

## **Biomedical Engineering M.S. and Ph.D.**



### **Contact Information**

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### **Advisory Council**

Professors Bang, Buck, Kalanovic, Kerk, Kjerengtroen, Korde, Langerman, Weiss, Associate Professors Medlin, Muci; Assistant Professors Fong, Yoon, AML lab-Sears.

### **Biomedical Engineering**

Offered jointly with University of South Dakota (USD).

Biomedical engineering (BME) is concerned with the application of engineering and science methodologies to the analysis of biological and physiological problems and to the delivery of health care.

The biomedical engineer serves as an interface between traditional engineering disciplines and living systems and may work in either direction, applying the patterns of living organisms to engineering design or engineering new approaches to human health.

Both the master of science and doctor of philosophy degrees are cross-disciplinary degrees. The objective of the M.S. program is to prepare a

student for research and development careers in biomedical industry and further research at the doctoral level. The Ph.D. program will prepare a student for a career as a researcher who advances the frontiers of biomedical science and engineering with attention to generating new ideas for commercialization.

Current focus areas of faculty activity within the program are (1) cardiovascular mechanics, pathology, and devices (heart valves, stents, etc.), (2) biomaterials (nanomaterials, bioadhesives, tissue engineering, etc.), (3) computational biomedical engineering (biomechanics, imaging, advanced modeling/simulations, etc.), and (4) assistive technology/rehabilitation engineering (advanced prosthetics, control, biomimetics, etc.). Students in the programs will be associated with one or more of several existing and newly formed research centers and laboratories, e.g., the Cardiovascular Research Institute, the Center for Accelerated Applications at the Nanoscale, the Center for Development of Light Activated Materials, the Computational Mechanics Laboratory, or the Direct Write Technology Laboratory.

The program is administered by the Dean of Graduate Education with input from the program coordinator, who is advised by the program advisory council. The program advisory council is comprised of faculty from the mechanical, materials science and metallurgical engineering, electrical and computer engineering, chemistry, and mathematics and computer science departments.

Admission to the programs will be based on the established graduate admission standards at the South Dakota School of Mines and Technology. The Graduate Record Examination (GRE), three letters of recommendation, and a GPA of 3.00 or better are expected of all applicants for the Ph.D. program. The TOEFL exam is required for students whose native language is not English. Students seeking exceptions warranted by special circumstances are requested to contact the biomedical engineering graduate program coordinator.

Students completing their M.S. degrees will graduate with a high level of competence in

- understanding of cardiovascular systems and devices;
- the application and characterization of various forms of biomaterials;
- the acquisition and processing of medical signals and images;
- the computation and simulation of phenomena in biomechanical systems; and
- transferring their understanding of biomaterials, biomechanics, and signal processing to the creation of new applications.

Students completing their Ph.D. degrees will graduate with a higher level of expertise in transferring their understanding of one of the program focus areas—cardiovascular mechanics/pathology/devices, biomaterials, computational biomedical engineering, or rehabilitation engineering/assistive technology to the creation of new knowledge and applications.

In addition, doctoral students will possess a high level of expertise in their specialized area of research. This competency will be developed through focused research objectives which culminate in the doctoral dissertation. Graduates of the programs will also demonstrate

- the ability to communicate effectively in written and oral presentations,
- intellectual honesty when working with data and ideas, and
- the ability to make an original contribution to their fields.

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

Students entering with baccalaureate degrees in biomedical engineering are required to take the courses listed in the table (Group A) below.

**Group A** (Required Courses for students entering with a B.S. in BME)

| Course #             | Course Title                    | Credits |
|----------------------|---------------------------------|---------|
| BME 603              | Molecular Biology for Engineers | 3       |
| BME 673 <sup>1</sup> | Engineering Analysis I          | 3       |
| BME 773 <sup>2</sup> | Engineering Analysis II         | 3       |

|         |                                     |    |
|---------|-------------------------------------|----|
| BME 790 | Graduate Seminar                    | 1  |
| BME 798 | Master's Thesis (M.S. students)     | 6  |
| BME 896 | Field Experience (Ph.D. students)   | 1  |
| BME 898 | Ph.D. Dissertation (Ph.D. students) | 30 |

Students entering with baccalaureate degrees in engineering disciplines other than biomedical engineering are required to take the courses listed in the table below (Group B). Depending on the student's background, the student's advisory committee may recommend that one or more of the required courses below be substituted by course(s) listed in the elective courses category.

**Group B** (Required courses for students entering with a B.S. in a non-BME engineering discipline)

| Course #                         | Course Title                         | Credits |
|----------------------------------|--------------------------------------|---------|
| BME 601                          | Biomaterials                         | 3       |
| BME 602                          | Anatomy and Physiology for Engineers | 3       |
| BME 603                          | Molecular Biology for Engineers      | 3       |
| BME 604                          | Sensing and Signal Processing        | 3       |
| <b>One of the following two:</b> |                                      |         |
| BME 606                          | Occupational Biomechanics            | 3       |
| BME 607                          | Biomechanics 3                       | 3       |
| BME 673 <sup>1</sup>             | Engineering Analysis I               | 3       |
| BME 773 <sup>2</sup>             | Engineering Analysis II              | 3       |
| BME 790                          | Graduate Seminar                     | 1       |
| BME 798                          | Master's Thesis (M.S. students)      | 6       |
| BME 896                          | Field Experience (Ph.D. students)    | 1       |
| BME 898                          | Ph.D. Dissertation (Ph.D. students)  | 30      |

Elective courses in the area of the student's intended research are to be selected in consultation with the student's advisory committee. These courses are listed in the Group C table below. The number of Group C elective courses required will depend on the student's background and educational goals, as summarized below.

## Elective Course Requirements

M.S.: Five Group C courses for those entering with a B.S. in biomedical engineering; one Group C course for those entering with a B.S. in a non-biomedical engineering program.

Ph.D.: Six Group C courses including one Special Topics course, and seven additional engineering or Group C courses; for those entering with a B.S. in biomedical engineering. Nine Group C courses including one Special Topics course for those entering with a B.S. in a non-biomedical engineering program.

Minimum of six Group C courses along with additional Group B and C courses for those entering with an M.S. degree. An additional 21 credits of prior graduate level course work may be applied toward the Ph.D. program at the discretion of the student's advisory committee.

### Group C (Elective Courses)

| Course #                                    | Course Title                                 | Credits |
|---|--|---------|
| <b>Biomaterials Area</b>                    |  |         |
| BME 721 <sup>3</sup>                        | Tissue Engineering                           | 3       |
| BME 722 <sup>4</sup>                        | Regeneration                                 | 3       |
| BME 724                                     | Biopolymers                                  | 3       |
| BME 725                                     | Biocomposites                                | 3       |
| BME 726                                     | Bio/MEMS and Nano Systems                    | 3       |
| BME 730                                     | Vascular Mechanics/Pathology                 | 3       |
| BME 751                                     | Drug Delivery                                | 3       |
| BME 761                                     | Bioadhesives                                 | 3       |
| BME 792                                     | Topics: Special Topics in Biomaterials       | 4       |
| BME 792                                     | Topics: Special Topics in Tissue Engineering | 3       |
| <b>Computational Biomedical Engineering</b> |  |         |
| BME 730                                     | Vascular Mechanics/Pathology                 | 3       |
| BME 731                                     | Advanced Biomechanics                        | 3       |
| BME 732                                     | Medical Imaging                              | 3       |
| BME 733                                     | Cardiovascular Fluid Dynamics                | 3       |
| BME 734                                     | Transport Phenomena in Biomedical Engr.      | 3       |
| BME 735                                     | CAD/CAM in Medicine and Surgery              | 3       |

|         |  |   |
|---------|--|---|
| BME 737 | Advanced Signal Processing and Imaging                         | 3 |
| BME 761 | Bioadhesives   | 3 |
| BME 738 | Information Technology in Medicine                             | 3 |
| BME 792 | Topics: Special Topics in computational Biomedical Engineering | 4 |

### Rehabilitation Engineering /Assistive Technology Area

| Course # | Course Title                                   | Credits |
|----------|--|---------|
| BME 743  | Bio/MEMS and Nano Systems                      | 3       |
| BME 732  | Medical Imaging                                | 3       |
| BME 745  | Molecular Machines                             | 3       |
| BME 737  | Advanced Signal Processing and Imaging         | 3       |
| BME 738  | Information Technology in Medicine             | 3       |
| BME 735  | CAD/CAM in Medicine and Surgery                | 3       |
| BME 761  | Bioadhesives                                   | 3       |
| BME 792  | Topics: Special Topics in Assistive Technology | 4       |

Graduate courses from another university or from a related engineering discipline 21 credits (max)

### Curriculum Notes

<sup>1</sup>May substitute: ME 673.

<sup>2</sup> May substitute: ME 773.

<sup>3,4</sup> Offered by USD.

The details of individual tracks can be discussed with the program director. An assessment of the student's qualifications will be undertaken early in his or her program. The assessment comprises preliminary and qualifying examinations. Additional information is available in the Handbook of Biomedical Engineering.

Each student is also required to pass a comprehensive examination. There is no language requirement for the BME Ph.D. program.

For program supervision purposes, the BME graduate program coordinator is the graduate advisor until the major professor is appointed. The major professor is the person responsible for

the student's dissertation research. The graduate office representative on the student's dissertation committee must be selected from outside of the department with which the major professor is affiliated, and also is to be a member of the BME advisory council. Each program of study must be approved by the BME advisory council. It is not necessary that the student be associated with the department of his or her major professor. Detailed information on examination policy, admission to candidacy, and defense of dissertation is included in the South Dakota School of Mines Biomedical Engineering M.S./Ph.D. Handbook.

