-0) 4
- MATH 451/551 Math Modeling Credits: (3-0) 3
- MATH 447/547 Design of Experiments Credits: (3-0) 3
- GEOL 201 Physical Geology Credits: (3-0) 3
- BIOL 121 Basic Anatomy Credits: (3-0) 3
- BIOL 121L Basic Anatomy Lab Credits: (0-1) 1
- BIOL 123 Basic Physiology Credits: (3-0) 3
- BIOL 123L Basic Physiology Lab Credits: (0-1) 1
Organizational Management Breadth

- PSYC 331 Industrial and Organizational Psychology Credits: (3-0) 3
- ENGM xxx
- ACCT 210
- ACCT 211
- BADM 350
- BADM 370
- BADM 407
- ECON 201
- ECON 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.

The atmospheric sciences specialization is designed for students whose career goal is meteorology or atmospheric research. Working with faculty from the Atmospheric and Environmental Sciences program, 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. For more information, students should review the resources available on the BSIS website at is.sdsmt.edu

Interdisciplinary Sciences B.S.

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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 professional and health services careers, including but not limited to law enforcement, 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

Interdisciplinary Sciences Program Admission Policy

After successful completion of at least 60 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.

Deadline 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.

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 120 total credits. Minors are available in applied biological sciences, chemistry, 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 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 professional 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 www.gotomines.com/academics/majors/non-degree/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 accelerated one-year certification program offered through Black Hills State University, 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 at www.bhsu.edu/select

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.

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II. English sequence (ENGL 101, ENGL 279, ENGL 289) 9 credits
III. Math, Computer Science, Sciences
   Math and Computer Sciences 1 min. 12
   Biology 2 min. 3
   Chemistry 2 min. 3
   Additional Natural Sciences 2 min. 24
   Other Math, CSC, Sciences min. 18
SUBTOTAL 60
IV. Humanities and Social Sciences
   Humanities general education 6
   Humanities upper division 6
   Social Sciences general education 6
   Social Science upper division 6
SUBTOTAL 24
V. Program Approved Electives 3 18

120 credits required for graduation

Curriculum Notes

1 All IS specializations require MATH 123 Calculus I or a math course requiring MATH 123 as its prerequisite. Some specializations require additional math courses beyond Math 123.

2 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. Chemistry must be at the CHEM 112 level or higher. Biology must be at the BIOL 121 level or higher. Students are expected to identify a science concentration and are encouraged to pursue a science minor as appropriate to their specialization. Students should work with their advisors to determine the most appropriate science courses for their career goals.

3 Engineering courses may be counted toward graduation as electives only.
Thirty-six of the required 120 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 three core courses, spread out over the course of three years. These courses are sequential and cannot be taken concurrently. IS courses cannot be counted for humanities/social science credit.

- **IS 201 Introduction to Science, Technology, and Society** Credits: (3-0) 3 in the sophomore year;
- **IS 401 Writing and Research in the Interdisciplinary Sciences** Credits: (3-0) 3 in the first semester of the senior year; and
- **IS 498 Undergraduate Research/Scholarship** Credits: (0-3) 3 (senior project) in the second semester of the senior year.

**Specialization in Atmospheric Sciences: Curriculum/Course Checklist**

Course sequences may vary by student entry year, math/science placements, availability of AES courses, and career objectives. Students should consult with an atmospheric and environmental sciences/interdisciplinary sciences advisor for a more personalized course of study based on career goals within the atmospheric and environmental sciences.

**Required Courses for the Atmospheric Sciences Specialization Are:**

- All courses and other curriculum requirements for the general IS degree requirement.
- The atmospheric sciences undergraduate series: AES 110, AES 201, AES 401, AES 404, AES 406, AES 430, AES 450, AES 455, AES 460.
- The following mathematics and science courses (including required prerequisites): BIOL 311, CHEM 112, CHEM 112L, CHEM 114, CHEM 114L, CSC 150, PHYS 211, PHYS 213, PHYS 213L, MATH 123, MATH 125, MATH 225, MATH 321.
- Sufficient professional development electives for a total of 120 academic credit hours.

**Freshman Year**

**First Semester**

- 🔸 **CHEM 112 General Chemistry I** Credits: (3-0) 3
- 🔸 **CHEM 112L General Chemistry I Lab** Credits: (0-1) 1
- 🔸 **ENGL 101 Composition I** Credits: (3-0) 3
- 🔸 **AES 110 Orientation to the Atmospheric Sciences** Credits: (1-0) 1
- 🔸 **MATH 123 Calculus I** Credits: (4-0) 4
- 🔸 Gen Ed Humanities/Social Science Elective Credits: 3

Total: 15

**Second Semester**

- 🔸 **CHEM 114 General Chemistry II** Credits: (3-0) 3
- 🔸 **CHEM 114L General Chemistry II Lab** Credits: (0-1) 1


- **CSC 150/150L Computer Science I/Lab** Credits: (2-1) 3
- **MATH 125 Calculus II** Credits: (4-0) 4
- Gen Ed Humanities/Social Science Elective Credits: 6

Total: 17

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**Sophomore Year**

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**First Semester**

- **AES 201 Introduction to Atmospheric Sciences** Credits: (3-0) 3
- **ENGL 279 Technical Communications I** Credits: (3-0) 3
- **MATH 225 Calculus III** Credits: (4-0) 4
- **PHYS 211/211-A University Physics I/Recitation** Credits: (3-0) 3
- Gen Ed Humanities/Social Science Elective Credits: 3

Total: 16

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**Second Semester**

- **ENGL 289 Technical Communications II** Credits: (3-0) 3
- **IS 201 Introduction to Science, Technology, and Society** Credits: (3-0) 3
- **MATH 321 Differential Equations** Credits: (3-0) 3
- **PHYS 213/213-A University Physics II/Recitation** Credits: (3-0) 3
- **PHYS 213L University Physics II Laboratory** Credits: (0-1) 1
- **AES 404/504 Atmospheric Thermodynamics** Credits: 2 or 3

Total: 16

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**Junior Year**

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**First Semester**

- **AES 450 Synoptic Meteorology I** Credits: (3-0) 3
- **AES 460/560 Atmospheric Dynamics** Credits: (3-0) 3
- **BIOL 311 Principles of Ecology** Credits: (3-0) 3
- Upper Division HUM/SS Elective Credits: 3

Total: 12
Second Semester

- **AES 403/503 Biogeochemistry** Credits: (3-0) 3
- **AES 430/530 Radar Meteorology** Credits: (3-0) 3
- **AES 455/555 Synoptic Meteorology II** Credits: (3-0) 3
- 3 AES/SCI/MATH/ENG Electives Credits: 3
- Upper Division HUM/SS Elective Credits: 3

Total: 15

Senior Year

First Semester

- **AES 401/501 Atmospheric Physics** Credits: (3-0) 3
- **IS 401 Writing and Research in the Interdisciplinary Sciences** Credits: (3-0) 3
- 3 AES/SCI/MATH/ENG Electives Credits: 6
- Upper Division HUM/SS Elective Credits: 3

Total: 15

Second Semester

- 3 AES/SCI/MATH/ENG Electives Credits: 8
- **IS 498 Undergraduate Research/Scholarship** Credits: (0-3) 3
- Upper Division HUM/SS Elective Credits: 3

Total: 14

120 credits required for graduation

Curriculum Notes

1 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.

2 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 not be used toward graduation requirements for IS-ATM specialization. Students in the IS-ATM specialization who begin their program with MATH 102 may require an additional 1-2 semester to complete their degree.

3 Students should consult with their atmospheric and environmental sciences/interdisciplinary sciences advisors on the most appropriate AES/science/math/engineering electives for their career paths. Engineering courses are counted as electives. See Atmospheric Sciences Minor.

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 radiography programs. Volunteer work in the community and complementary coursework in the humanities and social sciences are included to help students meet the admissions requirements of these professional schools.

Students planning to enter these professions should consult the programs of study for the schools of interest to them. 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.

For more information, students should review the resources available on the BSIS website at is.sdsmt.edu

Interdisciplinary Sciences B.S.

Contact Information for IS-ATM

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The benefits of the interdisciplinary sciences degree include

- Flexibility in a wide range of study;
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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

Interdisciplinary Sciences Program Admission Policy

After successful completion of at least 60 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.

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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 120 total credits. Minors are available in applied biological sciences, chemistry, 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

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Pre-law/Pre-medicine Study at 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 professional 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 www.gotomines.com/academics/majors/non-degree/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 accelerated one-year certification program offered through Black Hills State University, 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 at www.bhsu.edu/select

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 201, IS 401, IS 498)  
9 credits

II. English sequence (ENGL 101, ENGL 279, ENGL 289)  
9 credits

III. Math, Computer Science, Sciences  
Math and Computer Sciences  
min. 12
Biology  
min. 3
Chemistry  
min. 3
Additional Natural Sciences  
min. 24
Other Math, CSC, Sciences  
min. 18
SUBTOTAL  
60

IV. Humanities and Social Sciences  
Humanities general education  
6
Humanities upper division  
6
Social Sciences general education  
6
Social Science upper division  
6
SUBTOTAL  
24

V. Program Approved Electives  
18

120 credits required for graduation

Curriculum Notes

1 All IS specializations require MATH 123, Calculus I or a math course requiring MATH 123 as its prerequisite. Some specializations require additional math courses beyond Math 123.

2 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. Chemistry must be at the CHEM 112 level or higher. Biology must be at the BIOL 121 level or higher. Students are expected to identify a science concentration and are encouraged to pursue a science minor as appropriate to their specialization. Students should work with their advisors to determine the most appropriate science courses for their career goals.

3 Engineering courses may be counted toward graduation as electives only.

Thirty-six of the required 120 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 three core courses, spread out over the course of three years. These courses are sequential and cannot be taken concurrently. IS courses cannot be counted for humanities/social science credit.

- IS 201 Introduction to Science, Technology, and Society Credits: (3-0) 3 in the sophomore year;
- IS 401 Writing and Research in the Interdisciplinary Sciences Credits: (3-0) 3 in the first semester of the senior year; and
- IS 498 Undergraduate Research/Scholarship Credits: (0-3) 3 (senior project) in the second semester of the senior year.

Pre-Professional Health Sciences (IS-HLTH): 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

- **ENGL 101 Composition** | Credits: (3-0) 3
- **BIOL 151 General Biology** | Credits: (3-0) 3
- **BIOL 151L General Biology Lab** | Credits: (0-1) 1
- **^2 Math/CSC Elective** | Credits: 4
- **^3 Gen Ed Humanities/Social Science Elective** | Credits: 3

Total: 13

Second Semester

- **CHEM 112 General Chemistry** | Credits: (3-0) 3
- **CHEM 112L General Chemistry Lab** | Credits: (0-1) 1
- **BIOL 153 General Biology II** | Credits: (3-0) 3
- **BIOL 153L General Biology II Lab** | Credits: (0-1) 1
- **Math/CSC Elective** | Credits: 3
- **Gen Ed Humanities/Social Science Elective** | Credits: 6

Total: 17

Sophomore Year

First Semester

- **CHEM 114 General Chemistry II** | Credits: (3-0) 3
- **CHEM 114L General Chemistry II Lab** | Credits: (0-1) 1
- **ENGL 279 Technical Communications** | Credits: (3-0) 3
- **IS 201 Introduction to Science, Technology, and Society** | Credits: (3-0) 3
- **BIOL 221 Human Anatomy** | Credits: (3-0) 3
- **BIOL 221L Human Anatomy Lab** | Credits: (0-1) 1
- **Gen Ed Humanities/Social Science Elective** | Credits: 3

Total: 17

Second Semester
- **ENGL 289 Technical Communications II** Credits: (3-0) 3
- Math/CSC Elective Credits: 3
- Upper Division Humanities/Social Science Elective Credits: 3
- **BIOL 326 Biomedical Physiology** Credits: (3-0) 3
- **BIOL 326L Biomedical Physiology Lab** Credits: (0-1) 1

Total: 13

### Junior Year

#### First Semester

- ⁴ Science Electives Credits: 9
- Upper Division HUM/SS Elective Credits: 3
- ⁵ Electives Credits: 3

Total: 15

#### Second Semester

- Science Electives Credits: 6
- Upper Division HUM/SS elective Credits: 3
- Electives Credits: 7

Total: 16

### Senior Year

#### First Semester

- **IS 401 Writing and Research in the Interdisciplinary Sciences** Credits: (3-0) 3
- Science Electives Credits: 5
- Upper Division HUM/SS Elective Credits: 3
- Math/CSC Elective Credits: 3

Total: 14
Second Semester

- IS 498 Undergraduate Research/Scholarship Credits: (0-3) 3
- Science Elective Credits: 3
- Upper Division HUM/SS Elective Credits: 3
- Electives Credits: 6

Total: 15

120 credits required for graduation

Curriculum Notes

Thirty-six (36) credits of the 120 credits required for graduation must be at a junior or senior level (courses numbered 300 or above).

1 All IS specializations require a minimum of thirty (30) semester hours of natural sciences, including a minimum of three (3) semester hours in chemistry (Chem 112 or higher), three (3) semester hours in biology (Biol 121 or higher), and twelve (12) semester hours at the upper division. Of the thirty hours required in natural sciences, a minimum of six (6) credits must be sequential. The Professional Health Sciences specialization requires one year of general biology with labs, one year of general chemistry with labs, and one year of anatomy/physiology with labs. Students should consult with their advisors to determine the sequence of additional science courses appropriate for and required by their career paths, e.g., medicine, dentistry, physical or occupational therapy, chiropractic’s, radiography, and physician assistantships.

2 A minimum of twelve (12) semester hours of approved mathematics and computer sciences is required, including Math 123 or a math course requiring Math 123 as its prerequisite. Math 102 and Math 120 may be used towards graduation requirements for the IS-HLTH degree.. Students should consult with their advisors on the most appropriate math/computer science courses for their career paths.

3 A minimum of twenty-four (24) semester hours of university-approved humanities and social sciences is required. This minimum includes six (6) hours of general education coursework in Humanities, six (6) hours of general education coursework in Social Sciences, six (6) hours of upper division Humanities, and six (6) hours of upper division Social Sciences.

4 Science electives include additional coursework in math, computer science, and the natural sciences. Students should consult with their advisors on the most appropriate science electives for their career paths. Students are expected to identify a science concentration and are encouraged to pursue a science minor (e.g., applied biological sciences or chemistry) as appropriate to their specialization. A total of 60 hours in math, computer science, and natural sciences is required.

5 Elective credits may include additional college coursework at the 100 level or above in math, computer science, sciences, humanities, social sciences, business, military science, or engineering as needed to meet the required minimums or to qualify for a science minor.

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 and law enforcement, as science teachers, or as science lobbyists.

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   SUBTOTAL 60
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   Humanities general education 6
   Humanities upper division 6
   Social Sciences general education 6
   Social Science upper division 6
   SUBTOTAL 24
V. Program Approved Electives 3 18
120 credits required for graduation

Curriculum Notes

1 All IS specializations require MATH 123. Calculus I or a math course requiring MATH 123 as its prerequisite. Some specializations require additional math courses beyond Math 123.

2 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. Chemistry must be at the CHEM 112 level or higher. Biology must be at the BIOL 121 level or higher. Students are expected to identify a science concentration and are encouraged to pursue a science minor as appropriate to their specialization. Students should work with their advisors to determine the most appropriate science courses for their career goals.

3 Engineering courses may be counted toward graduation as electives only.

Thirty-six of the required 120 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 three core courses, spread out over the course of three years. These courses are sequential and cannot be taken concurrently. IS courses cannot be counted for humanities/social science credit.

- IS 201 Introduction to Science, Technology, and Society Credits: (3-0) 3 in the sophomore year;
- IS 401 Writing and Research in the Interdisciplinary Sciences Credits: (3-0) 3 in the first semester of the senior year; and
- IS 498 Undergraduate Research/Scholarship Credits: (0-3) 3 (senior project) in the second semester of the senior year.

Science, Technology, and Society (IS-STS): 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 goals.

Freshman Year

First Semester

- ENGL 101 Composition | Credits: (3-0) 3
- ¹Math/CSC Elective Credits: 4
- ²Science Elective Credits: 4
- ³Gen Ed Humanities/Social Science Elective Credits: 3

Total: 14

Second Semester
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<thead>
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<tr>
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<td>Science Electives</td>
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<tr>
<td>Upper Division HUM/SS Elective</td>
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<td>Science Elective</td>
<td>Credits 8</td>
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<tr>
<td>Elective</td>
<td>Credits 2</td>
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</tbody>
</table>
Second Semester

- Science Electives **Credits: 6**
- Upper Division HUM/SS elective **Credits: 3**
- Elective **Credits: 6**

Total: 15

Senior Year

First Semester

- **IS 401 Writing and Research in the Interdisciplinary Sciences** Credits: (3-0) 3
- Science Electives **Credits: 7**
- Upper Division HUM/SS Elective **Credits: 3**
- Elective **Credits: 2**

Total: 15

Second Semester

- **IS 498 Undergraduate Research/Scholarship** Credits: (0-3) 3
- Science Electives **Credits: 7**
- Upper Division HUM/SS Elective **Credits: 3**
- Elective **Credits: 2**

Total: 15

120 credits required for graduation

Curriculum Notes
Thirty-six (36) credits of the 120 credits required for graduation must be at a junior or senior level (courses numbered 300 or above).

1 A minimum of twelve (12) semester hours of university-approved mathematics and computer sciences is required, including Math 123 or a math course requiring Math 123 as its prerequisite. Math 102 and Math 120 may be used towards graduation requirements. Students should consult with their advisors on the most appropriate math/computer science courses for their career paths.

2 All IS specializations require a minimum of 30 semester hours of natural sciences including a minimum of three (3) semester hours in chemistry at the CHEM 112 level or higher, three (3) semester hours in biology at the BIOL 121 level or higher, and twelve (12) semester hours at the upper division level. Of the thirty hours required in natural sciences, a minimum of six (6) credits must be sequential. 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, biology, computer science, geology, geospatial technology, mathematics, physics) is highly encouraged. A total of 60 hours in math, computer sciences, and natural sciences is required. Students should consult with their advisors to determine the most appropriate science courses and sequence for their career paths.

3 A minimum of twenty-four (24) semester hours of university-approved humanities and social sciences is required. This minimum includes six (6) hours of general education coursework in Humanities, six (6) hours of general education coursework in Social Sciences, six (6) hours of upper division Humanities, and six (6) hours of upper division Social Sciences.

4 Elective credits may include additional college coursework at the 100 level or above in math, computer science, sciences, humanities, 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.

Contact Information

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Faculty

Professors Abata, Dolan, Kalanovic, Kjerengtroen, Korde, Muci-Kuchler and Langerman; Associate Professor Ash, Bedillion, and Widener; Assistant Professors Degen, Ellingsen, Heydari, Romkes, and Shahbazi; Professors Emeritus Buck, Chiang, Gnirk, Krause, and Pendleton; Instructor Lalley.

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,
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**

**First Semester**

- **MATH 123 Calculus** | Credits: (4-0) 4
- **CHEM 112 General Chemistry** | Credits: (3-0) 3
- **CHEM 112L General Chemistry Lab** | Credits: (0-1) 1
- **ME 110/110L Introduction to Mechanical Engineering/Lab** | Credits: (3-0) 3
- **ENGL 101 Composition** | Credits: (3-0) 3
• 1 Humanities or Social Sciences Elective(s) Credits: 3

Total: 17

Second Semester

• MATH 125 Calculus II Credits: (4-0) 4
• PHYS 211/211-A University Physics I/Recitation Credits: (3-0) 3
• CSC 150/150L Computer Science I/Lab Credits: (2-1) 3
• ME 125L Design for Manufacturing Credits: (0-1) 1
• Humanities or Social Sciences Elective(s) Credits: 6

Total: 17

Sophomore Year

First Semester

• ENGL 279 Technical Communications I Credits: (3-0) 3
• ME 210 Statics of Mechanisms Credits: (3-0) 3
• MATH 225 Calculus III Credits: (4-0) 4
• PHYS 213/213-A University Physics II/Recitation Credits: (3-0) 3
• PHYS 213L University Physics II Laboratory Credits: (0-1) 1
• Choose 4 credits from either:
  • ME 264 Electromechanical Systems Product Development and Design Credits: (2-0) 2
  • ME 264L Electromechanical Systems Product Development and Design Lab Credits: (0-2) 2
  • OR
  • ME 269/269L Energy Systems Product Development and Design/Lab Credits: (2-2) 4

Total: 18

Second Semester

• ME 221 Dynamics of Mechanisms Credits: (3-0) 3
• ME 211 Introduction to Thermodynamics Credits: (3-0) 3
• MATH 321 Differential Equations Credits: (3-0) 3
• ME 216 Introduction to Solid Mechanics Credits: (3-0) 3
• MET 231 Structures and Properties of Materials Lab Credits: (0-1) 1
• MET 232 Properties of Materials Credits: (3-0) 3

Total: 16
Junior Year

First Semester

- ENGL 289 Technical Communications II Credits: (3-0) 3
- ME 316 Solid Mechanics Credits: (3-0) 3
- EE 301/301L Introduction to Circuits, Machines, and Systems/Lab Credits: (3-1) 4
- ME 331 Thermo Fluid Dynamics Credits: (3-0) 3
- MATH 373 Introduction to Numerical Analysis Credits: (3-0) 3

Total: 16

Second Semester

- ME 312 Thermodynamics II Credits: (3-0) 3
- ME 313 Heat Transfer Credits: (3-0) 3
- ME 352 Introduction to Dynamic Systems Credits: (3-0) 3
- ME 322 Machine Design I Credits: (3-0) 3
- ME 351/351L Mechatronics and Measurement Systems/Lab Credits: (3-1) 4

Total: 16

Senior Year

First Semester

- ME 477 Mechanical Engineering Design I Credits: (0-2) 2
- IENG 301 Basic Engineering Economics Credits: (2-0) 2
- ME 4XX Mechanical Engr Elective #1 Credits: 4
- Humanities or Social Sciences Elective(s) Credits: 3
- ME 4XX Mechanical Engr Elective # 2 Credits: 3
- ME 481L Advanced Production Development Lab Credits: (0-1) 1

Total: 15

Second Semester
130 credits required for graduation

Curriculum Notes

* A minimum grade of C required for graduation

† 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.

Contact Information

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Mineral Industries 101
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E-mail: Michael.West@sdsmt.edu

Faculty

Douglas W. Fuerstenau Professor Kellar; Professors Howard and Salem; Associate Professors Cross, West, and Widener; Assistant Professors Crawford, Jasthi, and Safarzadeh; Research Scientist Hong; Adjunct Professor Medlin; Distinguished Professor Emeritus Han; Professor Emeritus Stone.

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 three 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-metallic 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](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.

**Curriculum**
Curriculum Flow Diagram for BS Metallurgical Engineering
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

- **5** MATH 123 Calculus I Credits: (4-0) 4
- **6** CHEM 112 General Chemistry I Credits: (3-0) 3
- **1** ENGL 101 Composition I Credits: (3-0) 3
- PE Physical Education Credits: 1
- **3** Humanities or Social Science Elective(s) Credits: 6

Total: 17

Second Semester

- **MATH 125 Calculus II** Credits: (4-0) 4
- **6** CHEM 114 General Chemistry II Credits: (3-0) 3
- OR
- **6** BIOL 151 General Biology I Credits: (3-0) 3
- OR
- **6** BIOL 153 General Biology II Credits: (3-0) 3
- PHYS 211/211-A University Physics I/Recitation Credits: (3-0) 3
- **CHEM 112L General Chemistry I Lab** Credits: (0-1) 1
- **3** Humanities or Social Sciences Elective(s) Credits: 6

Total: 17

Sophomore Year

First Semester

- **MET 232 Properties of Materials** Credits: (3-0) 3
- **MET 231 Structures and Properties of Materials Lab** Credits: (0-1) 1
- **MATH 321 Differential Equations** Credits: (3-0) 3
- PHYS 213/213-A University Physics II/Recitation Credits: (3-0) 3
- **CHEM 114L General Chemistry II Lab** Credits: (0-1) 1
- OR
Second Semester

- MATH 225 Calculus III Credits: (4-0) 4
- EM 321 Mechanics of Materials Credits: (3-0) 3
- OR
- ME 216 Introduction to Solid Mechanics Credits: (3-0) 3
- MET 220 Mineral Processing and Resource Recovery Credits: (3-0) 3
- MET 220L Mineral Processing and Resource Recovery Laboratory Credits: (0-1) 1
- Science Elective Credits: 3
- Free Elective Credits: 2

Total: 16

Junior Year

First Semester

- ENGL 289 Technical Communications II Credits: (3-0) 3
- MET 320 Metallurgical Thermodynamics Credits: (4-0) 4
- MET 351 Engineering Design I Credits: (2-0) 2
- Set A or C Credits: 7

Total: 16

Second Semester

- MET 352 Engineering Design II Credits: (1-0) 1
- MATH 373 Introduction to Numerical Analysis Credits: (3-0) 3
- Set B or D Credits: 11

Total: 15
Senior Year

First Semester

- **MET 464 Engineering Design III** Credits: (0-2) 2
- **IENG 301 Basic Engineering Economics** Credits: (2-0) 2
- 7 Science Elective Credits: 3
- Humanities or Social Sciences Elective(s) Credits: 3
- Set A or C Credits: 7

Total: 17

Second Semester

- **MET 433 Process Control** Credits: (3-0) 3
- **MET 465 Engineering Design IV** Credits: (0-1) 1
- Set B or D Credits: 11

Total: 15

130 credits required for graduation

Curriculum Notes

1 Satisfies General Education Goal #1
2 Satisfies General Education Goal #2
3 Satisfies General Education Goal #3
4 Satisfies General Education Goal #4
5 Satisfies General Education Goal #5
6 Satisfies General Education Goal #6
7 See Advisor for approved Science Electives
8 See Advisor for approved Directed Met Electives
Set A-Fall Even Years

- **MET 422 Transport Phenomena** Credits: (4-0) 4
- Free Elective Credits: 3

Set B-Spring Odd Years

- **MET 321/321L High Temperature Extraction, Concentration, and Recycling/Lab** Credits: (3-1) 4
- 8 Directed Met Elective Credits: 3
- **EE 301/301L Introduction to Circuits, Machines, and Systems/Lab** Credits: (3-1) 4

Set C-Fall Odd Years

- **MET 330 Physics of Metals** Credits: (3-0) 3
- **MET 330L Physics of Metals Lab** Credits: (0-1) 1
- **MET 332 Thermomechanical Processing** Credits: (3-0) 3

Set D-Spring Even Years

- **MET 440/540 Mechanical Metallurgy** Credits: (3-0) 3
- **MET 440L/540L Mechanical Metallurgy Lab** Credits: (0-1) 1
- 8 Directed Met Elective Credits: 3
- **MET 310 Aqueous Extraction, Concentration, and Recycling** Credits: (3-0) 3
- **MET 310L Aqueous Extraction, Concentration, and Recycling Lab** Credits: (0-1) 1
Contact Information

Dr. Lance Roberts
Professor and Department Head
Mining Engineering and Management
MI 235B
(605) 394-1973
E-mail: Lance.Roberts@sdsmt.edu

Faculty

Professors Kliche, Roberts, Tukkaraja, Wyatt and McCormick.

Adjunct Faculty

Dr. Ivy Allard and Mr. Rick Chancellor.

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.

**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 Curriculum/Checklist**

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

**Freshman Year**

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**First Semester**

- **CHEM 112 General Chemistry** | Credits: (3-0) 3
- **CHEM 112L General Chemistry Lab** | Credits: (0-1) 1
- **MATH 123 Calculus** | Credits: (4-0) 4
- **GEOE 110L Introduction to Geological and Mining Engineering/Lab** | Credits: (0-1) 1
- **ENGL 101 Composition** | Credits: (3-0) 3
- Humanities or Social Sciences Elective(s) | Credits: 3
- Physical Education **Credits: 1**

**Total: 16**

**Second Semester**

- **MATH 125 Calculus II** **Credits:** (4-0) 4
- **PHYS 211/211-A University Physics I/Recitation** **Credits:** (3-0) 3
- **MEM 120 Introduction to Mining, Sustainable Development and Introductory Management** **Credits:** (2-0) 2
- **Humanities or Social Sciences Elective(s)** **Credits:** 6

**Total: 15**

**Sophomore Year**

**First Semester**

- **MATH 205 Mining and Management Mathematics I** **Credits:** (2-0) 2
- **PHYS 213/213-A University Physics II/Recitation** **Credits:** (3-0) 3
- **EM 216 Statics and Dynamics** **Credits:** (4-0) 4
- **MEM 201L Surveying for Mineral Engineers** **Credits:** (0-2) 2
- **MEM 203 Introduction to Mine Health and Safety** **Credits:** (1-0) 1
- **ENGL 279 Technical Communications I** **Credits:** (3-0) 3
- **ECON 201 Microeconomics** **Credits:** 3
- **OR**
- **ECON 202 Macroeconomics** **Credits:** 3

**Total: 18**

**Second Semester**

- **MATH 321 Differential Equations** **Credits:** (3-0) 3
- **GEOE 221/221L Geology for Engineers/Lab** **Credits:** (2-1) 3
- **ENGL 289 Technical Communications II** **Credits:** (3-0) 3
- **MET 220 Mineral Processing and Resource Recovery** **Credits:** (3-0) 3
- **MEM 202 Materials Handling and Transportation** **Credits:** (2-0) 2
- **MEM 204 Surface Mining Methods and Unit Operations** **Credits:** (2-0) 2

**Total: 16**
Junior Year

First Semester

- MEM 301/301L Computer Applications in Mining/Lab Credits: (1-1) 2
- MEM 303 Underground Mining Methods and Equipment Credits: (2-0) 2
- MEM 305 Introduction to Explosives Engineering Credits: (3-0) 3
- GEOL 314/314L Mineralogy and Petrology for Mining Engineers/Lab Credits: (3-1) 4
- EE 303/303L Basic Circuits/Lab Credits: (2-1) 3
- MEM 307 Mineral Exploration and Geostatistics Credits: (3-0) 3

Total: 17

Second Semester

- MEM 302 Mineral Economics and Finance Credits: (3-0) 3
- MEM 304/304L Theoretical and Applied Rock Mechanics/Lab Credits: (2-1) 3
- EM 331 Fluid Mechanics Credits: (3-0) 3
- IENG 366 Engineering Management Credits: (3-0) 3
- AES 404/504 Atmospheric Thermodynamics Credits: 2 or 3
- Mining or Engineering Elective Credit: 3

Total: 17

Senior Year

First Semester

- BADM 407 International Business Credits: 3
- MEM 401/401L Theoretical and Applied Mine Ventilation/Lab Credits: (3-1) 4
- MEM 466 Mine Management Credits: (2-0) 2
- MEM 464 Mine Design and Feasibility Study Credits: (0-4) 4
- 'MEM 4XX Mining Technical Elective' Credits: 3

Total: 16

Second Semester
• MEM 4XX Mining Technical Elective Credits: 3
• ECON 304 Managerial Economics Credits: 3
• GEOL 322/322L Structural Geology/Lab Credits: (2-1) 3
• MEM 405 Mine Permitting and Reclamation Credits: (3-0) 3
• HRM 417 Human Resource Management Credits: 3

Total: 15

130 credits required for graduation

Curriculum Notes

1 Elective chosen from a list of approved mining or business courses.

Contact Information

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Electrical Engineering/Physics 235A  
(605) 394-2364  
E-mail: Andre.Petukhov@sdsmt.edu

Faculty
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.

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 Credits: (4-0) 4
- CHEM 112 General Chemistry I Credits: (3-0) 3
- CHEM 112L General Chemistry I Lab Credits: (0-1) 1
- ENGL 101 Composition I Credits: (3-0) 3
- Humanities or Social Sciences Elective(s) Credits: 3

Total: 14

Second Semester

- MATH 125 Calculus II Credits: (4-0) 4
- PHYS 211/211-A University Physics I/Recitation Credits: (3-0) 3
- CHEM 114 General Chemistry II Credits: (3-0) 3
- CHEM 114L General Chemistry II Lab Credits: (0-1) 1
- CSC 150/150L Computer Science I/Lab Credits: (2-1) 3
• Humanities or Social Sciences Elective(s) Credits: 3

Total: 17

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Sophomore Year

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First Semester

• MATH 225 Calculus III Credits: (4-0) 4
• PHYS 213/213-A University Physics II/Recitation Credits: (3-0) 3
• PHYS 213L University Physics II Laboratory Credits: (0-1) 1
• PHYS 275 Relativity Credits: (3-0) 3
• ENGL 279 Technical Communications I Credits: (3-0) 3
• Humanities or Social Sciences Elective(s) Credits: 3

Total: 17

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Second Semester

• MATH 321 Differential Equations Credits: (3-0) 3
• EE 220/220L Circuits I/Lab Credits: (3-1) 4
• ENGL 289 Technical Communications II Credits: (3-0) 3
• PHYS 331 Introduction to Modern Physics Credits: (3-0) 3
• Humanities or Social Sciences Elective(s) Credits: 3

Total: 16

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Junior Year

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First Semester

• MATH 432 Partial Differential Equations Credits: (3-0) 3
• PHYS 341 Thermodynamics Credits: (2-0) 2
• PHYS 343 Statistical Physics Credits: (2-0) 2
• PHYS 312 Experimental Physics Design I Credits: (0-2) 2
• CENG 244/244L Introduction to Digital Systems/Lab Credits: (3-1) 4
• PHYS 451/551 Classical Mechanics Credits: (4-0) 4

Total: 17
Second Semester

- **MATH 315 Linear Algebra** Credits: (3-0) 3
- **PHYS 471/571 Quantum Mechanics** Credits: (4-0) 4
- **PHYS 314 Experimental Physics Design II** Credits: (0-2) 2
- Physics/Math/Computer Science Elective(s) Credits: 3

Total: 12

Senior Year

First Semester

- **PHYS 421/521 Electromagnetism** Credits: (4-0) 4
- **PHYS 412 Advanced Design Projects I** Credits: (0-3) 3
- * **PHYS 361 Optics** Credits: (3-0) 3
- * **PHYS 481/581 Mathematical Physics** Credits: 4

Total: 14

Second Semester

- * **PHYS 433/533 Nuclear and Elementary Particle Physics** Credits: (3-0) 3
- * **PHYS 439/539 Solid State Physics** Credits: 3 or 4
- **PHYS 414 Advanced Design Projects II** Credits: (0-3) 3
- Math/Physics/Computer Science Elective(s) Credits: 3

Total: 13

120 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 15 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.

Courses offered alternate years.

Must be taken for 4 credits.

Contact Information

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Faculty

Professor Detwiler; Emeritus Professors Helsdon, Hjelmfelt and Smith; Associate Professors Capehart, Kliche and Sundareshwar; Assistant Professors French and Kunza; Instructor Clabo; Adjunct Professors Stamm, Johnson, and Monfredo; Adjunct Research Scientist Bunkers.

Atmospheric and Environmental Sciences

The South Dakota School of Mines & Technology offers advanced undergraduate and graduate courses leading to the master of science degree in atmospheric and environmental 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 please use the following link:

Atmospheric and Environmental Sciences Ph.D.

Faculty of Atmospheric and Environmental Sciences are also active research scientists that conduct research with sponsorship from the State of South Dakota and various federal agencies.
The primary objective of the atmospheric and environmental sciences graduate program is to give students a basic understanding of the factors influencing atmospheric phenomena, including solar and terrestrial radiation, fluid dynamics, 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 and environmental 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 Atmospheric and Environmental 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 and environmental sciences at the 500-level or above.
2. Nine additional credit hours of non-atmospheric and environmental sciences electives at the 400-level or above (300-level non-atmospheric and environmental sciences courses can be accepted if approved by the Graduate Education and Research Council), or atmospheric and environmental sciences electives at the 500-level. (Please note undergraduate credit limitations given under “Advanced Degree Grade Requirements” heading on the - Graduate Policies for master of science degrees.)
3. Thesis research - 6 credit hours.

**Other program requirements**

The following program requirements apply to all students in atmospheric and environmental sciences:

- Satisfactory performance on a general coursework exam.
- Registration in AES 690 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 AES 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 and environmental sciences or meteorology must take the following courses: AES 450 Synoptic Meteorology I (not for graduate credit),

AES 401/501 Atmospheric Physics

AES 455/555 Synoptic Meteorology II

. and

AES 460/560 Atmospheric Dynamics

. Additional coursework may be determined by the student’s graduate committee.

**Earth System Science Specialization**
All students will be required to take the following course:

AES 603 Biosphere-Atmosphere 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 and environmental 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 and environmental 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 within the general description of the Atmospheric and Environmental Sciences programs section of the catalog. Students in either specialization may pursue an M.S. degree in atmospheric and environmental 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 and environmental 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 and environmental sciences. They may then enter the graduate program with the necessary background for graduate study in atmospheric and environmental sciences as above.

**Contact Information**
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.

Current focus areas of faculty activity within the program are (1) biomaterials (nanomaterials, bioadhesives, tissue engineering, etc.), (2) computational biomedical engineering (biomechanics, imaging, advanced modeling/simulations, etc.), (3) assistive technology/rehabilitation engineering (advanced prosthetics, control, biomimetics, etc.), and (4) biomolecular and genetic engineering. Students in the programs may be associated with one or more of several SDSM&T research centers and laboratories.

Admission 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 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

- 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.

Courses are offered at both SDSM&T and USD campuses, and students may elect either campus as their campus of residence. Courses offered at SDSM&T are relayed to students at USD by video, and vice versa.

Financial Support

The Biomedical Engineering program has a limited number of Research Assistantships. All students admitted to the program are automatically considered for financial support. Financial support is dependent upon maintaining good academic standing and acceptable research progress in the laboratory.

M.S. Curriculum Requirements, Thesis Option

- **BME 601 Biomaterials** Credits: (3-0) 3
• **BME 602 Anatomy and Physiology for Engineers** **Credits:** (3-0) 3
• **BME 603 Molecular Biology for Engineers** **Credits:** (3-0) 3
• **BME 408/508 Biomedical Engineering** **Credits:** (3-0) 3
• **BME 710 Experimental Design and Data Analysis in Biological Engineering** **Credits:** (3-0) 3
• BME 790 Biomedical Engineering Seminar **Credits:** 3
• **BME 798 Master's Thesis** **Credits:** 12
• **BME Electives** **Credits:** 3

**Total: 33**

**Note(s):**

Elective courses in the area of the student's intended research are to be selected in consultation with the student's advisory committee.

**M.S. Curriculum Requirements, Non-Thesis Option**

• **BME 601 Biomaterials** **Credits:** (3-0) 3
• **BME 602 Anatomy and Physiology for Engineers** **Credits:** (3-0) 3
• **BME 603 Molecular Biology for Engineers** **Credits:** (3-0) 3
• **BME 408/508 Biomedical Engineering** **Credits:** (3-0) 3
• **BME 710 Experimental Design and Data Analysis in Biological Engineering** **Credits:** (3-0) 3
• BME 790 Biomedical Engineering Seminar **Credits:** 3
• **BME 788 Non-Thesis Project** **Credits:** 3
• **BME Electives** **Credits:** 12

**Total: 33**

**Note(s):**

Elective courses in the area of the student's intended research are to be selected in consultation with the student's advisor committee.
Contact Information

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http://www.sdsmt.edu/CBE/

Faculty

Professors Bang, Dixon, Puszynski, Salem and Winter; Associate Professors Benjamin, Gilcrease, Menkhaus (CBE Graduate Program Coordinator), Sani, and Shende; Assistant Professors Groven and Hadley.

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 engineering (for example, ENGM 640, ENGM 720, or ENGM 742) management as part of their required courses for the M.S. in chemical engineering.

An accelerated Master of Science (B.S./M.S.) degree program is available for qualified undergraduates enrolled in engineering B.S. programs at the South Dakota School of Mines and Technology. The accelerated master’s degree program allows B.S. engineering students to take up to nine (9) graduate level credits to simultaneously meet undergraduate and graduate degree program requirements.

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://www.sdsmt.edu/CBE/.
Core Curriculum

A core curriculum for all M.S. candidates in chemical engineering includes the following courses or approved substitutions:

- **CBE 450/550 Systems Analysis Applied to Chemical Engineering** Credits: 2 to 3
- **CBE 612 Transport Phenomena: Momentum** Credits: (3-0) 3
- **CBE 613 Transport Phenomena: Heat** Credits: (3-0) 3
- **CBE 621 Advanced Chemical Engineering Thermodynamics** Credits: (3-0) 3
- Kinetics Elective Credits: 3
- Applied Computation Elective Credits: 3
- **CBE 790 Seminar** Credits: (0.5-0) 0.5

Curriculum Notes

1. Kinetics Elective: **CBE 444/544** or **MES 728**
2. Applied Computation Elective: **CBE 616 /ME 616**, **MATH 432**, or **IENG 486**.
3. A total of one credit hour of seminar is required.

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.
Curriculum

All rules and regulations of the graduate office, included elsewhere, apply to candidates for the degree of Master of Science in civil engineering. Thesis and non-thesis options are available. All full-time MSCE students are required to attend the CEE graduate student seminar series during the course of their studies.

Thesis Option

The MS CENE thesis degree option consists of program of graduate coursework and independent thesis research. Candidacy for the MS CENE degree with the thesis option is contingent upon the student’s aptitude to do research. The thesis must constitute an original contribution to knowledge in civil and environmental engineering and must be successfully defended at a final oral presentation and examination. Students are accepted into the MS CENE thesis option upon the successful submission of a written thesis proposal, public presentation, and the recommendation of a major professor.

The requirements for the MS CENE thesis degree are as follows:

1. A program of at least 31 credit hours of coursework and research. At least 50% of the credit hours must be at the 600 level or higher.
2. At least 15 credit hours of CEE 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. Completion of a satisfactory thesis based upon independent research.
5. Meeting or exceeding prescribed academic standards.

Non-thesis Option

The non-thesis MSCENE degree consists of a program of graduate coursework. A thesis, project paper, or final examination is not required; this is a course-work only degree. The requirements for the MSCENE non-thesis degree are as follows:

1. A program of at least 33 credit hours of coursework, of which no more than 3 credits may be from CEE 691, CEE 788, CEE 790, CEE 791, CEE 798, or CP 697. At least 50% of the credit hours must be at the 600 level or higher.
2. At least 20 credit hours of approved CEE graduate coursework (500 level courses and above).
3. Meeting or exceeding prescribed academic standards.

Research Opportunities

Our faculty have established reputations of excellence and provide exciting opportunities for making your own contributions to cutting-edge research projects such as:

- Developing thermally resistant composite materials for extreme environments.
- Developing stronger, lighter, and more corrosion resistant aircraft components.
- Determining the fate and transport of mercury and arsenic in the environment.
- Developing geo-biological dust control techniques for construction or waste sites.
- Life cycle assessment modeling to prepare agricultural processes for a carbon-constrained and sustainability-aware marketplace.
- Investigating the influence of unsaturated soil characteristics on pavement systems.
- Evaluating response of turbine structures to wind loads.
- Developing a sustainable storm water management program for the Pine Ridge Indian Reservation, South Dakota.
- Characterizing transport of phthalate plasticizers in building materials leaching into the air and adsorbing to particles.
Improving the sustainability and evaluating the environmental suitability of geotechnical structures built with waste materials.

Contact Information

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Faculty

Professors Corwin, Logar, McGough and Weiss; Associate Professors Pyeatt and Riley; Assistant Professors Karlsson and Qiao; Lecturer Schrader.

Computational Sciences and Robotics

The Master of Science in Computational Sciences and Robotics (CSR) is a distinctive degree that combines the intelligent power of the computational sciences with the cutting edge utility present in modern day robotics.

The CSR graduate program provides students with the advanced skills they will need in a rapidly evolving field. The program has the specialized courses to develop technical skills along with a strong emphasis on teamwork, including research projects which involve faculty and students from a variety of disciplines.

The core of the program covers the fundamentals and the students have the opportunity to gain advanced knowledge in focus areas such as pattern recognition, machine intelligence, simulation, computer vision, nonlinear control, digital signal processing and communications.

The primary objective of the CSR program is to give students a basic understanding of the tools required to implement intelligent systems in a dynamic context.

Two options for the degree are offered: thesis and non-thesis. The thesis program provides a research experience which is more focused. The non-thesis option provides the opportunity for students to expand their technical background with additional course work.

Graduates of this program should have a variety of career options in industrial applications, defense, homeland security, space exploration, or graduates can elect to continue their studies with a more advanced degree.

General Background

The entering student will normally have completed a four year degree (B.S.) in either computer science, computer engineering, electrical engineering, 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. 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)
- Discrete Mathematics
- One semester of Linear Algebra
- One semester of Probability and Statistics

Physics Background

- Two semesters of calculus-based physics are suggested but not required.

Computing Background

- Three semesters of programming including a semester of data structures.

GRE

- Recommended but not required.

English Proficiency

International students must meet the Graduate School English requirements. See Graduate School website for details: graded.sdsmt.edu/

Thesis

The candidate who qualifies for the thesis 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 credit of course work is required.
3. The twenty-four credits of course work is divided into core and elective courses.
   a. CSC 415/415L/515/515L Introduction to Robotics/Lab is required.
   b. A minimum of 20 credits of elective courses.
   c. One credit of seminar.
4. A satisfactory thesis based on individual research. The student must present a formal defense of his or her thesis research.

Non-thesis

The candidate who qualifies for the non-thesis degree must satisfy the following requirements:

1. A minimum of 33 credits is required.
2. The 33 credits of course work is divided into core and elective courses.
   a. CSC 415/415L/515/515L Introduction to Robotics/Lab is required.
   b. A minimum of 26 credits of elective courses.
   c. Three credits of a Master’s Project.
   d. One credit of seminar.

Language Requirements
There is no foreign language requirement for the M.S. degree in CSR.

**CSR Electives**

The CSR electives may be found at the CSR website: [www.mcs.sdsmt.edu/csr](http://www.mcs.sdsmt.edu/csr)

**Note(s)**

There is room in the current course rotation for two background courses without having to extend the time of the degree or overload in hours.

**BS-MS Program**

The CSR program has aligned with the B.S. in Computer Science to allow for students to complete both the B.S. program and the M.S. program in five years. Students interested in this program need to apply to the CSR program before or during their junior year. Students accepted into the program can apply up to nine credits of graduate courses towards their undergraduate degree and these same courses will apply to their graduate program of study. Students should inquire about this program at the department office or contact the CSR program coordinator.

**Research Areas and Resources**

Currently active research areas include: Autonomy, Computer Vision, Controls, Localization, Mapping, Motion Planning, and Navigation.

Some of the active research projects include: Unmanned Aerial Vehicle, Autonomous Underwater Vehicle, Unmanned Ground Vehicle, and Intelligent Controls.

The CSR program has dedicated development labs including the recently dedicated L-3 Communications Embedded Systems and Robotics Laboratory. In addition, the interdisciplinary nature of the research and project teams allows students to utilize a variety of resources from around campus. Please see the CSR website for additional information: [www.mcs.sdsmt.edu/csr](http://www.mcs.sdsmt.edu/csr)
Contact Information

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Construction Engineering and Management (Online)

The Master of Science in Construction Engineering and Management (MSCM) degree is designed to provide a program 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 for working students.

Background Requirements

The construction engineering and management coursework is geared towards the working construction professional. Many students enter the program immediately after completing an appropriate undergraduate degree in the traditional disciplines of civil, electrical, mechanical, architectural, or industrial engineering. The successful applicant will have:

1. A GPA of 3.00 or better is required of all applicants.
2. Mathematics courses to include algebra, basic calculus, probability and statistics; and
3. Six semester hours of natural and physical science typically completed as a general education requirement in the fields of geology, astronomy, biology, meteorology, chemistry, and physics to include at least 3 credit hours of chemistry or physics.

The Graduate Record Examination (GRE) is recommended for all applicants from non-ABET accredited institutions. The TOEFL exam is required.
for students whose native language is not English.

An accelerated Master of Science (B.S./M.S.) degree program is available for qualified seniors enrolled in engineering B.S. programs at the South Dakota School of Mines and Technology. The accelerated master’s degree program allows B.S. engineering students to take up to nine (9) graduate level credits to simultaneously meet undergraduate and graduate degree program requirements. The following restrictions apply to the accelerated B.S./M.S. program:

1. The courses must be taken at the 500/600 level as an undergraduate.
2. Only courses taken at SDSM&T are eligible for dual credit. No transferred courses from other institutions will be allowed to count toward the accelerated master’s degree.

Background courses required for admission are posted on the [CEE webpage](#).

### Curriculum

The 33 hour non-thesis MSCEM degree program is an interdisciplinary curriculum that includes 18 hours of construction engineering and management oriented courses and 15 hours of electives allowing a candidate’s program of study to reflect both individual interests and career goals.

The requirements for the MSCEM degree are as follows:

1. A program of at least 33 credit hours of coursework, of which at least 18 credit hours must be CM graduate coursework.
2. At least 18 credit hours of coursework at the 600 level or higher.
3. No more than 3 credits may be [CEM 691](#) or [CEM 791](#).
4. Undergraduate courses (400 level and below) will not count toward graduation.
5. Meeting or exceed prescribed academic standards.
6. All rules and regulations of the graduate office, including elsewhere, apply to candidates for the degree of master of science in construction management.

### Online CEM Courses

- [CM 560 Sustainable Building Systems (SDSU)](#) Credits: (3-0) 3 Fall
- [CEM 608 Construction Contracts](#) Credits: (3-0) 3 Spring
- [CEM 610 Construction Project Management](#) Credits: (3-0) 3 Fall
- [CEM 619 Construction Company Management](#) Credits: (3-0) 3 Summer
- [CEM 665 Construction Equipment Management](#) Credits: (3-0) 3 Fall
- [CEM 706 Managing Sustainable Projects](#) Credits: (3-0) 3 Spring (not available spring 2015)
- [CEM 710 Advanced Construction Management](#) Credits: (3-0) 3 Fall
- [CEM 715 Construction Operations](#) Credits: (3-0) 3 Fall
- [CEM 770 Case Studies in Construction](#) Credits: (3-0) 3 Fall, Spring, Summer
- [CEM 788 Master's Research Problems and Projects](#) Credits: Credit to be arranged. Fall, Spring, Summer
Contact Information

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Faculty

Steven P. Miller Endowed Chair and Professor Whites; Professor Sohraby; Associate Professors Montoya, Tolle, and Anagnostou; Assistant Professors Zhao, Zhang, and Hoover; Instructor Linde and Rausch.

Electrical Engineering

The mission of the graduate program in 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.

Master of Science in Electrical Engineering Graduate Program:

A student may pursue a Master of Science in Electrical Engineering (M.Sc. EE) via one of the following three options: (i) M.Sc. with thesis, (ii) an accelerated M.Sc. (for SDSMT undergrad only), or (iii) a M.Sc. non-thesis (a course work only) degree. The student must focus within one of the
following discipline focus areas, as well as complete the specified requirements for the chosen degree option given below.

- Applied Electromagnetics
- Communications and Networking
- Controls and Autonomous Robotics Systems (CARS)
- Power Systems and Power Electronics

The courses for each area of focus are listed in Section H. Section A describes the detailed requirements for each of the M.Sc. EE degree options offered by the Electrical and Computer Engineering Department. Sections B-G describe additional department requirements, policies and capabilities.

A. Degree Options

(I) M.Sc. EE with Thesis

The thesis M.Sc. EE degree consists of a program of graduate course work and thesis research. Candidature for the M.Sc. EE degree with thesis is contingent on an aptitude to do research and/or development. A limited number of students are accepted into the M.Sc. EE thesis option, on the recommendation of a major professor. Teaching and research assistantships are normally reserved for thesis students. Upon commencement of this program, transfer from a M.Sc. EE thesis degree program to a non-thesis degree would require additional approvals from the student’s existing major professor and department head, and usually is not granted.

The requirements for the M.Sc. EE thesis degree are as follows:

1. A program of at least 30 credit hours of course work and research approved by the student’s major advisor and committee.
2. No more than 15 credit hours (included in the 30 credits required for graduation) can be taken at the 500 level or below (i.e. additional classes should be taken at the 600 level or above).
3. At least 6 credit hours, but no more then 9 credit hours, of thesis research may be included in the 30 credits required for graduation.
4. A satisfactory thesis based upon individual research and development.
5. Meeting or exceeding prescribed ECE and graduate program academic standards.

An example M.Sc. EE with thesis program of study would be:

- 4 courses within focus area, from the set specified in section G.
- 2 courses outside one’s focus area but within the discipline of Electrical and Computer Engineering- also specified in section G.
- 2 courses outside of the discipline of Electrical and Computer Engineering.
- 6-9 credits of thesis research, EE 798

(II) M.Sc. EE Accelerated Option (SDSMT Undergrads Only)

The accelerated M.Sc. EE degree consists of a program of graduate course work and a significant engineering project resulting in a project report and/or a peer-reviewed conference or journal paper. This degree is meant as an honors type of degree available to SDSMT students in good standing at the beginning of their junior year, i.e., a student with a GPA 3.0 or above within ECE related course work. Students desiring to be a part of the program need to apply to the M.Sc. EE graduate program at the beginning of their junior year and be accepted into the M.Sc. EE Accelerated option graduate program. The student must also be accepted into a focus track before taking any classes counted towards their master degree, i.e. obtain a major professor that will mentor their project research within a focus track. These degree students are normally not supported by the department via teaching or research assistantships. However, as an undergraduate student they may qualify for any available undergraduate scholarships. It is encouraged that the student aligns senior project with graduate research project. The degree is designed to allow the student to complete both their B.Sc. EE or B.Sc. CENG, and their M.Sc. EE within a five-year time frame. The student’s engineering project is meant to be completed during the summer between the senior and graduate year and/or the summer just after their graduate year, if needed. Students in this program are assumed to be able to complete their B.Sc. and M.Sc. degree requirement in 5 years.
The requirements for the M.Sc. EE accelerated degree are as follows:

1. A program consisting of at least 32 credit hours of course work is required for this degree approved by the student’s major advisor and the M.Sc. EE Graduate Coordinator (or designee). A student must apply and be admitted into a track at the beginning of their junior year before taking any of their “double counted” courses (specified below) towards the M.Sc. degree. Furthermore, the student must complete one of the following focus area tracks to be eligible for this degree. Courses taken within a focus area track (specified below) are considered “double counted” and apply towards both BS and MS degree program requirements. By completing a track, the 10 credits taken within the track as an undergraduate will then be applied towards both the undergraduate degree as well as their graduate degree. The tracks are listed below:

**Applied Electromagnetics Track Required Courses:**

- EE 481/481L/581/581L Microwave Engineering/Lab Credits: (3-1) 4
- EE 483/483L/583/583L Antennas for Wireless Communications/Lab Credits: (3-1) 4
- EE 465 Senior Design II Credits: (0-2) 2 Senior Design II topic selected should have some Applied EM component (not necessarily focused 100% on Applied EM). Counts towards EE 788 and EE 798 5 credit limit within degree.

**Communications and Networking Track Required Courses:**

- CENG 444/444L/544/544L Computer Networks/Lab Credits: (3-1) 4 *
- EE 421/421L/521/521L Communication Systems/Lab Credits: (3-1) 4
- EE 626 Wireless Communications Credits: (3-0) 3

**Controls and Autonomous Robotics Systems Track Required Courses:**

- EE 453/453L/553/553L Control Systems/Lab Credits: (3-1) 4
- EE 655 Linear System Theory Credits: (3-0) 3
- CENG 414/514 Introduction to Computer Vision Credits: (3-0) 3

**Power Systems and Power Electronics Track Required Courses:**

- EE 431/431L/531/531L Power Systems/Lab Credits: (3-1) 4 *
- EE 439/539 Grid-Connected Power Electronics Devices Credits: (3-0) 3 **
- EE 432/432L/532/532L Power Electronics/Lab Credits: (3-1) 4

*Courses MUST be taken at 500-level.
* Lab credit not double-counted.
** In the future, EE 547 will replace this course.

2. In addition to completing one of the focus area tracks above, the candidate’s program of study must include the following four “common” courses:

- EE 655 Linear System Theory Credits: (3-0) 3 **
- EE 626 Wireless Communications Credits: (3-0) 3
- EE 680 Engineering Electromagnetics Credits: (3-0) 3 **
- EE 431/431L/531/531L Power Systems/Lab Credits: (3-1) 4 *

* Course MUST be taken at 500 level.
* Lab section not taken.
** Planned curriculum change requests.

3. At least 4 credit hours of project research must be part of the candidate’s program of study, i.e. EE 788 Master’s Research Problems/Projects. (No more than 5 credit hours of project research may be applied to the degree requirements. This limit includes any
EE 465 credits that are double counted.) These credits are generally taken during the summer between the senior year and graduate year as well as the summer following the graduate year.

4. A student must prepare, submit, and have accepted a completed project report and/or have an accepted peer-reviewed conference article based upon the individual’s research and development contributions under the direction and collaboration of their major professor, with their major professor’s approval.

5. No more than 16 credit hours (included in the 32 credits required for graduation) can be taken at the 500 level (i.e., additional classes should be taken at the 600 level or above).

6. No more than 9 credits may be taken from outside the ECE department and count towards the 32 credits to graduate.

7. The student must meet or exceed the prescribed academic standards by the department and the graduate school.

An example M.Sc. EE accelerated program of study would be:

- 3 courses within a focus area track (double counted)
- 2 additional courses within a focus area (from the set specified in section G)
- 4 courses from the “common” courses prescribed above (one of these might be double counted within the focus track).
- 1 course outside of the discipline of Electrical and Computer Engineering 4-5 credits of EE 788 (includes any double counted EE 465 credits taken as part of a track above).

(III) M.Sc. EE with Non-Thesis Option:

The non-thesis M.Sc. EE degree consists of a program of graduate course work. A project and/or research are not required and are normally discouraged for the M.Sc. EE non-thesis option. These degree students are normally not supported by the department via teaching or research assistantships.

The requirements for the M.Sc. EE non-thesis degree are as follows:

1. A program of at least 32 credit hours of course work approved by the M.Sc. EE’s graduate coordinator (or designee), which must include the following four “common” courses, is required:

   - EE 655 Linear System Theory Credits: (3-0) 3 **
   - EE 626 Wireless Communications Credits: (3-0) 3
   - EE 680 Engineering Electromagnetics Credits: (3-0) 3 **
   - EE 431/431L/531/531L Power Systems/Lab Credits: (3-1) 4 *

   * Course MUST be taken at the 500 level.
   * Lab section not taken.
   ** Planned curriculum change requests.

2. In addition to the required common courses, the candidate’s program of study must focus within the field of electrical engineering by including a depth of at least four courses within a focus area listed in section G (as in the accelerated program).
3. No more then 16 credit hours (included in the 32 credits required for graduation) can be taken at the 500 level (i.e., additional classes should be taken at the 600 level or above).

4. No more than 12 credits may be taken from outside the ECE department and count towards the 32 credits to graduate.

5. No more than 3 credits of EE 788 Master’s Research Problems/Projects, may be counted towards the 32 credits to graduate.

6. Meeting or exceeding prescribed academic standards by the department and the graduate school.

An example M.Sc. EE non-thesis program of study would be:

- 4 common courses specified above in requirement 1
- 3 courses within a focus area track in addition to the common courses as given above, specified in section G
- 2 courses outside one’s focus area (as specified in section G) but within the discipline, of Electrical and Computer Engineering
- 2 courses outside of the discipline of Electrical and Computer Engineering

B. 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 in English composition and oral presentations.

C. 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.

D. Graduate Committee and Program of Study

The ECE Graduate Committee is the graduate committee for all M.Sc. EE non-thesis degree students, with the ECE Graduate Coordinator or designee serving as the advisor. M.Sc. EE thesis and accelerated students must form a graduate committee with a major professor who has agreed to supervise the research/project of the student. In both cases, the student must arrange to have a faculty member external to the Department of Electrical and Computer Engineering serve on their committee.

Each student must submit a program of study to the candidate’s graduate committee by the end of the first semester of study within their program. 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 a graduate degree in electrical engineering.

E. ECE Faculty Research Areas and Resources

The M.Sc. EE degree offers emphases in the areas of applied electromagnetics, antennas, and microwave, power systems and power electronics, robotics and autonomous systems, communications and networking. 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 Applied Electromagnetics area include:

- ** Electromagnetic materials** (development of accurate and novel materials characterization methods; artificial materials analysis, design, fabrication, and measurement; materials with tailorable properties).
- **Antennas** (electrically small antennas; miniaturization of ultra wideband antennas; reconfigurable / autonomous robotic antennas and antenna arrays; novel antenna reconfiguration methods and phase-change materials; “green” antennas on paper for security
applications; resistively loaded antennas; wideband, coplanar and flexible antennas; metamaterial-inspired antennas).

- **Artificial electromagnetic surfaces** (high impedance and textured surfaces).
- **Microwaves** (Design of passive microwave components and baluns; applications of metamaterial-inspired designs for microwave components and antennas from MHz to THz).
- **Direct-write manufacturing of electromagnetic devices** (antennas and microwave frequency devices; MEMS).

Resources in support of this program include an anechoic chamber, many vector network analyzers, a number of electromagnetic materials characterization systems, impedance analyzers, fast rise time pulse generators and detectors, 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 area of **controls, and autonomous robotics systems (CARS)** include: unmanned systems, autonomous systems, robotics, machine control, fuzzy logic control, nonlinear and adaptive control, visual servo-ing, system identification, fault analysis, modeling of power systems, power systems stability, generator dynamics, and wind power. In addition, a number of robotics and controls projects are performed in association with the School of Mines Center of Excellence in Advanced Manufacturing and Production (CAMP) and Advanced Material Processing Center (AMP). 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, Matlab/Simulink embedded coding tool sets, Kiel compiler tool chains, and printed circuit board manufacturing equipment.

Research activities in the area of **power systems and power electronics** include: the design, analysis and modeling of power system, control and protection of power transmission and distribution grids, electric machines and motor drives, design and control of power electronics converters based on semiconductor switching devices (Si, SiC, and GaN), integration of renewable energy resources (wind, solar, fuel-cell, etc.), and applied power electronics devices in power systems. Resources in support of this program include high-voltage dc power supply, DSpace board with toolbox embedded in Matlab for hardware-in-loop experiment, electric machines, DSP control boards, power modules, various relays, and many other related equipment, tools, and software for lab research.

Research activities in the area of **communications and networking** include problems in the physical layer, MAC, and networking layers, coding and modulation, flow and congestion control; mathematical and simulation techniques for the analysis of networks and communications systems; protocol design, performance evaluation and experimental implementation for wireless networking including cognitive radio networks, vehicular networks, wireless autonomous networks; optical and other technologies.

F. Deficiencies for Non-ECE Undergrads:

Students wishing to pursue a Master’s degree in Electrical Engineering that come from non-accredited Electrical or Computer Engineering Degree programs or equivalent, and ECE programs not equivalent to US-ABET accredited ECE programs, are generally deemed deficient in basic Electrical Engineering skills and knowledge required to perform basic EE tasks at the graduate level. As such, said students will be required to complete additional undergraduate classes before full acceptance into the MSEE degree program. Non-ECE undergrad students are accepted into the MSEE degree program as probationary students until they pass all of their classes listed as deficient. Deficiencies are mastered via successful completion of core competence classes. These classes must be taken by non-major undergrad students and do not count directly towards the required MSEE degree credits. They must be taken and passed with an individual grade of C or better and an overall cumulative grade of B or better within the first two semesters of a students program of study (additional details below). During this period, the student will remain on probationary status within the MSEE degree program.

Required core undergraduate deficiency classes:

- **EE 220/220L Circuits I/Lab Credits: (3-1) 4**
- **EE 221/221L Circuits II/Lab Credits: (3-1) 4**
- **EE 320/320L Electronics I/Lab Credits: (3-1) 4**

Plus two additional classes from the following list depending on student's MSEE focus area:

- **EE 311/311L Systems/Lab Credits: (3-0.5) 3.5**
- **EE 312/312L Signals/Lab Credits: (3-0.5) 3.5**
- **EE 322/322L Electronics II/Lab Credits: (3-1) 4**
- **EE 330/330L Energy Systems/Lab Credits: (3-1) 4**
- **EE 381 Electric and Magnetic Fields Credits: (3-0) 3**
- **EE 382/382L Applied Electromagnetics/Lab Credits: (2.5-0.5) 3**

Additional classes may be required and listed as deficiencies depending on the student's focus area and the student's entering
The formal list of deficiency classes for each MSEE student must be approved by the students' graduate advisor (generally for thesis students) or the MSEE Graduate Coordinator (or designee) (generally for non-thesis MS students) before deficiency classes can be formally taken. Said deficiency classes will be cleared, credited and marked complete when a grade of at least a C or better has been earned for each class with an overall cumulative grade point average (GPA) of B or higher for the complete deficiency class list. Said classes will be formally recorded on the student’s undergrad transcript and their cumulative GPA of B or higher will be calculated based solely on the deficiency class list, i.e. no additional classes will be taken into account when calculating the minimum passing cumulative deficiency GPA. After the deficiency class list has been completed as described above and the student is in good standing, they will be removed from probationary status and accepted as a full MSEE degree student within the program.

G. Additional ECE Graduate Policies:

1. Non-US Undergraduate Student Admissions:

WES (or similar) translation of foreign transcripts is required for regular admissions within the M.Sc. EE applications.

2. Regular Admissions:

Engineering graduates from an accredited US or Canada ABET-accredited school are required to have a minimum GPA of 3.0 on a 4.0 scale (i.e., a B average is required). Likewise, international students are required to have a minimum equivalent GPA of 3.0 on a 4.0 scale. Moreover, students from a non-ABET-accredited US Canada school or from an international school are additionally required to have a minimum score of 50% on the Quantitative Reasoning section of the GRE test.

In addition, to the minimums listed above, all students must submit a statement of purpose discussing why they wish to obtain a masters degree in electrical engineering at SDSMT. They must also submit three letters of reference in support of their pursuit of a graduate degree at SDSMT.

3. Probationary Admission:

A student not meeting the minimum requirements for regular admissions can be admitted under a probationary status with a minimum GPA of 2.75 on a scale of 4.0 given the additional requirements that a department faculty member agrees to serve as the students advisor. The student is then converted to a non-probationary student after passing, with a B average, at least 9 credits of approved M.Sc. EE program of study courses while attending SDSMT.

4. Probationary Status:

A student may continue their studies within the M.Sc. EE program at SDSMT while on probation for up to 2 semesters, if the student has not cleared up the issues that placed them in probation at the end of the second semester on probation the student will be required to end their graduate work in the M.Sc. EE program at SDSMT at that time.

5. GPA Graduation Policy:

In order to be eligible to graduate from the M.Sc. EE graduate program a student must obtain at least a 3.0 GPA on SDSMT’s 4.0 GPA scale within the classes listed on their approved program of study, i.e. the student must have a program of study GPA of B or better for graduation.

H. M.Sc. EE Classes Organized by Area of Focus:

Students should select their program of study classes from the list below with consultation and approval by their major advisor and/or committee or by the M.Sc. EE graduate program coordinator (or his designee) (depending on the degree option being sought). Classes not from this list maybe approved on a case-by-case basis by a student’s advisor and/or committee or by the M.Sc. EE graduate program coordinator (or his designee) (depending on the degree option being sought).

Applied Electromagnetics focus area courses:

- EE 481/481L/581/581L Microwave Engineering/Lab Credits: (3-1) 4
• EE 483/483L/583/583L Antennas for Wireless Communications/Lab Credits: (3-1) 4
• EE 680 Engineering Electromagnetics Credits: (3-0) 3
• EE 792 Topics Credits: 1 to 4 (Topics Options Below)
• Topics: Advanced Antenna Engineering Credits: 3
• Topics: Computational Electromagnetics Credits: 3
• Topics: Advanced Microwave Engineering Credits: 3
• Topics: Finite Difference Time Domain Credits: 3
• Topics: Guided Waves and Material Measurements Credits: 3
• * Courses MUST be taken at 500 level.

Communications and Networking (CN) focus area courses:

• * CENG 444/444L/544/544L Computer Networks/Lab Credits: (3-1) 4
• * EE 421/421L/521/521L Communication Systems/Lab Credits: (3-1) 4
• EE 623 Random Signals and Noise Credits: (3-0) 3
• EE 626 Wireless Communications Credits: (3-0) 3
• * EE 483/483L/583/583L Antennas for Wireless Communications/Lab Credits: (3-1) 4
• EE 655 Linear System Theory Credits: (3-0) 3
• EE 621 Information and Coding Theory Credits: (3-0) 3
• EE 622 Statistical Communication Systems Credits: (3-0) 3
• * Courses MUST be taken at 500 level.

CN out of department – out of discipline courses:

• MATH 421 Complex Analysis Credits: (3-0) 3
• MATH 423 Advanced Calculus I Credits: (4-0) 4
• MATH 424 Advanced Calculus II Credits: (4-0) 4
• MATH 432 Partial Differential Equations Credits: (3-0) 3
• * MATH 451/551 Math Modeling Credits: (3-0) 3
• MATH 471 Numerical Analysis I Credits: (3-0) 3
• * Course MUST be taken at 500 level.

Controls and Autonomous Robotics Systems (CARS) focus area courses:

• * EE 453/453L/553/553L Control Systems/Lab Credits: (3-1) 4
• * EE 456/456L/556/556L Digital Control Systems/Lab Credits: (3-1) 4
• * CENG 414/514 Introduction to Computer Vision Credits: (3-0) 3
• EE 655 Linear System Theory Credits: (3-0) 3
• EE 757 Intelligent Control Systems Credits: (3-0) 3
• EE 623 Random Signals and Noise Credits: (3-0) 3
• EE 641 Digital Systems Design Credits: (3-0) 3
• EE 643 Advanced Digital Systems Credits: (3-0) 3
• EE 751 Advanced Digital Control Systems Credits: (3-0) 3
• EE 753 Optimal Control Theory Credits: (3-0) 3
• EE 754 Nonlinear Control Theory Credits: (3-0) 3
• EE 792 Topics Credits: 1 to 4 (Topics Options Below)
• Topics: Adaptive Control Credits: 3
• Topics: System Identification Credits: 3
• Topics: State Space Digital Control Credits: 3
• Topics: Linear Control Systems Credits: 3
• EE 755 Linear State Space Control Credits: (3-0) 3
CARS out of department – out of discipline courses:

- **CSC 415/415L/515/515L Introduction to Robotics/Lab** Credits: (2-1) 3
- **CSC 416/416L/516/516L Introduction to Autonomous Systems/Lab** Credits: (2.5-0.5) 3
- **CSC 449/549 Pattern Recognition** Credits: (3-0) 3
- **CSC 752 Computer Vision** Credits: (3-0) 3
- **CSC 761 Advanced Artificial Intelligence** Credits: (3-0) 3
- **CSC 762 Neural Networks** Credits: (3-0) 3
- **MATH 421 Complex Analysis** Credits: (3-0) 3
- **MATH 423 Advanced Calculus I** Credits: (4-0) 4
- **MATH 424 Advanced Calculus II** Credits: (4-0) 4
- **MATH 432 Partial Differential Equations** Credits: (3-0) 3
- **MATH 451/551 Math Modeling** Credits: (3-0) 3
- **MATH 471 Numerical Analysis I** Credits: (3-0) 3
- **ME 455/455L Vehicle Dynamics/Lab** Credits: (2-1) 3
- **ME 673 Applied Engineering Analysis I** Credits: (3-0) 3
- **ME 683 Advanced Mechanical System Control** Credits: (3-0) 3
- **ME 781 Robotics** Credits: (3-0) 3

Courses MUST be taken at 500 level.

Power Systems and Power Electronics focus area courses:

- **EE 431/431L/531/531L Power Systems/Lab** Credits: (3-1) 4
- **EE 547 Advanced Power Systems** Credits: 3 *
- **EE 432/432L/532/532L Power Electronics/Lab** Credits: (3-1) 4
- **EE 435/535 Power Transmission and Distribution** Credits: (3-0) 3
- **EE 448/448L Power Generation** Credits: (3-0) 3
- **EE 439/539 Grid-Connected Power Electronics Devices** Credits: (3-0) 3
- **EE 437 Electronic Motor Drives** Credits: (3-0) 3
- **EE 449 Power Conversion** Credits: (3-0) 3
- **EE 633 Power Systems Analysis I** Credits: (3-0) 3
- **EE 634 Power System Analysis II** Credits: (3-0) 3

* This course will be offered in future terms

Courses MUST be taken at 500 level.

Contact Information

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School of Mines Faculty

Professor Kellogg; Ervin Pietz Professor Kerk; Associate Professors Matejcik, Karlin and Jensen; Assistant Professor Piper; and Instructor Jensen.

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.

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 Credits: 1 to 4
- ENGM 640 Business Strategy Credits: (3-0) 3

Management

- ENGM 742 Engineering Management and Labor Relations Credits: (3-0) 3
- IENG 466/566 Project Planning and Control Credits: (3-0) 3
Quantitative Methods

- ENGM 631 Optimization Techniques Credits: (3-0) 3
- ENGM 732 Stochastic Models in Operations Research Credits: (3-0) 3
- ENGM 745 Forecasting for Business and Technology Credits: (3-0) 3

Operations Management

- ENGM 663 Operations Planning Credits: (3-0) 3
- ENGM 620 Quality Management Credits: (3-0) 3

Note(s):

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.

- ENGM 640 Business Strategy Credits: (3-0) 3
- ENGM 650 Safety Management Credits: (3-0) 3
- ENGM 655 Ergonomics for Managers Credits: (3-0) 3
- ENGM 675 Legal and Ethical Issues in Engineering Management Credits: (3-0) 3
- ENGM 625 Innovation and Commercialization Credits: (3-0) 3
- ENGM 720 Statistical Process Control Credits: (3-0) 3
- ENGM 732 Stochastic Models in Operations Research Credits: (3-0) 3
- ENGM 745 Forecasting for Business and Technology Credits: (3-0) 3
- ENGM 792 Topics Credits: 1 to 3

Transfer Credits

Students may transfer up to 12 credits from another accredited institution or from another SDSM&T graduate degree program provided they meet the graduate office guidelines and program approval.

Sample Programs

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** Credits: 1 to 4
- **ENGM 742 Engineering Management and Labor Relations** Credits: (3-0) 3
- **IENG 466/566 Project Planning and Control** Credits: (3-0) 3
- **ENGM 663 Operations Planning** Credits: (3-0) 3
- **ENGM 631 Optimization Techniques** Credits: (3-0) 3
- Elective Credits: 3
- **ENGM 620 Quality Management** Credits: (3-0) 3
- **ENGM 732 Stochastic Models in Operations Research** Credits: (3-0) 3
- **ENGM 650 Safety Management** Credits: (3-0) 3
- **ENGM 745 Forecasting for Business and Technology** Credits: (3-0) 3
- **ENGM 788 Master's Research Problems/Project** Credits: Credit to be arranged.

Total: 32

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**Student B**

- **ENGM 661 Engineering Economics for Managers** Credits: 1 to 4
- **ENGM 742 Engineering Management and Labor Relations** Credits: (3-0) 3
- **IENG 466/566 Project Planning and Control** Credits: (3-0) 3
- **ENGM 663 Operations Planning** Credits: (3-0) 3
- **ENGM 631 Optimization Techniques** Credits: (3-0) 3
- Elective Credits: 3
- **ENGM 732 Stochastic Models in Operations Research** Credits: (3-0) 3
- **ENGM 720 Statistical Process Control** Credits: (3-0) 3

Total: 3

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**Contact Information**

Dr. Laurie Anderson  
Department of Geology and Geological Engineering  
Mineral Industries 303  
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**Geology Faculty**

Professors L. Anderson, Duke, Paterson, Price and Uzunlar; Associate Professor Masterlark; Assistant Professors Belanger, Oner and Pagnac; Professors Emeritus Fox, Lisenbee, Martin and Redden; Adjunct Faculty Bapst, Benton and McCormick; Haslem Post-doctoral Fellow Boyd.

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**Geological Engineering Faculty**

Professors Davis and Stetler; Assistant Professors Katzenstein and Sawyer; Professor Emeritus Rahn; Adjunct Faculty M. Anderson, Iles, Long, Roggenthen, and Stamm.

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**Geology and Geological Engineering**

The Department of Geology and Geological Engineering offers advanced study leading to M.S. and Ph.D. degrees 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 and program requirements. The available coursework and current faculty expertise support the following areas of concentration.
1. Energy and Resources
2. Geocomputing
3. Groundwater and Environment
4. Paleontology*
5. Petrology and Mineral Resources
6. Structural Geology and Tectonics
7. Underground Science and Engineering (SURF)

* Students concentrating in paleontology at the Master's level may apply for the separate M.S. in Paleontology.

The Accelerated BS/MS option is available for this degree.

**Background Requirements for M.S.**

The Graduate Record Examination (GRE) is required of all applicants. The TOEFL exam is required for students whose native language is not English. Many factors contribute to the success of an application, including the goals statement, coursework, grades, test scores, work experience, recommendations, and availability of a faculty member in the student’s anticipated research area. In general we prefer to see a GPA of 3.0 or above and GRE scores greater than the 50th percentile. Different specializations have different background coursework requirements, as described below.

**Background Expected for Geology Specialization**

Incoming students are expected to have substantial preparation in general science, math, and geological sciences; successful applicants will ideally have completed the subjects listed below. The student’s graduate committee may require that deficiencies important to the student’s area of interest be remedied by taking additional undergraduate courses that will not count towards the graduate degree credit requirements.

- Calculus I and II
- Statistics
- General Chemistry I and II
- General Physics I and II, or General Biology I and II
- Stratigraphy/Sedimentation
- Petrology
- Structural Geology
- Field Geology

**Background Expected for Geological Engineering Specialization**

Incoming students are expected to have substantial preparation in science, math, geological sciences, and engineering; successful applicants will ideally have completed the subjects listed below. The student’s graduate committee may require that deficiencies important to the student’s area of interest be remedied by taking additional undergraduate courses that will not count towards the graduate degree credit requirements.

- Calculus I, II, and III
- Differential Equations
- General Chemistry I and II
- General Physics I and II
- Stratigraphy/Sedimentation
- Petrology
- Structural Geology
- Statics
- Mechanics of Materials
- Fluid Mechanics, or Rock Mechanics

**MS in Geology and Geological Engineering Program Requirements**

The M.S. thesis option requires 30 credits, including six (6) credits of thesis research and twenty-four (24) credits of coursework. No more than 15 credits may come from courses at the 500-level or below. The non-thesis option includes 32 credits of coursework and is available to students at the discretion of the department head (see below for non-thesis M.S. guidelines. Candidates for the M.S. degree must fulfill all degree requirements of the graduate office and the program, including an oral comprehensive exam covering course material.
Geology Specialization Requirements

The candidate's committee is responsible for assisting the student in developing a program of study that prepares the student for his/her intended field of study.

**GEOL 700 Research Methods**
is required the first fall semester of enrollment. In addition, the program of study must include at least one GEOL/GEOE course emphasizing field/analytical methods and one GEOL/GEOE course emphasizing computational methods. The student's advising committee determines the courses that meet these criteria.

Geological Engineering Specialization Requirements

All M.S. students in the Geological Engineering specialization are expected to focus in one of the three areas of groundwater/environmental, geomechanics, or energy/mineral resources. The candidate's committee is responsible for assisting the student in developing a program of study that prepares the student for his/her intended focus area.

**GEOE 700 Research Methods**
is required the first fall semester of enrollment. In addition, the program of study must include at least one GEOL/GEOE course emphasizing field methods, one GEOL/GEOE course emphasizing analytical methods and one GEOL/GEOE course emphasizing computational methods. The student's advising committee determines the courses that meet these criteria.

Non-Thesis Option Guidelines

The department considers the thesis option to be its primary degree and strongly prefers that all M.S. students complete a thesis. However, under certain circumstances a non-thesis degree may be granted to accommodate special circumstances. Central to the decision is the judgment whether the student constitutes a quality graduate of the program as compared to other graduates, despite the lack of a completed thesis.

Students considering the non-thesis option are strongly encouraged to discuss it with their committee prior to making a request. The request must be made in writing to the department head with a justification as to why the non-thesis option is being requested. The department head will provide the letter to the student's graduate committee and ask for a written recommendation regarding the request. Both the student and committee letters will be provided to the department Graduate Committee, which will also consider the request and write a recommendation. These recommendations may include conditions that must be completed before the degrees may be awarded. The department head will make the decision guided by the input from these two committees, and inform the student of the decision, including any conditions that may be attached to completing the non-thesis option.

The following conditions must be met by the student to be eligible to apply for the non-thesis option:

1. The student should have a graduate GPA of 3.5 or higher.
2. The student must have been continuously registered in the program or on a formally approved leave of absence since the first semester in residence to be eligible for a non-thesis option.
3. The student must have been actively working towards a thesis project with regular communication with the advisor during the months prior to the non-thesis request.
4. The student must complete a significant project and write up the results in a project report, in lieu of a formal thesis. The student's committee will make the determination whether the student's work may be deemed a significant contribution to the profession. This requirement may include content-appropriate work performed for an employer.
5. If the student has received research funding, he or she is obligated to work with the faculty member who provided the funds to establish a written plan to fulfill any outstanding obligations to the research effort, which shall be submitted with the non-thesis request. Should they not be able to agree on the plan, the matter will be referred to the department Graduate Committee for resolution.

The following circumstances should be considered when deciding whether the non-thesis option is appropriate.

1. Has the student encountered external circumstances that would make the completion of the thesis unreasonably difficult or time-consuming?
2. Does the student have outstanding obligations to a funded or important project that might not otherwise be completed?
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, Corey, Fong, Howard, Petukhov, Salem, Sinden, Sobolev, and Wells; Associate Professors Cross, DeVeaux, Heglund, West, Widener, and Zhu; Assistant Professors Bai, Corwin, Crawford, Jasthi, Oszwaldowski, Safarzadeh, and Smirnova; 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.

Core Courses

- MES 601 Fundamentals of Materials Engineering Credits: (4-0) 4
- MES 603 Condensed Matter Physics Credits: (4-0) 4
- MES 604 Chemistry of Materials Credits: (4-0) 4
In addition

- **MES 790/890 Seminar** Credits: (1-0) 1 is a required course.

Additional Information

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.

Contact Information

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**Lisa Carlson, MBA**  
Director  
Recruitment and Graduate Programs/ WiSE  
Civil Mechanical 131  
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Faculty

Professors Abata, Dolan, Kalanovic, Kjerengtroen, Korde, Muci-Kuchler and Langerman; Associate Professors Ash, Bedillion, and Widener; Assistant Professors Degen, Ellingsen, Heydari, Romkes, and Shahbazi; Professors Emeritus Buck, Chiang, Gnirk, Krause, and Pendleton.

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
   - ME 788 Master's Research Problems/Projects Credits: Credit to be arranged.

   Remaining 28 hours are taken
   - (maximum) at the 400/500 level Credits: 9
   - (minimum) at the 600/700 level Credits: 19

2. Thesis:

   Total credit hours required: 30
   - ME 798 Thesis Credits: Credit to be arranged.

   Remaining 24 hours are taken
   - (maximum) at the 400/500 level Credits: 9
   - (minimum) at the 600/700 level Credits: 15

Accelerated Master of Science Option

The Mechanical Engineering Department has an accelerated M.S. degree option for academically motivated students. Students admitted to the accelerated program may apply up to nine (9) credits of 400/500/600 level coursework taken as an undergraduate for M.S. degree requirements to either the thesis or non-thesis option. All elective courses must be approved in advance of registration by major professor or program coordinator. Students must apply for normal graduate school admission and notate their desire for the accelerated option on the application. In order for credits to be double counted, students must be admitted into the program before beginning the courses.

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 then choose a major professor, and with the major professor’s assistance develop a plan of study. The plan is due by the mid-term of the student’s second semester in residence. The plan will be submitted to the program coordinator, who will disseminate 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** Credits: (3-0) 3
- **ME 773 Applied Engineering Analysis II** Credits: (3-0) 3

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** Credits: (3-0) 3
- **ME 613 Transport Phenomena: Heat** Credits: (3-0) 3
- **ME 616 Computations in Transport Phenomena** Credits: (3-0) 3
- **ME 618 Conduction Heat Transfer** Credits: (3-0) 3
- **ME 619 Convection Heat Transfer** Credits: (3-0) 3
- **ME 620 Radiation Heat Transfer** Credits: (3-0) 3

**Mechanical Systems**

- **ME 623 Advanced Mechanical Vibrations** Credits: (3-0) 3
- **ME 680 Advanced Strength of Materials** Credits: (3-0) 3
- **MES 713 Advanced Solid Mechanics I** Credits: (3-0) 3
- **MES 714 Advanced Solid Mechanics II** Credits: (3-0) 3
- **ME 770 Continuum Mechanics** Credits: (3-0) 3 OR
- **MES 770 Continuum Mechanics** Credits: (3-0) 3

**Manufacturing and Controls**

- **ME 683 Advanced Mechanical System Control** Credits: (3-0) 3
- **ME 781 Robotics** Credits: (3-0) 3
- **ME 625 Smart Structures** Credits: (3-0) 3
Additional Information

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.
Contact Information

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Mining Engineering

The Master of Science in Mining Engineering is designed to provide a program of advanced study in either management-oriented or technically-oriented disciplines for candidates planning a career in the mining, mine management or underground construction field. The available course work and current faculty expertise support the following emphasis areas:

1. Applied geo-mechanics, including advanced rock mechanics, rock slope stability, and tunneling;
2. Mining engineering management, including mineral economics and finance, and mining business management; and
The course delivery is geared towards both campus and hybrid-distance delivery modes.

**Background Requirements**

The mining engineering coursework is geared primarily towards the working professional in the mining industry who requires distance delivery of the courses, although students can be admitted directly to the on-campus program. In either case, the student should have completed an appropriate undergraduate engineering degree. For those holding a non-mining engineering undergraduate degree the applicant should have significant experience in the mining or underground construction industry. Additionally, an undergraduate course in probability and statistics is highly recommended.

**Curriculum**

The thirty-two credit hour non-thesis MS MinE degree consists of a program of acceptable graduate work culminating in the preparation, presentation and defense of a final project report. The interdisciplinary curriculum includes 12 core credits (4 courses) that are required for all students, 9 credit hours of specialization courses and 9 credit hours of elective courses approved by the student’s major advisor. Additionally, the final project and report, normally completed in the student’s last semester, is two credit hours.

The requirements for the MS MinE degree are as follows:

- A program of at least 32 credits of course work (including 2 credit hours for the final project) which must include as required core courses:
  - MEM 550-Rock Slope Engineering or MEM 525-Advanced Rock Mechanics
  - MEM 510-Advanced Mineral Economics for Managers
  - MEM 580-Advanced Explosives and Blasting
  - MEM 610-Topics in Mineral Economics, Sustainability and Mine Regulation.
- At least 18 credit hours of approved graduate-level elective coursework (500 level courses and above).
- Meeting or exceeding prescribed academic standards.
- Preparation, presentation and successfully defending the required final project, which would normally be a practical project approved by the student’s major advisor.
- Complying with all rules and regulations of the Graduate office, which are presented elsewhere in this catalog.

**Required Core Courses:**

- **MEM 450/550 Rock Slope Engineering** Credits: (3-0) 3
- **OR**
- **MEM 425/525 Advanced Rock Mechanics** Credits: (3-0) 3
- **AND**
- **MEM 410/510 Advanced Mineral Economics for Managers** Credits: (3-0) 3
- **MEM 480/580 Advanced Explosives and Blasting** Credits: (3-0) 3
- **MEM 610 Topics in Mineral Economics, Sustainability and Mine Regulation** Credits: (3-0) 3

**Recommended Elective Courses**

Students may use approved graduate-level transfer courses from another institution for up to 6 credit hours of elective credit, provided they are included in the approved Program of Study.

All 500- and 600-level courses offered through the Mining Engineering and Management Department (MEM courses) are acceptable elective coursework.

The following lists acceptable out-of-department classes which can be used as electives for any of the three specializations (NOTE: Not all the following courses are taught via distance delivery methods):

- **MEM 415/515 Advanced Mining Geotechnical Engineering** Credits: (3-0) 3
- **MEM 420/520 Advanced Tunneling and Underground Excavation** Credits: (3-0) 3
- **MEM 430/530 Resource Industry Mergers and Acquisitions** Credits: (3-0) 3
- **MEM 433/433L/533/533L Computer Applications in Geoscience Modeling/Lab** Credits: (3-1) 4
Note(s):

* Acceptable 400-level class with permission of major advisor.
Contact Information

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Faculty

Professors Anderson and Price; Assistant Professors Belanger and Pagnac; Associate Director and Instructor Shelton; Haslem Post-doctoral Fellow Boyd; Adjunct Faculty Bapst and Benton; Professors Emeritus Fox and Martin.

MS in Paleontology

The Department of Geology and Geological Engineering offers advanced study leading to an M.S. degree in paleontology. Resources available to graduate students in paleontology include the extensive collections of the Museum of Geology. The M.S. in paleontology has a strong emphasis on field-based research as well as courses in museum studies.

The Accelerated BS/MS option is available for this degree.

The thesis option is the only option for the M.S. in paleontology.

Background Requirements

The GRE exam is required of all applicants. The TOEFL exam is required for students whose native language is not English. Many factors contribute to the success of an application, including the goals statement, coursework, grades, test scores, work experience, recommendations, and availability of a faculty member in the student's anticipated research area. In general we prefer to see a GPA of 3.0 or above and GRE scores greater than the 50th percentile.

Incoming students are expected to have substantial preparation in general science, math, and geological sciences; successful applicants will ideally have completed the subjects listed below. The student's graduate committee may require that deficiencies important to the student's area of interest be remedied by taking additional undergraduate courses that will not count towards the graduate degree credit requirements.
Candidates for the M.S. degree must fulfill all degree requirements of the graduate office and of the program, including an oral comprehensive exam covering course material.

**MS in Paleontology Degree Requirements**

The M.S. thesis option requires 30 credits, including twenty-four (24) credits of coursework and six (6) credits of thesis research. No more than 15 credits may come from courses at the 500-level or below. Required courses include:

- **GEOL 700 Research Methods**
  - is required in the first fall semester of enrollment.
- **GEOL 771/771L Paleobiology/Lab**
- **GEOL 471/571 Field Paleontology** or **GEOL 604 Advanced Field Geology**

Candidates will work with their advisors and committee members to develop an approved program of study to fulfill the remaining coursework requirements.

**Additional Information**

All thesis samples, specimens, and their documentation collected while a registered student must be curated into the collections of the Museum of Geology.
Contact Information

Dr. Andre G. Petukhov  
Department of Physics  
Electrical Engineering/Physics 235A  
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Faculty

Professors Corey, Detwiler, Petukhov, Sobolev, Wells; Associate Professors Schnee and Strieder, Assistant Professors Bai, Corwin, French, Oszwaldowski, and Reichenbacher; Instructor Dowding; Emeriti Professors Foygel and Helsdon.

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 Credits: (3-0) 3
- PHYS 723 Electrodynamics II Credits: (3-0) 3
- PHYS 743 Statistical Mechanics Credits: (3-0) 3
- PHYS 751 Theoretical Mechanics Credits: (3-0) 3
- PHYS 771 Quantum Mechanics I Credits: (3-0) 3
- PHYS 773 Quantum Mechanics II Credits: (3-0) 3
- PHYS 790 Seminar Credits: 1 to 3

Subtotals: 19
Electives

- PHYS 433/533 Nuclear and Elementary Particle Physics Credits: (3-0) 3
- PHYS 439/539 Solid State Physics Credits: 3 or 4
- PHYS 481/581 Mathematical Physics Credits: 4
- MES 603 Condensed Matter Physics Credits: (4-0) 4
- PHYS 683 Mathematical Physics II Credits: (3-0) 3
- PHYS 691 Independent Study Credits: 1 to 3
- PHYS 692 Topics Credits: 1 to 3
- PHYS 739 Condensed Matter Physics I Credits: (3-0) 3
- PHYS 749 Condensed Matter Physics II Credits: (3-0) 3
- PHYS 775 General Relativity Credits: (3-0) 3
- PHYS 779 Group Theory Credits: (3-0) 3
- PHYS 781 Nuclear and Particle Physics Credits: (3-0) 3
- PHYS 783 Quantum Field Theory Credits: (3-0) 3
- PHYS 785 Astrophysics and Cosmology Credits: (3-0) 3
- PHYS 787 Research Credits: 1-9 *
- PHYS 788 Master's Research Problems/Projects Credits: 1-5 **
- PHYS 791 Independent Study Credits: 1 to 3
- PHYS 792 Topics Credits: 1 to 3
- PHYS 798 Thesis Credits: 1 to 9

Subtotal: 29-58

Curriculum Notes

* Offered by SDSU

** Offered by SDSU/USD
**Contact Information**

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**Faculty**

Professors Davis, Detwiler, Duke, Fontaine, Fox, Kenner, Price and Stetler; Associate Professors Capehart, Kliche, Riley, Stone and Sundareshwar; Assistant Professors Benning and French; Adjunct Professors Stamm, Johnson, and Monfredo; 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 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 understanding atmospheric dynamics, precipitation patterns, vegetation distribution and condition, topographic factors, and more. Similarly, in terrestrial ecosystems, rapid exchange of CO₂, 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 Ph.D. program links expertise in atmospheric and environmental 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 ability 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 wildfire 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 state-of-the-art computers equipped 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 Ph.D. 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 core of basic and specialized scientific and technical knowledge;
- An understanding of the basic scientific tools of measuring, monitoring, and modeling;
- The ability to apply these tools to understand atmospheric, hydrologic and land-surface interactions;
- 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;
- The understanding and application of professional methods and ethics in their work; and
- 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 and environmental 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

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>AES 808 Fundamental Problems in Engineering and Science</td>
<td>3</td>
</tr>
<tr>
<td>AES 690 Seminar</td>
<td>1</td>
</tr>
<tr>
<td>Research Program Academic Courses*</td>
<td>32</td>
</tr>
<tr>
<td>AES 898 Dissertation</td>
<td>maximum 36</td>
</tr>
</tbody>
</table>
Total required for the degree  72

* Ph.D. Candidates can apply up to 24 supported classroom credit hours from their previous M.S. program into their Ph.D. program of study pending approval by the candidate’s committee.

** Ph.D. Candidates can apply up to 6 supported research credit hours from their M.S. program into their Ph.D. program of study pending approval by the candidate’s committee.

The required academic courses include:

- AES 690 Seminar Credits: (1-0) 1
- AES 808 Fundamental Problems in Engineering and Science Credits: (3-0) 3

Program 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. Courses supporting the AES program are offered at the School of Mines to fulfill this 3 credit elective course requirement. These courses are offered in Atmospheric and Environmental Sciences and also programs on campus that include Civil and Environmental Engineering, Geology and Geological Engineering, Chemistry and Applied Biological Sciences, Chemical and Biological Engineering, and Mathematics and Computer Sciences. 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:

Cross-listed 400/500-level coursework must be taken at the 500-level to apply.

- AES 401/501 Atmospheric Physics Credits: (3-0) 3
- AES 406/506 Global Environmental Change Credits: (3-0) 3
- AES 403/503 Biogeochemistry Credits: (3-0) 3
- AES 405/505 Air Quality Credits: (3-0) 3
- AES 515 Earth Systems Modeling Credits: (3-0) 3
- AES 520 Remote Sensing for Research Credits: (3-0) 3
- AES 430/530 Radar Meteorology Credits: (3-0) 3
- AES 540 Atmospheric Electricity Credits: (3-0) 3
- AES 455/555 Synoptic Meteorology II Credits: (3-0) 3
- AES 460/560 Atmospheric Dynamics Credits: (3-0) 3
- AES 603 Biosphere-Atmosphere Interactions Credits: (3-0) 3
- AES 612 Atmospheric Chemistry Credits: (3-0) 3
- AES 625 Scaling in Geosciences Credits: (3-0) 3
- AES 643 Precipitation Physics and Cloud Modification Credits: (3-0) 3
- AES 644 Numerical Dynamics and Prediction Credits: (3-0) 3
- AES 660 Atmospheric Dynamics II Credits: (3-0) 3
- AES 670 Boundary Layer Processes Credits: (3-0) 3
- AES 673 Mesometeorology Credits: (3-0) 3
- CEE 634 Surface Water Hydrology Credits: (3-0) 3
- CEE 421/521 Aqueous Geochemistry Credits: (3-0) 3
- CEE 426/526 Environmental Engineering Unit Operations and Processes Credits: (3-0) 3
- CEE 427/527 Environmental Engineering Biological Process Design Credits: (3-0) 3
- CEE 528L Advanced Treatment Plant Design
- CEE 433/533 Open Channel Flow Credits: (3-0) 3
Additional Information

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.
Contact Information

Dr. Richard Sinden (Program Coordinator)
Department of Chemistry and Applied Biological Sciences
Chemistry/Chemical Engineering Bldg, Room 2219
(605) 394-1678
E-mail: Richard.Sinden@sdsmt.edu

Dr. Grant Crawford
Associate Program Coordinator
Department of Materials and Metallurgical Engineering

Dr. Linda DeVeaux
Associate Program Coordinator
Department of Chemistry and Applied Biological Sciences

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 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) biomaterials (nanomaterials, bio-adhesives, tissue engineering, etc.), (2) computational biomedical engineering (biomechanics, imaging, advanced modeling/simulations, etc.), (3) assistive technology/rehabilitation engineering (advanced prosthetics, control, bio-mimetic, etc.), (4) bio-molecular and genetic engineering. Students in the programs may be associated with one or more of several SDSM&T research centers and laboratories.

Admission 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.

Doctoral students will possess a high level of expertise in their specialized area of research - biomaterials, computational biomedical engineering, rehabilitation engineering/assistive technology, or bio-molecular/genetic engineering. This competency will be developed through focused research, which culminates in the doctoral dissertation. Graduates of the program 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 field.

Ph.D. students are expected to participate in the creation of new knowledge and applications in biomedical engineering.

Courses are offered at both SDSM&T and USD campuses, and students may elect either campus as their campus of residence. Courses offered at SDSM&T are relayed to students at USD by video, and vice versa.

Financial Support

The Biomedical Engineering program has a limited number of Research Assistantships. All students admitted to the program are automatically considered for financial support. Financial support is dependent upon maintaining good academic standing and acceptable research progress in the laboratory.

Ph.D. Curriculum Requirements

- **BME 601 Biomaterials** Credits: (3-0) 3
- **BME 602 Anatomy and Physiology for Engineers** Credits: (3-0) 3
- **BME 603 Molecular Biology for Engineers** Credits: (3-0) 3
- **BME 408/508 Biomedical Engineering** Credits: (3-0) 3
- **BME 710 Experimental Design and Data Analysis in Biological Engineering** Credits: (3-0) 3
- **BME 790 Biomedical Engineering Seminar** Credits: 6
- **BME Research and Dissertation** Credits: 36
- *BME Electives** Credits: 6
- **Additional Electives** Credits: 9

Total: 72

Note(s):

Elective courses in the area of the student’s intended research are to be selected in consultation with the student’s advisory committee.

*A list of possible BME electives can be found in the course description section of this catalog.

**Each Ph.D. program of study is individually designed to meet the goals of the student. Courses from a variety of areas, including materials and metallurgical engineering, mechanical engineering, chemistry, electrical and computer engineering, genetics and molecular biology, and mathematics and computer science, may be used to fulfill the elective requirements in a manner intended to complement the student’s research.

Each student is also required to pass a comprehensive examination and defend the dissertation. There is no language requirement for the BME Ph.D. program. Detailed information on examination policies, admission to candidacy, and defense of dissertation may be found in the Graduate Education section of this catalog and the BME Graduate Handbook.
Contact Information

Dr. Todd Menkhaus  
Department of Chemical and Biological Engineering  
(605) 394-2422 Fax: (605) 394-1232 Dept: (605) 394-2421  
E-mail: Todd.Menkhaus@sdsmt.edu  
http://www.sdsmt.edu/CBE/  

Faculty

Professors Bang, Dixon, Puszynski, Salem and Winter; Associate Professors Benjamin, Gilcrease, Menkhaus (CBE Graduate Program Coordinator), Sani, and Shende; Assistant Professors Groven and Hadley.

CBE Ph.D. Program Advisory Council

Professors Bang, Dixon, Menkhaus (Program Coordinator) and Winter; Associate Professor Gilcrease and Benjamin; Assistant Professor Groven.

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://www.sdsmt.edu/CBE/. The modern Chemical and Biological Engineering and Chemistry (CBEC) building houses the CBE research laboratories.

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 National Science Foundation Industry/University Cooperative Research Center (NSF I/UCRC) for BioEnergy Research and Development (CBeRD). This unique national center is focused on bio-based energy and chemical feedstocks, is comprised of four universities, including the SDSM&T, North Carolina State University, State University of New York - Stony Brook, University of Hawaii, and more than 20 industries and state and federal laboratories. Students participating in CBeRD I/UCRC Center research are 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 these two research centers - pretreatment, conversion, extremophiles, separations, and process simulation and economic analysis - rely 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 materials and advanced manufacturing including 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/. The CBE research laboratories along with CAPE, CBeRD, and CBRD provide CBE Ph.D. students a wealth of modern resources to participate in cutting-edge research funded by the National Science Foundation, the Department of Energy, the Department of Defense, the Department of Agriculture, NASA, 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 fundamental chemical 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:

<table>
<thead>
<tr>
<th>Category</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required courses (minimum 6 credits from Chemical Engineering and 6 credits from Biological Engineering focus areas) selected from the two focus area lists</td>
<td>24</td>
</tr>
<tr>
<td>Required seminar</td>
<td>2</td>
</tr>
<tr>
<td>Minimum required research credits</td>
<td>30</td>
</tr>
<tr>
<td>Minimum electives</td>
<td>12</td>
</tr>
<tr>
<td>TOTAL</td>
<td>80</td>
</tr>
</tbody>
</table>

**Curriculum Notes**

1 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.

2 Elective courses may be selected from the two focus area lists, from the example elective list, or 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.

**Focus Area — Chemical Engineering**

Students pursuing a Ph.D. in Chemical and Biological Engineering must take the 500 and above level courses, not the 400 level courses.

- **CBE 444/544 Reactor Design** Credits: (3-0) 3
- OR
- **CBE 450/550 Systems Analysis Applied to Chemical Engineering** Credits: 2 to 3
- **CBE 612 Transport Phenomena: Momentum** Credits: (3-0) 3
- **CBE 613 Transport Phenomena: Heat** Credits: (3-0) 3
- **CBE 616 Computations in Transport Phenomena** Credits: (3-0) 3
- **CBE 621 Advanced Chemical Engineering Thermodynamics I** Credits: (3-0) 3
- **CBE 714 Transport Phenomena: Mass** Credits: (3-0) 3
- **CBE 728 Heterogeneous Kinetics** Credits: (3-0) 3

**Focus area — Biological Engineering**

Students pursuing a Ph.D. in Chemical and Biological Engineering must take the 500 and above level courses, not the 400 level courses.

- **CBE 484/584 Fundamentals of Biochemical Engineering** Credits: (3-0) 3
- **CBE 484L/584L Biochemical Engineering Laboratory** Credits: (0-1) 1
- **CBE 603 Molecular Biology for Engineers** Credits: (3-0) 3
- **CBE 735 Bioseparations** Credits: (3-0) 3
- **CBE 741 Microbial and Enzymatic Processing** Credits: (3-0) 3
Required courses (Seminar and Research)

Two (2) credits of CBE 890 Seminar and a minimum of thirty (30) credits of CBE 898D Dissertation are required.

- **CBE 890 Seminar** Credits: (0.5-0) 0.5
- **CBE 898D Dissertation** Credits: 1 to 12

**Example elective courses**

Students pursuing a Ph.D. in Chemical and Biological Engineering must take the 500 and above level courses, not the 400 level courses.

- **CBE 424/524 Molecular Modeling and Simulation** Credits: (3-0) 3
- **CBE 445/545 Oxidation and Corrosion of Metals** Credits: (3-0) 3
- **CBE 455/555 Pollution Phenomena and Process Design** Credits: (3-0) 3
- **CBE 474/574 Polymer Technology** Credits: 2 to 3
- **CBE 474L/574L Experimental Polymer Technology** Credits: (0-1) 1
- **CBE 475/575 Advances in Processing and Nanoengineering of Polymers** Credits: (2-0) 2
- **CBE 476/576 Organosilicon Polymer Chemistry and Technology** Credits: (1-0) 1
- **CBE 485/585 Renewable and Sustainable Energy** Credits: (3-0) 3
- **CBE 485L/585L Renewable and Sustainable Energy Lab** Credits: (0-1) 1
- **CBE 488/588 Applied Design of Experiments for the Chemical Industry** Credits: (2-0) 2
- **CBE 489/589 Composites Manufacturing** Credits: (1-0) 1
- **CBE 791 Independent Study** Credits: 1 to 4
- **CBE 792 Topics** Credits: 1 to 4
- **CBE 890 Seminar** Credits: (0.5-0) 0.5
- **CBE 894 Internship** Credits: 1 to 6
- **CHEM 482/582 Environmental Chemistry** Credits: (3-0) 3
- **MES 712 Interfacial Phenomena** Credits: (3-0) 3
- **NANO 701 Nano Materials** Credits: (3-0) 3
- **ENGM 631 Optimization Techniques** Credits: (3-0) 3
- **ENGM 720 Statistical Process Control** Credits: (3-0) 3

**Contact Information**

Dr. Sangchul Bang  
Professor and CENE Graduate Coordinator  
Civil and Environmental Engineering (CEE)  
Email: Sangchul.Bang@sdsmt.edu  
Phone: (605) 394-2440  
Office: CM 238

**Faculty**

Professors Bang, Fontaine, Gribb, and Kenner; Associate Professor Stone; Assistant Professors Benning, Cetin, Gadhamshetty, Nam, Robinson, and Shearer.

**Background Requirements**

All SDSM&T Graduate College admissions requirements apply to the Civil and Environmental Engineering (CENE) Ph.D. program. In addition, a
GPA of 3.00 or better is required, as is the Graduate Record Examination (GRE) for applicants except School of Mines graduates.

Students with a B.S. degree who apply to the Ph.D. program will be admitted to the CENE M.S. program until they have accumulated sufficient course credits for an M.S. degree. Admission to the CENE Ph.D. program is normally limited to qualified students who have already earned an M.S. degree in Civil or Environmental Engineering or a related field. Students holding an M.S. but with extensive undergraduate deficiencies may be placed into the CENE M.S. program until these deficiencies are remedied. Students placed into the M.S. under one of these two circumstances will be admitted to the CENE Ph.D. program after passing the qualifying exam.

Incoming students should have completed the courses presented below. Deficiencies in these areas must be remedied by taking the necessary coursework prior to enrollment in the doctoral program.

Calculus I, II, and III
Differential Equations
Probability and Statistics
General Chemistry I and II
General Physics I
Statics

All CENE doctoral students are also expected to have completed the appropriate background courses for their intended research emphasis area (refer to the CENE Ph.D. Program Handbook: http://www.sdsmt.edu/Academics/Departments/Civil-and-Environmental-Engineering/Roadmap-To-Success/). Additional subjects may be required by the student’s graduate committee. These requirements will be documented as a formal component of a student’s Program of Study.

Qualifying Exam

All CENE 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. program due to undergraduate deficiencies must take the qualifying exam in the semester immediately following completion of all deficiencies. Students entering with a completed M.S. degree will take the qualifying exam 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 CENE Ph.D. program coordinator Dr. Sangchul Bang; 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 student’s Advisory Committee. The paper should reflect a sustained effort and culminate in an analysis of potentially significant research problems. The identified problems need not match the eventual dissertation topic.

The Comprehensive Examination and Admission to Ph.D. Candidacy

When the student’s program of coursework has been substantially completed, she or he will undertake the comprehensive examination for admission to candidacy. This exam will consist of two parts:

- A written examination based on emphasis area courses as specified by the student’s advisory committee. This will be a 3-hour written examination. The written examination will be graded by the student’s advisory committee prior to the dissertation proposal presentation.
- The student will prepare a written dissertation research proposal and complete an oral presentation of that proposal in the presence of the CENE faculty and the student’s Advisory Committee, preferably as a presentation of the CENE graduate seminar series.

Satisfactory completion of the comprehensive examination requires successful completion of the written exam and the dissertation proposal defense, with no more than one member of the graduate student advisory committee votes against passing. If the student has conditional pass (usually requiring a re-write and/or re-submital of the proposal), the committee shall inform the student promptly as to how and when the conditions may be removed. Admission to candidacy should normally be passed at least 5 months before the dissertation is defended. Additional details about the comprehensive exam are presented in the CENE Ph.D. Program Handbook.

Dissertation Defense Requirements

The dissertation defense will be scheduled at any time after the student has completed the required coursework and after the graduate student advisory committee is satisfied that the dissertation is an acceptable manuscript. A schedule of exam and defense deadlines is available on the Graduate Education web page. Additional details regarding scheduling and other requirements are presented in the CENE Ph.D. Program Handbook.

The dissertation defense may not be scheduled during the period of university final examinations. The student will be required to give an oral presentation, open to the public, on the major findings of his/her research. CENE doctoral candidates are expected to present their dissertation defenses during the CENE graduate seminar series. An oral examination will follow the presentation, led by the student’s major professor with only
the student's advisory committee in attendance. The student's advisory committee will question the student to test the quality and completeness of the research. Additional details about the dissertation defense procedure may be found on the Graduate Education web page and in the CENE Ph.D. Program Handbook.

**Curriculum**

The CENE Ph.D. program consists of 90 total credits for qualified students entering the program with a B.S. degree. Nine credit hours of required coursework to ensure competency in research methods and communication skills. The student's graduate advisory committee will assess the student's academic transcripts and approve a combination of coursework (between 15 and 27 credits) and dissertation (between 24 and 36 credits) that meets all degree requirements.

**Requirements**

- **MATH 447/547 Design of Experiments** Credits: (3-0) 3
- **GEOL 808 Fundamental Problems in Engineering and Science** Credits: (3-0) 3
- 1 CEE 790 Seminar Credits: (1-0) 3
- 2, 3 Elective Credits: 45-57
- 4 Dissertation Research Credits: 24-36

**Total: 90**

**Curriculum Notes**

1. Course taken for credit 3 times for a total of 3 credits. CENE Ph.D. students are expected to attend and participate in the CENE seminar series whether they are taking it for credit or not.

2. Elective courses may be selected from the focus area lists or from other graduate courses as a part of a student's Program of Study, subject to approval of his/her major professor and advisory committee.

3. Students entering with a M.S. degree in Civil or Environmental 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 CENE graduate committee.

4. Students entering with a M.S. degree in Civil or Environmental Engineering or a closely related discipline may apply a maximum of six (6) course credit hours toward the research credit requirements, subject to approval of the CENE graduate committee.

**Recommended Electives - Civil Engineering Materials Focus Area**

- **CEE 655/655L Applied Composites/Lab** Credits: (2-1) 3
- CBE 658 Composites Manufacturing Credits: (3-0) 3
- **EM 680 Advanced Strength of Materials** Credits: (3-0) 3
- ME 715 Advanced Composite Materials Credits: (3-0) 3

**Recommended Electives - Environmental/Water Resources Focus Area**

- **GEOE 663/663L Groundwater Geochemistry/Lab** Credits: (2-1) 3
- **CEE 730 Statistics Methods in Water Resources** Credits: (3-0) 3
- **CEE 731 Contaminant Fate and Transport** Credits: (3-0) 3
Recommended Electives- Structures Focus Area

- CEE 651 Advanced Steel Design Credits: (3-0) 3
- CEE 653 Reinforced Concrete Design Credits: (3-0) 3
- CEE 657 Advanced Structural Analysis Credits: (3-0) 3
- EM 680 Advanced Strength of Materials Credits: (3-0) 3
- CEE 753 Stability of Metal Structures Credits: (3-0) 3
- ME 736 Advanced Finite Element Methods Credits: (3-0) 3
- CEE 743 Advanced Soil Mechanics Credits: (3-0) 3
- CEE 745 Advanced Foundations Credits: (3-0) 3
- CEE 746 Stability of Soil and Rock Slopes Credits: (3-0) 3

Additional Information

For program supervision purposes, the CENE Ph.D. program coordinator is the graduate advisor until the major professor is appointed. The major professor is responsible for providing academic advising and supervising the student’s dissertation research. The graduate office representative on the student’s dissertation committee must be selected from outside of the department. Detailed information about the program is included in the CENE Ph.D. Program Handbook.

Contact Information

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Geology Faculty

Professors L. Anderson, Duke, Price and Uzunlar; Associate Professor Masterlark; Assistant Professors Belanger, Oner and Pagnac; Professors Emeritus Fox, Lisenbee, Martin, Paterson, and Redden; Adjunct Faculty Bapst, Benton and McCormick; and Haslem Post-doctoral Fellow Boyd.

Geological Engineering Faculty

Professors Davis and Stetler; Associate Professor Sawyer; Assistant Professors Katzenstein and Sawyer; Professor Emeritus Rahn; Adjunct Faculty M. Anderson, Iles, Long, Roggenthen, and Stamm.

PhD 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.

1. Energy and Resources
2. Geo-computing
3. Groundwater and Environment
4. Paleontology
5. Petrology and Mineral Resources
6. Structural Geology/Tectonics
7. Underground Science and Engineering (SURF)

* Students concentrating in Paleontology at the Master’s level may apply for the separate M.S. in Paleontology.

Background Requirements for Ph.D.

The Graduate Record Examination (GRE) is required of all applicants. The TOEFL exam is required for students whose native language is not English. Many factors contribute to the success of an application, including the goals statement, coursework, grades, test scores, work experience, recommendations, and availability of a faculty member in the student’s anticipated research area. In general we prefer to see a GPA of 3.0 or above and GRE scores greater than the 50th percentile. Different specializations have different background coursework requirements, as described below.

Background Expected for Geology Specialization (including Paleontology)

Incoming students are expected to have substantial preparation in general science, math, and geological sciences; successful applicants will ideally have completed the subjects listed below. The student’s graduate committee may require that deficiencies important to the student’s area of interest be remedied by taking additional undergraduate courses that will not count towards the graduate degree requirements.

- Calculus I and II
- Statistics
- General Chemistry I and II
- General Physics I and II, or General Biology I and II
- Stratigraphy/Sedimentation
- Petrology
- Structural Geology
- Field Geology

Background Expected for Geological Engineering Specialization

Incoming students are expected to have substantial preparation in science, math, geological sciences, and engineering; successful applicants will ideally have completed most of the subjects listed below. The student’s graduate committee may require that deficiencies important to the student’s area of interest be remedied by taking additional traditional undergraduate courses that will not count towards the graduate degree credit requirements.
Calculus I, II, and III
Differential Equations
General Chemistry I and II
General Physics I and II
Stratigraphy/Sedimentation
Petrology
Structural Geology
Statics
Mechanics of Materials
Fluid Mechanics, or Rock Mechanics

PhD Degree Requirements

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 the qualifying exam in the semester immediately following completion of all deficiencies. Students entering with a completed M.S. degree will take the qualifying exam 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 head; 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 and culminate in an analysis of potentially significant research problems. The identified problems need not match the eventual dissertation topic.

Curriculum

A minimum of seventy-two (72) credit hours are required beyond the B.S. degree. At least thirty-six (36) of these credits must be for coursework. No more than 36 credits may be from 500-level courses or lower. 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 candidate’s committee is responsible for assisting the student in developing a program of study that prepares the student for his/her intended field as well as provides general knowledge for the discipline. It is recommended that six (6) to twelve (12) hours of coursework be taken outside the department.

Geology Specialization

GEOL 700 Research Methods
is required the first fall semester of enrollment.
GEOL 808 Fundamental Problems in Engineering and Science
also is required. In addition, the program of study must include at least one GEOL/GEOE/PALE course emphasizing field methods, one GEOL/GEOE/PALE course emphasizing analytical methods, and one GEOL/GEOE/PALE course emphasizing computational methods. The student’s advising committee determines the courses that meet these criteria.

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.
The candidate's committee is responsible for assisting the student in developing a program of study that prepares the student for his/her intended focus.

**GEOL 700 Research Methods**

Research Methods is required the first fall of enrollment.

**GEOL 808 Fundamental Problems in Engineering and Science**

also is required.

In addition, the program of study must include at least one GEOL/GEOE course emphasizing field methods, one GEOL/GEOE course emphasizing analytical methods and one GEOL/GEOE course emphasizing computational methods. The student's advising committee determines the courses that meet these criteria.

**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 evaluate whether 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 Organization**

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 candidacy 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 examinations 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 approximately 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.

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>General (written)</td>
<td>25%</td>
</tr>
<tr>
<td>Specific Topic (written)</td>
<td>25%</td>
</tr>
<tr>
<td>Specific Topic (written)</td>
<td>25%</td>
</tr>
<tr>
<td>Oral Examination</td>
<td>25%</td>
</tr>
</tbody>
</table>

**Geology Ph.D. Specialization**

The General part of the comprehensive exam will include General Geology. Specific topics will be chosen from the following list:

- Structural Geology
A student may propose hybrid fields with other disciplines if approved by his or her graduate committee.

**Geological Engineering Ph.D. Specialization**

The General part of the comprehensive exam will include:

- Geological Engineering
- Geology
- Fundamentals of Engineering

Specific topics will be chosen from the following list:

- Groundwater
- Engineering Geology
- Petroleum Engineering
- Mineral Exploration/Production
- Hydrology and Hydraulic Engineering
- Geophysics
- Geochemistry
- 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 may propose hybrid fields with other disciplines if approved by his or her graduate committee.
Contact Information

Dr. Jon J. Kellar  
Department of Materials and Metallurgical Engineering  
Mineral Industries 112  
(605) 394-2343  
E-mail: 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

- Computational Modeling
- Polymer Synthesis
- Corrosion Inhibition
- Development of Multiphase
- Strengthening Mechanisms
- Surface Chemistry of Flotation
- Thermophysical Properties
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 Electrical and Computer Engineering, 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 898:

<table>
<thead>
<tr>
<th>Category</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analytical Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>Numerical Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>Program Major Emphasis (Engineering or Science)</td>
<td>44-54</td>
</tr>
<tr>
<td>Dissertation Research</td>
<td>20-30</td>
</tr>
<tr>
<td>Total beyond the B.S. degree</td>
<td>80</td>
</tr>
</tbody>
</table>

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 Applied Engineering Analysis | Credits: (3-0) 3
- PHYS 481/581 Mathematical Physics Credits: 4

Numerical Mathematics (3 credits)

- MATH 447/547 Design of Experiments Credits: (3-0) 3
Program Emphasis (30 credits)

Two program emphasis areas are available: materials science and materials engineering. See sections below.

Research (20 credits)

- **MES 898 Dissertation** Credits: Credit to be arranged.
- **MES 790/890 Seminar** Credits: (1-0) 1

Additional research credits

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 Interfacial Phenomena** Credits: (3-0) 3
- **PHYS 743 Statistical Mechanics** Credits: (3-0) 3
- **CBE 613 Transport Phenomena: Heat** Credits: (3-0) 3
- **CBE 714 Transport Phenomena: Mass** Credits: (3-0) 3
- **MES 728 Heterogeneous Kinetics** Credits: (3-0) 3

**Crystal Structure/Chemistry of Solids (3 credits)**

- **MES 603 Condensed Matter Physics** Credits: (4-0) 4
- **MES 604 Chemistry of Materials** Credits: (4-0) 4
- **PHYS 771 Quantum Mechanics I** Credits: (3-0) 3

**Bulk or Surface Analysis (3 credits)**

- **NANO 703/703L Instrumentation and Characterization of Nano-Materials/Lab** Credits: (3-1) 4

**Fundamental Engineering Mechanics (6 credits)**
Courses from the engineering emphasis section can also be used to fulfill this requirement.

- **ME 425 Probabilistic Mechanical Design** Credits: (3-0) 3
- **MET 450/550 Forensic Engineering** Credits: (3-0) 3
- **MET 440/540 Mechanical Metallurgy** Credits: (3-0) 3
- **ME 443 Composite Materials** Credits: (3-0) 3 OR
- **MET 443 Composite Materials** Credits: (3-0) 3
- **MET 625 Strengthening Mechanisms in Metals** Credits: (3-0) 3

Dissertation Related Topics (12 credits)

**Engineering Emphasis Requirements**

(minimum program requirements: 30 credits)

**Analytical Mechanics**

- **ME 623 Advanced Mechanical Vibrations** Credits: (3-0) 3
- **ME 613 Transport Phenomena: Heat** Credits: (3-0) 3
- **MES 713 Advanced Solid Mechanics I** Credits: (3-0) 3
- **MES 770 Continuum Mechanics** Credits: (3-0) 3

**Elasticity/Plasticity**

- **CEE 743 Advanced Soil Mechanics** Credits: (3-0) 3
- **MES 713 Advanced Solid Mechanics I** Credits: (3-0) 3
- **MEM 450/550 Rock Slope Engineering** Credits: (3-0) 3

**Failure Analysis Fracture Mechanics**

- **ME 715 Advanced Composite Materials** Credits: (3-0) 3

**Fundamental Materials Science (6 credits)**

Courses from the science emphasis section can also be used to fulfill this requirement.

- **CHEM 420/520 Organic Chemistry III** Credits: (3-0) 3
- **CHEM 452/552 Inorganic Chemistry** Credits: (3-0) 3
- **CHEM 426/526 Polymer Chemistry** Credits: (3-0) 3
- **MES 603 Condensed Matter Physics** Credits: (4-0) 4
- **MES 601 Fundamentals of Materials Engineering** Credits: (4-0) 4
Additional Information

An assessment of the student's qualifications will be undertaken early in their program. The assessment is comprised of performance in predetermined 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.

Contact Information

Dr. Michael Langerman  
Department of Mechanical Engineering  
Civil Mechanical 172  
(605) 394-2408
Faculty

Professors Abata, Dolan, Kalanovic, Kjerengtroen, Korde, Muci-Kuchler and Langerman; Associate Professors Ash, Bedillion, and Widener; Assistant Professors Degen, Ellingsen, Heydari, Romkes, and Shahbazi; Professors Emeritus Buck, Chiang, Gnirk, Krause, and Pendleton.

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 898D). The program of study allows the student to take 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 Courses

- ME 673 Applied Engineering Analysis I Credits: (3-0) 3
- ME 773 Applied Engineering Analysis II Credits: (3-0) 3

Total: 6

Coursework: Choose 32 credits from below (or equivalent courses):

- ME 612 Transport Phenomena: Momentum Credits: (3-0) 3
- ME 613 Transport Phenomena: Heat Credits: (3-0) 3
- ME 616 Computations in Transport Phenomena Credits: (3-0) 3
- ME 618 Conduction Heat Transfer Credits: (3-0) 3
- ME 619 Convection Heat Transfer Credits: (3-0) 3
- ME 620 Radiation Heat Transfer Credits: (3-0) 3
- ME 623 Advanced Mechanical Vibrations Credits: (3-0) 3
- ME 625 Smart Structures Credits: (3-0) 3
- EE 751 Advanced Digital Control Systems Credits: (3-0) 3
- ME 680 Advanced Strength of Materials Credits: (3-0) 3
- ME 683 Advanced Mechanical System Control Credits: (3-0) 3
- ME 691 Independent Study Credits: 1 to 3
- ME 692 Topics Credits: 1 to 3
- ME 713 Advanced Solid Mechanics I Credits: (3-0) 3
- ME 715 Advanced Composite Materials Credits: (3-0) 3
• ME 736 Advanced Finite Element Methods Credits: (3-0) 3
• ME 770 Continuum Mechanics Credits: (3-0) 3 OR
• MES 770 Continuum Mechanics Credits: (3-0) 3

Total: 32

Credits Outside Department (if applicable)

• MATH/PHY/EE/CEE/ChE/MES/BME/NANO Credits: 12

Total: 12

Dissertation

• ME 898D Dissertation Credits: Credit to be arranged.

Total: 30
Contact Information

Dr. Steve Smith
Nanoscience and Nano-engineering
(605) 394-5268
E-mail: Steve.Smith@sdsmt.edu
http://nano.sdsmt.edu

Advisory Council

Professors Salem and Smith (Chair); Miller Professor Whites; Associate Professors Ahrenkiel, Anagnoustou, Cross, Fong, Yang, and Zhu; Research Faculty Hong; Dean Wells (ex-officio)

Nanoscience and Nano-engineering

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.

Requirements

- NANO 701 Nano Materials Credits: (3-0) 3
- NANO 702 Theory and Application of Nanoscale Materials Credits: (3-0) 3
- NANO 703/703L Instrumentation and Characterization of Nano-Materials/Lab Credits: (3-1) 4
- NANO 890 Seminar Credits: (1-0) 1
- Program Major Emphasis Credits: 27-37
- Dissertation Research Credits: 30-40

Total: 80

Curriculum Notes

1 Course taken three times for a total of 3 credits.

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.

- NANO 445/545 Introduction to Nanomaterials Credits: (3-0) 3
- NANO 504 Nano-photonic Materials Credits: (3-0) 3
- NANO 716 Printed Electronics: Materials and Processes Credits: (3-0) 3
- NANO 704 Crystallography and Structure of Nanomaterials Credits: (3-0) 3
- NANO 705 Nano-electronics Credits: (3-0) 3
- NANO 706 Diffraction Methods for Nanomaterials Research Credits: (3-0) 3
- NANO 707 Defects in Nanomaterials Credits: (3-0) 3
- NANO 708 Nanomaterials for Photovoltaics Credits: (3-0) 3
- NANO 712/712L Electromagnetic Properties of Heterogeneous Materials/Lab Credits: (2-1) 3
- NANO 715 Polymeric Nanomaterials Credits: (3-0) 3
- NANO 717 Nano-chemistry Credits: (3-0) 3
- NANO 791 Independent Study Credits: 1 to 3
- NANO 792 Topics Credits: 1 to 3
- MES 601 Fundamentals of Materials Engineering Credits: (4-0) 4
- MES 603 Condensed Matter Physics Credits: (4-0) 4
- MES 604 Chemistry of Materials Credits: (4-0) 4
- ME 612 Transport Phenomena: Momentum Credits: (3-0) 3 OR
  CBE 612 Transport Phenomena: Momentum Credits: (3-0) 3
- ME 613 Transport Phenomena: Heat Credits: (3-0) 3 OR
  CBE 613 Transport Phenomena: Heat Credits: (3-0) 3
- CBE 714 Transport Phenomena: Mass Credits: (3-0) 3
- PHYS 721 Electrodynamics I Credits: (3-0) 3
- PHYS 743 Statistical Mechanics Credits: (3-0) 3
- PHYS 771 Quantum Mechanics I Credits: (3-0) 3
- PHYS 773 Quantum Mechanics II Credits: (3-0) 3
- MES 712 Interfacial Phenomena Credits: (3-0) 3
- MES 713 Advanced Solid Mechanics I Credits: (3-0) 3
- MES 728 Heterogeneous Kinetics Credits: (3-0) 3
- MES 770 Continuum Mechanics Credits: (3-0) 3

Additional Information

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.

Contact Information

Dr. Andre G. Petukhov
Department of Physics
Electrical Engineering/Physics 235A
(605) 394-2364
E-mail: Andre.Petukhov@sdsmt.edu

Faculty

Professors Corey, Detwiler, Petukhov, Sobolev, Wells; Associate Professors Schnee and Strieder, Assistant Professors Bai, Corwin, French,
Program Description

The Ph.D. program in physics will prepare students for a variety of career paths, including positions in academia, industry and at national labs. While degree candidates may pursue specialized research foci based on the research expertise of individual faculty members, the most significant goal of the program is to focus on research areas germane to the needs and special resources of the Sanford Underground Research facility (SURF). Examples of specialized research areas connected to SURF include nuclear/particle physics and particle astrophysics involving next-generation neutrino detection; double beta-decay, dark matter searches and gravitational wave detection experiments, as well as condensed matter physics concentrating on novel low background radiation materials and devices.

Admissions Information/Application Process

The following items have to be submitted by students who apply:

- Completed application
- Three letters of recommendation from parent institution instructors
- General GRE scores
- Official transcripts from all universities attended (Applicants must have at least a 3.0 (B) grade point average in their undergraduate work.)
- International students should refer to the Graduate School policy for language requirements.

Scholarships

A limited number of graduate assistantships are awarded each year on a competitive basis to fully admitted, full-time, on-campus M.S. and Ph.D. students. Applications for graduate assistantships are due on February 1.

Physics (Ph.D)

72 CREDIT HOURS REQUIRED

- Required core 24 credit hours
- Electives 12 credit hours
- Dissertation 36 credit hours

Collaborative Program between the University of South Dakota and South Dakota School of Mines & Technology.

Required Core: Total 24 credit hours

- \texttt{PHYS 721 Electrodynamics I} Credits: (3-0) 3
- \texttt{PHYS 723 Electrodynamics II} Credits: (3-0) 3
- \texttt{PHYS 743 Statistical Mechanics} Credits: (3-0) 3
- \texttt{PHYS 751 Theoretical Mechanics} Credits: (3-0) 3
- \texttt{PHYS 771 Quantum Mechanics I} Credits: (3-0) 3
- \texttt{PHYS 773 Quantum Mechanics II} Credits: (3-0) 3
- \texttt{PHYS 781 Nuclear and Particle Physics} Credits: (3-0) 3
- \texttt{PHYS 790 Seminar} Credits: 1 to 3

Electives: Total 12 credit hours

- \texttt{PHYS 683 Mathematical Physics II} Credits: (3-0) 3
- \texttt{PHYS 691 Independent Study} Credits: 1 to 3
Students interested in pursuing a specific minor offered by SDSM&T should contact the coordinator of that minor for more specific information on the application process and the appropriate forms.

- 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 (90 or more credit hours completed) on a form available in the Registrar and Academic Services (RAS) office. 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.

**Contact Information**

Dr. Richard Sinden, Department Head
Department of Chemistry and Applied Biological Sciences
Chemistry/Chemical Engineering 2219
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E-mail: Richard.Sinden@sdsmt.edu

**MINOR IN APPLIED BIOLOGICAL SCIENCES**

Credits Required 19

The core curriculum requires students to complete 12 hours of core biology classes that are required in the ABS major program. The additional 7 hours of electives are chosen from a variety of biology classes that will supplement the student’s major field to broaden the student’s overall academic preparation for a science or engineering career.

A grade of ‘C’ or better will be required for all courses needed for the biology minor. At least 50% of biology courses applied toward a minor must be completed at SDSM&T.

**Required Courses: 12 Credits**

- **BIOL 151 General Biology I** Credits: (3-0) 3
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 and environmental science coursework must be earned.

Two courses

- AES 201 Introduction to Atmospheric Sciences Credits: (3-0) 3
- AES 403/503 Biogeochemistry Credits: (3-0) 3 are required for the minor.
MINOR IN CHEMISTRY

The goal of this minor is to provide students with a solid, albeit limited, background in chemistry. The major requires 20 hours of CHEM courses (8 hours of required courses; 12 hours of elective courses). A grade of ‘C’ or better is required for all courses needed for the chemistry minor. At least 50% of chemistry courses applied toward a minor must be completed at SDSM&T.

Required Courses: 8 Credit Hours

- CHEM 112 General Chemistry I Credits: (3-0) 3
- CHEM 112L General Chemistry I Lab Credits: (0-1) 1
- CHEM 114 General Chemistry II Credits: (3-0) 3
- CHEM 114L General Chemistry II Lab Credits: (0-1) 1

Elective Courses: 12 Credit hours

Twelve (12) credit hours of courses at the 300-level, or above, including one 400-level course, are required. Elective courses must represent 3 of the 5 areas of chemistry (Analytical, Biochemistry, Inorganic, Organic, and Physical Chemistry). Laboratory courses are required for two (2) of these elective courses.

Elective options include:

- CHEM 326 Organic Chemistry I Credits: (3-0) 3
- CHEM 326L Organic Chemistry I Lab Credits: (0-2) 2
- CHEM 328 Organic Chemistry II Credits: (3-0) 3
- CHEM 328L Organic Chemistry II Lab Credits: (0-2) 2
- CHEM 332 Analytical Chemistry Credits: (3-0) 3
- CHEM 332L Analytical Chemistry Lab Credits: (0-1) 1
- CHEM 342 Physical Chemistry I Credits: 2 to 3
- CHEM 342L Physical Chemistry I Lab Credits: (0-1) 1
- CHEM 344 Physical Chemistry II Credits: 2 to 3
- CHEM 344L Physical Chemistry II Lab Credits: (0-1) 1
- CHEM 420/520 Organic Chemistry III Credits: (3-0) 3
- CHEM 421/521 Spectroscopic Analysis Credits: (3-0) 3
- CHEM 426/526 Polymer Chemistry Credits: (3-0) 3
- CHEM 434 Instrumental Analysis Credits: (3-0) 3
- CHEM 434L Instrumental Analysis Lab Credits: (0-2) 2
- CHEM 452/552 Inorganic Chemistry Credits: (3-0) 3
- CHEM 452L/552L Inorganic Chemistry Lab Credits: (0-1) 1
- CHEM 464/564 Biochemistry I Credits: (3-0) 3
- CHEM 464L Biochemistry I Lab Credits: (0-1) 1
- CHEM 482/582 Environmental Chemistry Credits: (3-0) 3
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 150/150L Computer Science I/Lab** Credits: (2-1) 3
- **CSC 250 Computer Science II** Credits: (4-0) 4
- **CSC 251 Finite Structures** Credits: (4-0) 4
- **CSC 300 Data Structures** Credits: (4-0) 4
- At least 6 credit hours from an approved list.

The approved list of courses for the minor:

- **CSC 314/314L Assembly Language/Lab** Credits: (2-1) 3
- **CSC 317 Computer Organization and Architecture** Credits: (3-0) 3
- **CSC 372 Analysis of Algorithms** Credits: (3-0) 3
- **CSC 410/510 Parallel Computing** Credits: (3-0) 3
- **CSC 412/512 Cryptography** Credits: (3-0) 3
- **CSC 415/415L/515/515L Introduction to Robotics/Lab** Credits: (2-1) 3
- **CSC 416/416L/516/516L Introduction to Autonomous Systems/Lab** Credits: (2.5-0.5) 3
- **CSC 421/521 Graphical User Interfaces with Object-Oriented Programming** Credits: (3-0) 3
- **CSC 433/533 Computer Graphics** Credits: (3-0) 3
- **CSC 440/440L Advanced Digital Systems/Lab** Credits: (3-1) 4
- **CSC 441/541 Networking and Data Communications** Credits: (3-0) 3
- **CSC 442/542 Introduction to Digital Image Processing and Computer Vision** Credits: (3-0) 3
- **CSC 445/545 Introduction to Theory of Computation** Credits: (3-0) 3
- **CSC 447/547 Artificial Intelligence** Credits: (3-0) 3
- **CSC 448/548 Machine Learning** Credits: (3-0) 3
Environmental engineers design systems and solve pressing global problems in all areas related to the environment and public health: sustainable design of drinking water treatment and wastewater treatment, and solid hazardous waste disposal systems; development of air quality monitoring and pollution prevention programs; design of site remediation and mining reclamation programs; and development of ecosystem protection and restoration efforts, among others. Students may study environmental engineering as an emphasis area in the B.S. civil engineering degree program, and/or pursue an environmental engineering minor.

Students from any discipline at the School of Mines may pursue a minor in environmental engineering by completing 18 credit hours of coursework as described below.

**Required core courses:**

- **CBE 217 Chemical Engineering Material Balances** Credits: (3-0) 3
- **CEE 326 Environmental Engineering I** Credits: (3-0) 3
- **CEE 327/327L Environmental Engineering II/Lab** Credits: (2-1) 3
- **BIOL 341 Microbial Processes in Engineering and Natural Sciences** Credits: (3-0) 3

**Elective course**
In addition, students select two 3-credit elective courses from the list below. To ensure that enrollees gain the broad and interdisciplinary background expected in the environmental engineering discipline, one elective must be taken from a discipline outside the student's major field of study.

- **CBE 455/555 Pollution Phenomena and Process Design** Credits: (3-0) 3
- **CEE 426/526 Environmental Engineering Unit Operations and Processes** Credits: (3-0) 3
- **CHEM 326 Organic Chemistry I** Credits: (3-0) 3
- **CHEM 482/582 Environmental Chemistry** Credits: (3-0) 3
- **GEOE 475/475L Groundwater/Lab** Credits: (2-1) 3
- **IENG 331 Safety Engineering** Credits: (3-0) 3
- **MEM 405 Mine Permitting and Reclamation** Credits: (3-0) 3
- **MET 220 Mineral Processing and Resource Recovery** Credits: (3-0) 3
- **MET 220L Mineral Processing and Resource Recovery Laboratory** Credits: (0-1) 1
- **GEOE 421/521 Aqueous Geochemistry** Credits: (3-0) 3
- **OR**
- **CEE 421/521 Aqueous Geochemistry** Credits: (3-0) 3

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**Contact Information**

Dr. Laurie Anderson  
Department of Geology and Geological Engineering  
Mineral Industries 303  
(605) 394-2461  
E-mail: Laurie.Anderson@sdsmt.edu

**Geology Courses**

Science and engineering majors may pursue a minor in geology by completing eighteen (18) credit hours of geology courses including the following:

- **GEOL 201 Physical Geology** Credits: (3-0) 3  
- **GEOL 201L Physical Geology Laboratory** Credits: (0-1) 1  
- **GEOL 212/212L Mineralogy and Crystallography/Lab** Credits: (2-1) 3  
- **GEOL 331/331L Stratigraphy and Sedimentation/Lab** Credits: (2-1) 3  
- **GEOL 341/341L Igneous and Metamorphic Petrology/Lab** Credits: (2-1) 3  
- **GEOL 322/322L Structural Geology/Lab** Credits: (2-1) 3

**Note(s):**

**GEOL 221/221L** and one additional geology elective credit may be substituted for **GEOL 201 /GEOL 201L**. No other substitutions are permitted for this minor.

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**Contact Information**

Dr. Laurie Anderson  
Department of Geology and Geological Engineering
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.

Science and engineering majors may pursue a Minor in Geospatial Technology by completing eighteen (18) credit hours of courses, including:

- **GEOL 416/416L/516/516L Introduction to GIS/Lab** (2-1) 3
- **GEOL 417/517 Geospatial Databases** (3-0) 3
- **GEOL 419/519 Advanced Geospatial Analysis** (3-0) 3
- **GEOL 420/520 Introduction to Remote Sensing** (3-0) 3

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, Dr. Maribeth Price. E-mail: Maribeth.Price@sdsmt.edu

**One of these surveying courses may be applied to the minor:**

- **CEE 206/206L Engineering Surveys I/Lab** Credits: (2-1) 3
- **MEM 201L Surveying for Mineral Engineers** Credits: (0-2) 2

**One of these statistics courses may be applied to the minor:**

- **MEM 307 Mineral Exploration and Geostatistics** Credits: (3-0) 3
- **MATH 281 Introduction to Statistics** Credits: (3-0) 3
- **MATH 381 Introduction to Probability and Statistics** Credits: (3-0) 3

**One of these programming courses may be applied to the minor:**

- **CEE 284 Applied Numerical Methods** Credits: (3-0) 3
- **CBE 117L Programming for Chemical and Biological Engineering** Credits: (0-1) 1

**Any of these courses may be applied to the minor:**

- **CEE 437/437L/537/537L Watershed and Floodplain Modeling/Lab** Credits: (2-1) 3
- **CSC 111/111L Introduction to Computer Programming/Lab** Credits: (2-0) 2
- **CSC 150/150L Computer Science I/Lab** Credits: (2-1) 3
- **CSC 250 Computer Science II** Credits: (4-0) 4
- **CSC 442/542 Introduction to Digital Image Processing and Computer Vision** Credits: (3-0) 3
- **CSC 484 Database Management Systems** Credits: (3-0) 3
- **GEOL 376 Geospatial Field Methods** Credits: (0-3) 3
- **MEM 301/301L Computer Applications in Mining/Lab** Credits: (1-1) 2
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.

**The requirements for a minor in materials science - Metals are**

- **MET 232 Properties of Materials** Credits: (3-0) 3
- **MET 330 Physics of Metals** Credits: (3-0) 3
- **MET 332 Thermomechanical Processing** Credits: (3-0) 3
- **MET 443 Composite Materials** Credits: (3-0) 3

**Two classes from**

- **MET 430/430L Welding Engineering and Design of Welded Structures/Lab** Credits: (2-1) 3
- **MET 440/540 Mechanical Metallurgy** Credits: (3-0) 3
- **MET 445/545 Oxidation and Corrosion of Metals** Credits: (3-0) 3

**Total: 18 Credits**

**Curriculum Notes**

MET 330, MET 332, MET 440/540, MET 443 and MET 445/545 are offered in alternate years, so plans for a materials science-metals minor should be made early.
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.

Contact Information

Dr. Carter Kerk
Industrial Engineering
IER 309
(605) 394-6067
E-mail: Carter.Kerk@sdsmt.edu

The minor in occupational safety is offered to students pursuing any B.S. degree program.

Application Procedures

Students should contact the program coordinator for the application procedure and appropriate forms.

Certification Check

Once an application is filed, it is included in the degree audit form. It is the responsibility of the student's advisor to certify certification completion along with the final degree audit.

The minimum math and science course requirements are

- **CHEM 112 General Chemistry** | Credits: (3-0) 3
- **CHEM 112L General Chemistry | Lab** Credits: (0-1) 1
- **MATH 123 Calculus** | Credits: (4-0) 4
- **PHYS 111 Introduction to Physics** | Credits: (3-0) 3 OR
- **PHYS 211/211-A University Physics I/Recitation** Credits: (3-0) 3
MATH 281 Introduction to Statistics Credits: (3-0) 3 OR
MATH 381 Introduction to Probability and Statistics Credits: (3-0) 3 OR
MATH 441 Engineering Statistics Credits: 4

Required courses are

- IENG 321/321L Ergonomics/Human Factors Engineering/Lab Credits: (2-1) 3
- IENG 331 Safety Engineering Credits: (3-0) 3
- IENG 341
- PSYC 331 Industrial and Organizational Psychology Credits: (3-0) 3 OR
- POLS 407 Environmental Law & Policy Credits: (3-0) 3
- Senior Design or Senior Project in home department

A minimum of 6 credit hours:

- BIOL 121 Basic Anatomy Credits: (3-0) 3
- BIOL 121L Basic Anatomy Lab Credits: (0-1) 1
- BIOL 123 Basic Physiology Credits: (3-0) 3
- BIOL 123L Basic Physiology Lab Credits: (0-1) 1
- ENVE 7326
- CHEM 114 General Chemistry II Credits: (3-0) 3
- CHEM 114L General Chemistry II Lab Credits: (0-1) 1
- CHEM 480
- CP 297/397/497 Cooperative Education Credits: 1 to 3 ¹
- IENG 491 Independent Study Credits: 1 to 3 ¹
- ME 380
- MEM 203 Introduction to Mine Health and Safety Credits: (1-0) 1
- PE 105 Wellness & Physical Fitness Credits: (1-0) 1

Curriculum Notes

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](http://ie.sdsmt.edu).

¹ Projects must be pre-approved and have significant safety content.

Contact Information

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Petroleum Systems

The petroleum industry employs a wide variety of engineers and scientists and this interdisciplinary minor is available to any student on campus interested in expanding their portfolio of coursework to include additional content relevant to the energy sector.

Program Requirements

Science and engineering majors may pursue a Minor in Petroleum Systems by completing eighteen (18) credit hours of courses. A minimum of six credits must be for courses outside of those that are required or elective in their major.

Required Courses (9 credits)

- GEOE 412/512 Science and Engineering Field Applications Credits: 3 to 6 (Petroleum Field Camp section only)
- GEOE 461 Petroleum Drilling and Production Engineering Credits: (3-0) 3
- One of:
  - CBE 218 Chemical Engineering Fluid Mechanics Credits: (3-0) 3
  - or
  - ME 331 Thermo Fluid Dynamics Credits: (3-0) 3

Elective Courses (9 credits from this list)

- CBE 217 Chemical Engineering Material Balances Credits: (3-0) 3
- CBE 222 Chemical Engineering Process Thermodynamics Credits: (3-0) 3
- CBE 321 Chemical Engineering Equilibrium Thermodynamics Credits: (3-0) 3
- CBE 417 Chemical Engineering Equilibrium Separations Credits: (2-0) 2
- CBE 444/544 Reactor Design Credits: (3-0) 3
- CBE 445/545 Oxidation and Corrosion of Metals Credits: (3-0) 3
- CBE 482 Upstream Oil and Gas Processing
- CBE 483 Petroleum Refining
- CBE 485/585 Renewable and Sustainable Energy Credits: (3-0) 3
- CBE 485L/585L Renewable and Sustainable Energy Lab Credits: (0-1) 1
- CEE 326 Environmental Engineering I Credits: (3-0) 3
- CEE 428 Oil and Gas Development and the Environment Credits: (3-0) 3
- GEOE 324/324L Engineering Geophysics I/Lab Credits: (2-1) 3
- GEOL 476/576 Petroleum Geology Credits: (3-0) 3
- ME 269/269L Energy Systems Product Development and Design/Lab Credits: (2-2) 4
- ME 402/502 Gas Dynamics Credits: (3-0) 3
- ME 492 Topics Credits: 1 to 5

Contact Information

Dr. Andre G. Petukhov
Department of Physics
Electrical Engineering/Physics 223
(605) 394-2364
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A minor in physics requires a minimum of 18 hours of courses in physics, which must include PHYS 213/213-A, and at least 15 hours of physics courses numbered higher than PHYS 213/213-A. All minors in physics must be approved by the department and must conform to the institutional policies and guidelines for minors.
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 150/150L** Computer Science I/Lab Credits: (2-1) 3
- **CSC 250** Computer Science II Credits: (4-0) 4
- **CSC 251** Finite Structures Credits: (4-0) 4
- **CSC 300** Data Structures Credits: (4-0) 4
- **CSC 415/415L/515/515L** Introduction to Robotics/Lab Credits: (2-1) 3
- OR
- **CENG 415/415L/515/515L** Introduction to Robotics/Lab Credits: (2-1) 3

Additional 6 credits from courses on an approved list

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 416/416L/516/516L** Introduction to Autonomous Systems/Lab Credits: (2.5-0.5) 3
- **CSC 447/547** Artificial Intelligence Credits: (3-0) 3
- **CSC 449/549** Pattern Recognition Credits: (3-0) 3
- **CSC 442/542** Introduction to Digital Image Processing and Computer Vision Credits: (3-0) 3
- **IENG 475/475L** Computer-Controlled Manufacturing Systems and Robotics Credits: (2-1) 3
- **ME 351/351L** Mechatronics and Measurement Systems/Lab Credits: (3-1) 4
- **ME 352** Introduction to Dynamic Systems Credits: (3-0) 3
- **CENG 452/452L** Robotic Control Systems/Lab Credits: (2.5-0.5) 3
Contact Information

Dr. Jennifer Benning, Program Coordinator
Department of Civil and Environmental Engineering, Civil/Mechanical 237A
(605) 394-2425
E-mail: Jennifer.Benning@sdsmt.edu

Sustainable engineering describes a new approach for solving complex classes of social problems that result from the rising competition for increasingly limited supplies of resources, water and land. Sustainable engineering seeks to transform engineering practice to meet these challenges. Interdisciplinary in nature and application, sustainable engineering involves the application of life cycle assessment and other innovative techniques to determine the long term implications of a proposed design solution with the ultimate goal of minimizing overall environmental impacts from products, services, businesses, communities and nations, as well as create engineering solutions that are fair and just in a global societal context.

Students from any major at the School of Mines may pursue a minor in sustainable engineering by completing 18 credit hours of coursework that includes two required courses.

**Required courses**

- **CEE 325 Introduction to Sustainable Design** Credits: (3-0) 3
- **CEE 425/525 Sustainable Engineering** Credits: (3-0) 3

**Engineering Electives**

Six elective credit hours are selected from the following list of engineering courses with sustainability content, with a minimum of three credits outside their major.

- **CEE 326 Environmental Engineering I** Credits: (3-0) 3
- **CEE 337 Engineering Hydrology** Credits: (3-0) 3
- **CBE 455/555 Pollution Phenomena and Process Design** Credits: (3-0) 3
- **IENG 352 Creativity and Innovation** Credits: (1-0) 1
- **IENG 431/531 Industrial Hygiene** Credits: (3-0) 3
- **IENG 451/451L Operational Strategies/Lab** Credits: (2-1) 3
- **IENG 475/475L Computer-Controlled Manufacturing Systems and Robotics** Credits: (2-1) 3
- **ME 492 Topics** Credits: 1 to 5
- **MET 220 Mineral Processing and Resource Recovery** Credits: (3-0) 3
- **MET 310 Aqueous Extraction, Concentration, and Recycling** Credits: (3-0) 3
- **MET 321/321L High Temperature Extraction, Concentration, and Recycling/Lab** Credits: (3-1) 4
- **MEM 120 Introduction to Mining, Sustainable Development and Introductory Management** Credits: (2-0) 2
- **MEM 405 Mine Permitting and Reclamation** Credits: (3-0) 3

**Science or mathematics electives**

Three elective credit hours are selected from the following list of science or mathematics courses with sustainability content.

- **AES 403/503 Biogeochemistry** Credits: (3-0) 3
- **AES 405/505 Air Quality** Credits: (3-0) 3
- **AES 406/506 Global Environmental Change** Credits: (3-0) 3
- **BIOL 311 Principles of Ecology** Credits: (3-0) 3
- **BIOL 341 Microbial Processes in Engineering and Natural Sciences** Credits: (3-0) 3
- **GEOL 351 Earth Resources and the Environment** Credits: (3-0) 3
- **GEOG 400 Cultural Geography** Credits: (3-0) 3
- **MATH 451/551 Math Modeling** Credits: (3-0) 3

### Humanities/Social Science Electives

- Finally, three elective credit hours are selected from the following list of humanities/social science courses with sustainability.

  - **ANTH 210 Cultural Anthropology** Credits: (3-0) 3
  - **ENGL 300 The Literary Experience of Nature** Credits: (3-0) 3
  - **HUM 200 Connections: Humanities & Technology** Credits: (3-0) 3
  - **POLS 250 World Politics** Credits: (3-0) 3
  - **POLS 407 Environmental Law & Policy** Credits: (3-0) 3

These course requirements provide students with the broad, cross-disciplinary background that leads to the type of interdisciplinary, systems thinking that is essential for developing sustainable solutions.

SDSM&T degree seeking students may complete requirements for any minor at any Regental university (Black Hills State University, Dakota State University, Northern State University, South Dakota State University or the University of South Dakota) that has been approved to grant that minor. This minor will be recorded on the transcript in conjunction with the degree/minor from the South Dakota School of Mines and Technology. (BOR Policy 2:2)

For information about the minors offered in the Regental system, the contact person for each university is listed below.

- Black Hills State University - Contact Ramona Collins (605-642-6577) or Ramona.Collins@bhsu.edu
- Dakota State University - Contact Sandy Anderson ((605-256-5144) or Sandy.Anderson@dsu.edu
- Northern State University - Contact Cherie Sauer (605-626-7768) or sauerc@northern.edu
- South Dakota School of Mines and Technology - Contact Carla Tiu (605-394-2497) or Carla.Tiu@sdsmt.edu
- South Dakota State University - Contact Bailey Davis (605-688-4488) or Bailey.Davis@sdstate.edu
- University of South Dakota - Contact Larry Hudson (605-677-5339) or Larry.Hudson@usd.edu

### Contact Information

**Mr. Clifford Bienert**  
Interim CEM Program Coordinator  
Department of Civil and Environmental Engineering  
(605) 394-1694  
E-mail: Clifford.Bienert@sdsmt.edu

**Dr. Molly M. Gribb**  
Professor and Head
Construction Management (Online)

The Construction Management Certificate is designed to provide a program 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 for working students.

Practicing professionals or students seeking to enhance their marketability for upper level management positions in various construction related industries may be initially interested in the 12-hour certificate in Construction Management. Successful completion of four certificate courses with grades of “B” or better will qualify the student for further studies leading to the Master of Science (MS) degree in Construction Engineering and Management.

Background Requirements

The construction engineering and management coursework is geared towards the working construction professional. The successful applicant will have a background in business, science, engineering, technology or a related field with at least one semester of calculus and a course in probability and statistics.

Approved Certificate Courses

Choose any four from the following:

- CEM 574 Construction Engineering and Management Credits: (3-0) 3 Spring
- CEM 608 Construction Contracts Credits: (3-0) 3 Fall
- CEM 610 Construction Project Management Credits: (3-0) 3 Spring
- CEM 619 Construction Company Management Credits: (3-0) 3 Summer
- CEM 665 Construction Equipment Management Credits: (3-0) 3 Fall
- CEM 706 Managing Sustainable Projects Credits: (3-0) 3 Spring
- CEM 710 Advanced Construction Management Credits: (3-0) 3 Spring
- CEM 715 Construction Operations Credits: (3-0) 3 Fall
- CEM 770 Case Studies in Construction Credits: (3-0) 3 Fall, Spring, Summer

Contact Information

Dr. Jennifer Karlin
Industrial Engineering
IER 302
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Program Information

Industry wants to hire engineers who are not only competent in their discipline, but also have a beginning understanding of engineering management and leadership. As defined by the American Society for Engineering Management, this discipline is “the art and science of planning, organizing, allocating resources, and directing and controlling activities which have a technological component.” This certificate is an opportunity for engineering students to graduate ready to meet the challenges unique to leadership in the engineering environment.

Application Procedures

Students should contact the program coordinator for the application procedure and appropriate forms.
Certification Check

Once an application is filed, it is included in the degree audit form. It is the responsibility of the student's advisor to certify certification completion along with the final degree audit.

Certificate Requirements

- IENG 302 Engineering Economics Credits: (3-0) 3
- IENG 366 Engineering Management Credits: (3-0) 3

Elective Courses (6 credits required)

- IENG 215 Cost Estimating for Engineers I Credits: (1-0) 1
- IENG 216 Cost Estimating for Engineers II Credits: (1-0) 1
- IENG 217 Cost Estimating for Engineers III Credits: (1-0) 1
- IENG 352 Creativity and Innovation Credits: (1-0) 1
- IENG 353 Commercialization of New Technology Credits: (1-0) 1
- IENG 354 Marketing Technology Innovations Credits: (1-0) 1
- IENG 355 Financing Technology Innovations Credits: (1-0) 1
- IENG 356 Technology Start Ups Credits: (1-0) 1
- IENG 451/451L Operational Strategies/Lab Credits: (2-1) 3
- PSYC 331 Industrial and Organizational Psychology Credits: (3-0) 3
- MEM 466 Mine Management Credits: (2-0) 2

Contact Information

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Industrial Engineering
IER 309
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Program Summary

The graduate level Occupational Safety Certificate at SDSM&T is designed to respond to a business need across all sectors (including general industry, construction, mining, health care, service, etc.) that places occupational safety at the highest level of organizational priorities. This certificate is open to any graduate student at SDSM&T. (For undergraduate students, refer to the Occupational Safety Minor.)

Program Description

The Occupational Safety Certificate program is designed to enable students to enhance their graduate degree with a concentration of occupational safety related courses. While the certificate could enrich any graduate degree, it would be particularly well-suited for Biomedical Engineering, Chemical Engineering, Civil and Environmental Engineering, Construction Management, Engineering Management, and Mechanical Engineering. Courses are offered on-campus and it is possible to complete the certificate through distance offerings. The core course and core electives provide a foundation in the identification, evaluation, and control of hazards relating to safety, industrial hygiene, and ergonomics. These courses will provide students with knowledge of regulatory aspects (OSHA, MSHA, EU, etc.), standards (ISO, ANSI, OHSAS, NIOSH, etc.), program development and evaluation, as well as professional licensing, certification, and ethics.

Application Procedures

Students should contact the program coordinator for the application procedure and appropriate forms.
Certification Check

Once an application is filed, it is included in the degree audit form. It is the responsibility of the student’s advisor to certify certification completion along with the final degree audit.

Required Courses

- **ENGM 650 Safety Management** Credits: (3-0) 3

Core Electives

- **BME 606 Occupational Biomechanics** Credits: (3-0) 3
- **ENGM 655 Ergonomics for Managers** Credits: (3-0) 3
- **IENG 431/531 Industrial Hygiene** Credits: (3-0) 3

Other Electives

- **AES 405/505 Air Quality** Credits: (3-0) 3
- **BME 602 Anatomy and Physiology for Engineers** Credits: (3-0) 3
- **CBE 455/555 Pollution Phenomena and Process Design** Credits: (3-0) 3
- **CP 697 Cooperative Education** Credits: 1 to 3 ▲
- **ENGM 791 Independent Study** Credits: 1 to 3 ▲
- **MEM 440/540 Advanced Mine Ventilation and Environmental Engineering** Credits: (3-0) 3

Notes

Note A: With significant safety content and pre-approved by the certificate coordinator.

Nine (9) Total Credit Hours = 3 (required course) + 3 (one of the core electives) + 3 (combined additional core electives and other elective credits).

A Certificate of Occupational Safety must be approved by the student’s graduate advisor and the certificate coordinator on a form available at the Office of the Registrar and Academic Services or from the certificate coordinator. Additional information may be found at the Industrial Engineering Department website [ie.sdsmt.edu](http://ie.sdsmt.edu).
Contact Information

Dr. Dean Jensen
Industrial Engineering
IER 308
(605) 394-1278
E-mail: Dean.Jensen@sdsmt.edu

Program Information

Lack of Six Sigma Greenbelt Certification is limiting the job opportunities for our otherwise highly qualified students. Six Sigma certification is strongly valued by many organizations in industry for its standardized problem solving process and adherence to statistically rigorous quality tools. The concepts that make up the Six Sigma philosophy and tools are already contained within the industrial engineering curriculum. The certification program would increase recognition from employers that students in South Dakota are acquiring these skills.

Application Procedures

Students should contact the program coordinator for the application procedure and appropriate forms.

Certification Check

Once an application is filed, it is included in the degree audit form. It is the responsibility of the student's advisor to certify certification completion along with the final degree audit.

Program Requirements

Probability and Statistics Requirement

- IENG 381 Introduction to Probability and Statistics Credits: (3-0) 3
- OR
- MATH 281 Introduction to Statistics Credits: (3-0) 3

Quality Requirement
Six Sigma Philosophy Requirement

- IENG 452 Introduction to Six Sigma Credits: (1-0) 1
- OR
- IENG 451/451L Operational Strategies/Lab Credits: (2-1) 3

Six Sigma Proficiency Requirement

- IENG 463 Six Sigma Greenbelt Project Credits: (1-0) 1
- IENG 461 Six Sigma Greenbelt Exam Credits: (1-0) 1

Contact Information

Dr. Stuart D. Kellogg
Industrial Engineering
IER 301
(605) 394-1271
E-mail: Stuart.Kellogg@sdsmt.edu

Program Information

The Technology Innovation Certificate program is designed to provide the background and requisite instruction for students interested in introducing a new product or innovation to the marketplace. As such, this program is ideal for students interested in entrepreneurial endeavors or for employment with companies that promote a strong entrepreneurial culture.

The Technology Innovation Certificate is available for both undergraduate and graduate students. The program provides flexibility in course offerings by making use of a variety of courses already available either on this campus or elsewhere in the state system. In addition, every attempt has been made to modularize and invert courses required to meet core requirements. Specifically, all core requirements may be completed through 1 or 2 credit offerings. In some cases, core offerings feature classroom inversion which allows some content to be available through online offerings supplemented with hands and creative problems solving exercises in the classroom.

Philosophically, the program is based on the holistic learner development model which incorporates whole brain thinking, multi-disciplinary team problem solving exercises, and, where ever possible, real world applications in innovation or product development.

Application Procedures

Students should contact the program coordinator for the application procedure and appropriate forms.

Certification Check

Once an application is filed, it is included in the degree audit form. It is the responsibility of the student’s advisor to certify certification completion along with the final degree audit.
Geospatial Technology

Geospatial technology is a career field that measures, visualizes, and analyzes features on the earth’s surface. It includes diverse applications such as mapping and cartography, aerial photography and satellite remote sensing, geographic information systems (GIS), global positional systems (GPS), geostatistics, LIDAR, photogrammetry, and geolocation. It forms an integral part of government services and industries, including natural resources management, environmental protection, architecture, urban planning, insurance, retail, marketing, agriculture, forestry, mining, petroleum, water resources, transportation, utilities, and more. It is an actively growing field with high demand for trained workers. It requires good computer skills.

Background Requirements

This certificate program is designed to enhance an individual’s existing work or academic training by building specific geospatial competencies required in the workplace. The ideal career preparation is to combine this certificate with a degree or work experience in one of the fields listed above. It is strongly recommended that persons wishing to pursue this certificate already have or will soon have an associate’s or bachelor’s degree. Before enrolling in any classes for this certificate, the candidate must have good computer skills including the Windows operating system, word processing, spreadsheets, presentations, Internet, e-mail, and file management. Training in statistics is also recommended.

Program Requirements

The certificate consists of four required core courses. Students who have not yet achieved a bachelor’s degree will take the undergraduate (400 level) courses; students holding a bachelor’s degree may enroll in the graduate (500 level) courses. The two levels are offered simultaneously in the same classroom, but additional requirements and expectations pertain to students enrolled at the graduate level.

- GEOL 416/416L/516/516L Introduction to GIS/Lab Credits: (2-1) 3
- GEOL 417/517 Geospatial Databases Credits: (3-0) 3
- GEOL 419/519 Advanced Geospatial Analysis Credits: (3-0) 3
- GEOL 420/520 Introduction to Remote Sensing Credits: (3-0) 3

Contact Information

Dr. Maribeth Price
Department of Geology and Geological Engineering
South Dakota School of Mines & Technology
MI-301
605-394-2468
E-mail: Maribeth.Price@sdsmt.edu

Geospatial Technology

Geospatial technology is a career field that measures, visualizes, and analyzes features on the earth’s surface. It includes diverse applications such as mapping and cartography, aerial photography and satellite remote sensing, geographic information systems (GIS), global positional systems (GPS), geostatistics, LIDAR, photogrammetry, and geolocation. It forms an integral part of government services and industries, including natural resources management, environmental protection, architecture, urban planning, insurance, retail, marketing, agriculture, forestry, mining, petroleum, water resources, transportation, utilities, and more. It is an actively growing field with high demand for trained workers. It requires good computer skills.
Background Requirements

This certificate program is designed to enhance an individual’s existing work or academic training by building specific geospatial competencies required in the workplace. The ideal career preparation is to combine this certificate with a degree or work experience in one of the fields listed above. It is strongly recommended that persons wishing to pursue this certificate already have or will soon have an associate’s or bachelor’s degree. Before enrolling in any classes for this certificate, the candidate must have good computer skills including the Windows operating system, word processing, spreadsheets, presentations, Internet, e-mail, and file management. Training in statistics is also recommended.

Program Requirements

The certificate consists of four required core courses. Students who have not yet achieved a bachelor’s degree will take the undergraduate (400 level) courses; students holding a bachelor’s degree may enroll in the graduate (500 level) courses. The two levels are offered simultaneously in the same classroom, but additional requirements and expectations pertain to students enrolled at the graduate level.

- GEOL 416/416L/516/516L Introduction to GIS/Lab Credits: (2-1) 3
- GEOL 417/517 Geospatial Databases Credits: (3-0) 3
- GEOL 419/519 Advanced Geospatial Analysis Credits: (3-0) 3
- GEOL 420/520 Introduction to Remote Sensing Credits: (3-0) 3

Contact Information

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Professor
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Civil/Mechanical 135
(605) 394-5173
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Program Information

Many engineers encounter projects in unfamiliar cultures and work on multinational teams. The Certificate in Global Engineering provides cross cultural insight and experience that will increase the ability of engineers to work on projects and teams in other countries and cultures. Students learn advanced intercultural communication and teaming skills, and then complete a cross cultural design project while working on multinational teams, or by working on a project in Latin America, Asia, or Africa for example.

Students from any engineering discipline at the School of Mines may pursue the Certificate in Global Engineering by completing 9 credit hours of coursework as described below.

Certificate Requirements

Cross Cultural Engineering Design

Students must complete a 3 credit cross cultural engineering design activity (e.g., an approved design project, co-op, or engineering design course in a foreign culture or country.)

- CP 297/397/497 Cooperative Education Credits: 1 to 3
- EXPL 285/385/485/585/685 Study Abroad Experiences Credits: 1 to 3
- EXCH 289 Student Exchange - International Credits: 0 to 18
- EXCH 389 Student Exchange - International Credits: 0 to 16
- EXCH 489 Student Exchange - International Credits: 0 to 18
Cross Cultural Communication

Students must complete 3 credits from the following list of courses to expand their understanding of human nature, social systems, or cross cultural communication in a global context.

- **SOC 100 Introduction to Sociology** Credits: (3-0) 3
- **GEOG 400 Cultural Geography** Credits: (3-0) 3
- **POLS 250 World Politics** Credits: (3-0) 3
- **POLS 350 International Relations** Credits: (3-0) 3
- **ANTH 210 Cultural Anthropology** Credits: (3-0) 3

Cross Cultural Teamwork or Project Management

Students must complete 3 credits from the following courses to improve their understanding in cross cultural teamwork or project management.

- **CEE 474/574 Construction Engineering and Management** Credits: (3-0) 3
- **MSL 201 Innovative Team Leadership** Credits: (1-0) 1
- **IENG 352 Creativity and Innovation** Credits: (1-0) 1
- **IENG 366 Engineering Management** Credits: (3-0) 3
- **PSYC 319 Teams and Teaming** Credits: (1-0) 1
- **PSYC 331 Industrial and Organizational Psychology** Credits: (3-0) 3

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 Credits: (3-0) 3
- ENGL 201 Composition II Credits: (3-0) 3
- ENGL 279 Technical Communications I Credits: (3-0) 3
- ENGL 289 Technical Communications II Credits: (3-0) 3

Curriculum Notes

1 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 Technical Communications I Credits: (3-0) 3
- ENGL 289 Technical Communications II Credits: (3-0) 3
- SPCM 101 Fundamentals of Speech Credits: (3-0) 3

Curriculum Notes

1 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 Credits: (3-0) 3
- GEOG 101 Introduction to Geography Credits: (3-0) 3
- GEOG 210 World Regional Geography Credits: (3-0) 3
- GEOG 212 Geography of North America Credits: (3-0) 3
- HIST 151 United States History I Credits: (3-0) 3
- HIST 152 United States History II Credits: (3-0) 3
- POLS 100 American Government Credits: (3-0) 3
- POLS 250 World Politics Credits: (3-0) 3
- PSYC 101 General Psychology Credits: (3-0) 3
- SOC 100 Introduction to Sociology Credits: (3-0) 3
- SOC 150 Social Problems Credits: (3-0) 3
- SOC 250 Courtship and Marriage Credits: (3-0) 3

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 111/111A Drawing Credits: (3-0) 3
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** Credits: (3-0) 3
- **MATH 115 Pre-calculus** Credits: (5-0) 5
- **MATH 120 Trigonometry** Credits: (3-0) 3
- **MATH 123 Calculus I** Credits: (4-0) 4
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 General Biology I** Credits: (3-0) 3
- **BIOL 151L General Biology I Lab** Credits: (0-1) 1
- **BIOL 153 General Biology II** Credits: (3-0) 3
- **BIOL 153L General Biology II Lab** Credits: (0-1) 1
- **CHEM 106 Chemistry Survey** Credits: (3-0) 3
- **CHEM 106L Chemistry Survey Lab** Credits: (0-1) 1
- **CHEM 108 Organic and Biochemistry** Credits: (4-0) 4
- **CHEM 108L Organic and Biochemistry Lab** Credits: (0-1) 1
- **CHEM 112 General Chemistry I** Credits: (3-0) 3
- **CHEM 112L General Chemistry I Lab** Credits: (0-1) 1
- **CHEM 114 General Chemistry II** Credits: (3-0) 3
- **CHEM 114L General Chemistry II Lab** Credits: (0-1) 1
- **GEOL 201 Physical Geology** Credits: (3-0) 3
- **GEOL 201L Physical Geology Laboratory** Credits: (0-1) 1
- **PHYS 111 Introduction to Physics I** Credits: (3-0) 3
- **PHYS 111L Introduction to Physics I Laboratory** Credits: (0-1) 1
- **PHYS 113 Introduction to Physics II** Credits: (3-0) 3
- **PHYS 113L Introduction to Physics II Laboratory** Credits: (0-1) 1
- **PHYS 211/211-A University Physics I/Recitation** Credits: (3-0) 3
- **PHYS 213/213-A University Physics II/Recitation** Credits: (3-0) 3
- **PHYS 213L University Physics II Laboratory** Credits: (0-1) 1
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. Students meet this requirement with GOAL 1 and GOAL 2.

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 Credits: (3-0) 3
- SPCM 101 Fundamentals of Speech Credits: (3-0) 3
- ENGL 201 Composition II Credits: (3-0) 3
- ENGL 279 Technical Communications I Credits: (3-0) 3
- ENGL 289 Technical Communications II Credits: (3-0) 3

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.

Systemwide General Education Requirements Checklist

For your convenience, below is a link to the Board of Regents Systemwide General Education Requirements Checklist which contains a list of courses being currently offered within the system which will meet the individual general education goals.

General Education Core Requirements

Pre General Education Courses in English and Mathematics

Pre-general education courses include

- ENGL 033 Basic Writing Credits: 1 to 3
- MATH 021 Basic Algebra Credits: (3-0) 3
- MATH 101 Intermediate Algebra Credits: (3-0) 3

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:

All courses numbered 300 and above are upper level courses.

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 111/111A Drawing I Credits: (3-0) 3
- ART 112/112A Drawing II Credits: (3-0) 3
- ARTH 211 History of World Art I Credits: (3-0) 3
- ARTH 321 Modern and Contemporary Art Credits: (3-0) 3
- ARTH 491 Independent Study Credits: 1 to 9
- ARTH 492 Topics Credits: 1 to 6

English:
- ENGL 210 Introduction to Literature Credits: (3-0) 3
- ENGL 212 World Literature II Credits: (3-0) 3
- ENGL 221 British Literature I Credits: (3-0) 3
- ENGL 222 British Literature II Credits: (3-0) 3
- ENGL 241 American Literature I Credits: (3-0) 3
- ENGL 242 American Literature II Credits: (3-0) 3
- ENGL 250 Science Fiction Credits: (3-0) 3
- ENGL 300 The Literary Experience of Nature Credits: (3-0) 3
- ENGL 330 Shakespeare Credits: (3-0) 3
- ENGL 343 Selected Authors Credits: (1-0) 1
- ENGL 350 Humor in American Culture Credits: (3-0) 3
- ENGL 360 Studies in European Literature Credits: (3-0) 3
- ENGL 374 Studies in American Literature Credits: 1 to 3
- ENGL 383 Creative Writing Credits: (3-0) 3
- ENGL 391 Independent Study Credits: 1 to 3
- ENGL 392 Topics Credits: 1 to 3

Foreign Language:
- CHIN 101 Introductory Chinese I Credits: (4-0) 4
- CHIN 102 Introductory Chinese II Credits: (4-0) 4
- GER 101 Introductory German I Credits: (4-0) 4
- GER 102 Introductory German II Credits: (4-0) 4
- SPAN 101 Introductory Spanish I Credits: (4-0) 4
- SPAN 102 Introductory Spanish II Credits: (4-0) 4

History:
- HIST 121 Western Civilization I Credits: (3-0) 3
- HIST 122 Western Civilization II Credits: (3-0) 3

Humanities:
- HUM 100 Introduction to Humanities Credits: (3-0) 3
- HUM 200 Connections: Humanities & Technology Credits: (3-0) 3
HUM 291 Independent Study Credits: 1 to 4
HUM 292 Topics Credits: 1 to 3
HUM 350 American Social History Credits: (3-0) 3
HUM 375 Computers in Society Credits: (3-0) 3
HUM 491 Independent Study Credits: 1 to 4
HUM 492 Topics Credits: 1 to 3

Music:

MUAP 200 Applied Music-Voice Credits: 1 to 4
MUAP 201 Applied Music-Voice Credits: 1 to 4
MUS 100 Music Appreciation Credits: (3-0) 3
MUS 110 Basic Music Theory I Credits: 2 to 4
MUS 317 Music in Performance II Credits: (1-0) 1

Philosophy:

PHIL 100 Introduction to Philosophy Credits: (3-0) 3
PHIL 200 Introduction to Logic Credits: (3-0) 3
PHIL 220 Introduction to Ethics Credits: (3-0) 3
PHIL 233 Philosophy and Literature Credits: (3-0) 3

Social Sciences

Anthropology:

ANTH 210 Cultural Anthropology Credits: (3-0) 3

Geography:

GEOG 101 Introduction to Geography Credits: (3-0) 3
GEOG 210 World Regional Geography Credits: (3-0) 3
GEOG 212 Geography of North America Credits: (3-0) 3
GEOG 400 Cultural Geography Credits: (3-0) 3
GEOG 492 Topics Credits: 1 to 3

History:

HIST 151 United States History I Credits: (3-0) 3
HIST 152 United States History II Credits: (3-0) 3
HIST 492 Topics Credits: 1 to 4

Political Science:
- **POLS 100 American Government** Credits: (3-0) 3
- **POLS 250 World Politics** Credits: (3-0) 3
- **POLS 350 International Relations** Credits: (3-0) 3
- **POLS 407 Environmental Law & Policy** Credits: (3-0) 3
- **POLS 492 Topics** Credits: 1 to 3

**Psychology:**

- **PSYC 101 General Psychology** Credits: (3-0) 3
- **PSYC 319 Teams and Teaming** Credits: (1-0) 1
- **PSYC 323 Human Development Through the Lifespan** Credits: (4-0) 4
- **PSYC 331 Industrial and Organizational Psychology** Credits: (3-0) 3
- **PSYC 391 Independent Study** Credits: 1 to 3
- **PSYC 392 Topics** Credits: 1 to 3
- **PSYC 451 Psychology of Abnormal Behavior** Credits: (3-0) 3
- **PSYC 461 Theories of Personality** Credits: (3-0) 3

**Sociology:**

- **SOC 100 Introduction to Sociology** Credits: (3-0) 3
- **SOC 150 Social Problems** Credits: (3-0) 3
- **SOC 250 Courtship and Marriage** Credits: (3-0) 3
- **SOC 351 Criminology** Credits: (3-0) 3
- **SOC 391 Independent Study** Credits: 1 to 3
- **SOC 392 Topics** Credits: 1 to 3
- **SOC 411 Licit and Illicit Drugs** Credits: (3-0) 3
- **SOC 420 Alcohol Use and Abuse** Credits: (3-0) 3

**B. All degree candidates must complete**

- **ENGL 101 Composition** Credits: (3-0) 3
- **ENGL 279 Technical Communications I** Credits: (3-0) 3
- **ENGL 289 Technical Communications II** Credits: (3-0) 3
- These courses cannot be used to meet the humanities and social sciences requirements.

**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 and environmental science.

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.

Every semester

Classes that are typically offered every semester include

- **CSC 150/150L Computer Science I/Lab** Credits: (2-1) 3
- **CSC 250 Computer Science II** Credits: (4-0) 4
- **CSC 251 Finite Structures** Credits: (4-0) 4
- **CSC 300 Data Structures** Credits: (4-0) 4
- **CSC 314/314L Assembly Language/Lab** Credits: (2-1) 3

Every fall semester

Classes that are typically offered every fall semester include

- **CSC 110 Survey of Computer Science and Mathematics** Credits: (1-0) 1
- **CSC 111/111L Introduction to Computer Programming/Lab** Credits: (2-0) 2
- **CSC 372 Analysis of Algorithms** Credits: (3-0) 3
- **CSC 415/415L/515/515L Introduction to Robotics/Lab** Credits: (2-1) 3
- **CSC 421/521 Graphical User Interfaces with Object-Oriented Programming** Credits: (3-0) 3
- **CSC 464 Senior Design I** Credits: (2-0) 2
- **CSC 484 Database Management Systems** Credits: (3-0) 3

Every spring semester

Classes that are typically offered every spring semester include

- **CSC 317 Computer Organization and Architecture** Credits: (3-0) 3
- **CSC 461 Programming Languages** Credits: (3-0) 3
- **CSC 456/456L Operating Systems/Lab** Credits: (3-1) 4
- **CSC 465 Senior Design II** Credits: (2-0) 2
- **CSC 470 Software Engineering** Credits: (3-0) 3

MATH 021 and MATH 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.

Every semester
Classes that are typically offered every semester include

- MATH 102 College Algebra Credits: (3-0) 3
- MATH 120 Trigonometry Credits: (3-0) 3
- MATH 123 Calculus I Credits: (4-0) 4
- MATH 125 Calculus II Credits: (4-0) 4
- MATH 225 Calculus III Credits: (4-0) 4
- MATH 315 Linear Algebra Credits: (3-0) 3
- MATH 321 Differential Equations Credits: (3-0) 3
- MATH 373 Introduction to Numerical Analysis Credits: (3-0) 3
- MATH 381 Introduction to Probability and Statistics Credits: (3-0) 3

Every fall semester

Classes that are typically offered every fall semester include

- MATH 281 Introduction to Statistics Credits: (3-0) 3
- MATH 486 Statistical Quality and Process Control Credits: (3-0) 3

Every spring semester

Classes that are typically offered every spring semester include

- MATH 382 Probability Theory and Statistics II Credits: (3-0) 3
- MATH 353 Linear Optimization Credits: (3-0) 3

Fall semester of even numbered years

Classes that are typically offered in the fall semester of even numbered years, for example fall 2014, include

- MATH 413 Abstract Algebra I Credits: (3-0) 3
- MATH 452/552 Advanced Studies in Mathematics Credits: (3-0) 3

Spring semester of odd numbered years

Classes that are typically offered in the spring semester of odd numbered years, for example spring 2015, include

- MATH 421 Complex Analysis Credits: (3-0) 3
- MATH 443/543 Data Analysis Credits: (3-0) 3

Fall semester of odd numbered years

Classes that are typically offered in the fall semester of odd numbered years, for example fall 2013, include
- MATH 432 Partial Differential Equations Credits: (3-0) 3
- MATH 423 Advanced Calculus | Credits: (4-0) 4

Spring semester of even numbered years

Classes that are typically offered in the spring semester of even numbered years, for example spring 2014, include

- MATH 424 Advanced Calculus II Credits: (4-0) 4
- MATH 451/551 Math Modeling Credits: (3-0) 3
- MATH 447/547 Design of Experiments Credits: (3-0) 3