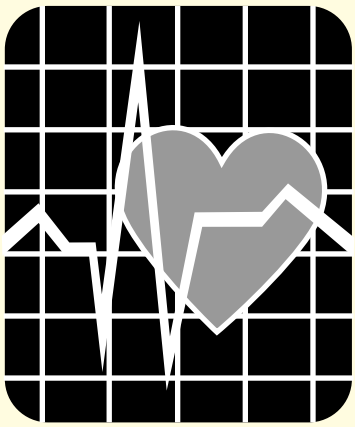

ENGINEERING — BIOMEDICAL

MASTER OF SCIENCE

PROGRAM DESCRIPTION

Biomedical engineering is that branch of engineering which focuses on the solution of problems involving both living and physical systems. The CSUS Master of Science program provides an educational experience that prepares students for a variety of careers in biomedical engineering.

The MS program offers both a core group of courses which provide the necessary breadth of preparation for a flexible life-long career and the opportunity to focus on a specialty area through the choice of elective courses. Each student is encouraged to complete a work experience (fieldwork) assignment in a biomedical engineering facility. Through close working relationships with local hospitals, clinical laboratories, and industrial biomedical engineering groups, students are provided an opportunity to develop skills in the application of biomedical engineering in each of these environments. Selected qualified students may receive additional experience through employment as part-time interns or as research assistants in industry, hospitals, or on research and development projects at CSUS. On-campus collaborative activities involve students and faculty in biomedical engineering nursing, physical education, physical therapy, psychology, and speech pathology, as well as other CSUS programs.

FACULTY

John Oldenburg, Warren Smith, *Co-Coordinators*

Robin Bandy; Colette Coleman; Trevor Davey; Thomas Grey; Miriam Legare

Department Office, ECS-3018E, 278-7977

BIOMEDICAL ENGINEERING • MS

Admission Requirements

Admission as a classified graduate student in Biomedical Engineering requires:

- a baccalaureate degree **and**
- a minimum 3.0 GPA in science, mathematics, and engineering courses; or a minimum 3.0 GPA overall or in the last 60 units attempted **and**
- completion of MATH 30, 31, 32 and PHYS 11A, 11B, 11C (or the equivalents of these six courses)

An undergraduate degree in engineering or physics is preferred; an undergraduate degree in life sciences is acceptable. Due to the interdisciplinary nature of biomedical engineering, many students will not have an adequate background in both the biomedical and the engineering components of this field. For this reason, it may be necessary to spend extra time in the acquisition of background material. Engineering students may have deficiencies in the life sciences. Likewise, life science students will generally not have taken fundamental courses in engineering. Students who have deficiencies in Admission Requirements or in background courses that can be removed by specified additional preparation may be admitted to the program with conditionally classified graduate status. Any such deficiencies will be noted on a written response to the student's admission application.

Admission Procedures

Applications are accepted as long as room for new students exists. However, students are urged to apply by April 1 for the following Fall or October 1 for the following Spring in order to allow time for admission before the Computer Access Student Phone Entry System (CASPER) deadline. All prospective graduate students, including CSUS graduates, must file the following with the CSUS Graduate Center:

- an application for admission and a supplemental application for graduate admission (Forms A and B in the CSU application booklet)
- two sets of official transcripts from all colleges and universities attended, *other than CSUS*

At the same time, each applicant should forward to the Graduate Coordinator in Biomedical Engineering two or three letters of recommendation from persons in a position to judge the student's potential for graduate study. Although not required, it is advisable that each applicant make an appointment for an interview with the Graduate Coordinator in Biomedical Engineering.

Approximately six weeks after receipt of all items listed above, a decision regarding admission will be mailed to the applicant. Based on analysis of their transcripts, admitted applicants will receive a list of undergraduate background courses required before advancement to candidacy.

Advancement to Candidacy

Each student must file an application for Advancement to Candidacy, indicating a proposed program of graduate study. This procedure should begin as soon as the classified graduate student has:

- removed any deficiencies in Admission Requirements **and**
- completed, or received transfer credit for the following set of background requirements or their equivalent:
  a. BIO 131; BIO 22 (recommended)
  b. CHEM 1A*
  c. MATH 45, CSC 16 or 25, CPE 64
  d. ENGR 17, 30, 45, 110, 115, 124, 132
  e. EEE 117, 180 **and either**
     CPE 184, EEE 118, 155, (EEE series) **OR**
     ENGR 112, ME 118, 119, 175, 180
     (ME series)
  f. Completed, or received credit for, *one* of the following courses: BME 120, 167 **and**
- completed at least 12 units in the graduate program with a minimum 3.0 GPA, including at least 3 courses at the 200 level **and**
- obtained approval for thesis

*Students interested in clinical laboratory instrumentation systems should also complete courses in organic and biochemistry such as CHEM 20 and CHEM 161.

Advancement to Candidacy forms are available in the Graduate Center. The student fills out the form after planning a degree program in consultation with a Biomedical Engineering adviser. The completed form is then returned to the Graduate Center for approval.

Degree Requirements

Although some background requirements must be satisfied as prerequisites to graduate biomedical engineering courses, others may be taken concurrently with the curriculum below. A special program has been developed for life science students in which a second bachelor's degree in either electrical or mechanical engineering may be pursued concurrently with the MS in Biomedical Engineering.

The Master of Science in Biomedical Engineering requires completion of 30 units of coursework with a minimum 3.0 GPA.

An outline of degree requirements follows:

A. Required Courses (15 units)

(3)	BME 210	Principles of Bioengineering Analysis (ENGR 115, EEE 180, or equivalents)
(3)	BME 230	Engineering Applied to Bioelectric Phenomena (BIO 131, and EEE 180 or equivalent)
(3)	BME 231	Engineering Applied to Homeostatic Transport Systems (BIO 131 or equivalent; and BME 210)
(3)	BME 261	Human Factors in the Design of Medical & Assistive Technology (BIO 131, EEE 180, or equivalents) **OR**
	BME 262	Rehabilitation Engineering Design (EEE 180. Corequisite: BME 280)
(2)	BME 280	Engineering Applied to Body Materials & Fluids (BIO 131 or equivalent; ENGR 45)
(1)	BME 299	Special Problems

B. Other Course Requirements (10 units)

(10) Units of electives chosen with consent of advisor. These may include one of the following course sequences for emphasis in particular areas, although electives may be selected from multiple areas:
Instrumentation: BME 211, 220, 270, EEE 221
Rehabilitation Engineering: BME 260, 261, 262
Signal Processing and Modeling: BME 211, 220, EEE 241
Biomechanics and Biomaterials: ME 173, 182

C. Culminating Requirement (5 units)

(5) BME 500 Master's Thesis

Rehabilitation Engineering Certificate Program

A student may obtain a certificate in Rehabilitation Engineering along with the Masters Degree in Biomedical Engineering by completing the following additional courses: BME 167 (3 units), BME 295 (4 units), and PSYC 115 (4 units).

Undergraduate Study

Although there is no formal BS level program in biomedical engineering at CSUS, undergraduate courses are offered regularly. These courses have been developed for engineering majors to include an introduction to biomedical engineering in their CE, CPE, CSC, EEE or ME program. These technically oriented courses provide experience in the application of engineering principles and devices to medicine. These courses may be included as electives in the CE, CPE, CSC, EEE or ME BS programs. Together with a course in physiology (BIO 131), they provide both an introduction to biomedical engineering and preparation for graduate study. BME 167 is also open to non-engineering students and offers interdisciplinary experience in the delivery of assistive devices to the disabled through actual client exposure. This course is useful to students in allied health, nursing, laboratory technology, rehabilitation, speech pathology and audiology, therapeutic recreation, clinical psychology, and special education programs.

UPPER DIVISION COURSES

120. Electronic Instrumentation. Junior level course introducing electronic instrumentation design and systems concepts using examples from both biomedical engineering and other engineering application areas. Lecture/discussion covers the areas of systems design, electronic circuit analysis and design, analog and digital recording systems, sensors for transducers, signal conditioning, statistical methods, selected transducer/measurement system design examples and electrical safety design considerations and device testing. The laboratory features experience with time and frequency domain measuring instruments; transducers for displacement, force, light intensity, ionic current, temperature, pressure, and flow; analog signal conditioning and analog/digital conversion; use of National Instruments LabVIEW software for virtual instrument design. Lecture three hours, laboratory three hours. **Prerequisite:** ENGR 17. Course is cross-listed as EEE 120 and may be taken only once for credit. 4 units.

167. Applications of Assistive Devices. A discussion of and laboratory experience concerning physical and cognitive disability, assistive devices and the clinical assessment of people with disabilities for the purpose of recommending and implementing appropriate assistive devices. Topics include: physical disabilities, speech and language disorders, current technology, communication devices, assessment of human needs and human factors in engineering design. Students will work in interdisciplinary teams on assistive technology problems. Lecture two hours, laboratory three hours. 3 units.

196. Experimental Offerings in Biomedical Engineering. When a sufficient number of qualified undergraduate students apply, one of the staff will conduct a pro-seminar in some topic of biomedical engineering. May be repeated for credit with permission of advisor. 1-4 units.

199. Special Problems. Individual projects or directed reading. **Note:** open only to students competent to carry on individual work. Admission to course requires approval of the faculty member under whom the individual work is to be conducted, and approval of the advisor. May be repeated for credit. 1-3 units.

GRADUATE COURSES

210. Principles of Bioengineering Analysis. A study of the theory and practice of biomedical data processing and biosystems analysis. Characterization and processing of biomedical data to facilitate meaningful interpretation. Modeling of biosystem structure and estimation of parameter values. Frequency and time domain approaches. Stochastic and deterministic applications. **Prerequisites:** ENGR 115, EEE 180; or equivalents. 3 units.

211. Advanced Topics in Biomedical Signal Acquisition and Processing. Guided experience in the development and virtual instrument implementation of signal acquisition, processing, and display for selected biomedical applications. Signals associated with the central nervous system (EEG, evoked potentials) and the cardiovascular (ECG, VCG) and respiratory (pressures, flows, volumes) systems will be considered. **Prerequisites:** BME 120 or equivalent; BME 210, 230. 2 units.

220. Advanced Topics in Medical Instrumentation. A detailed discussion of the design of sophisticated medical instruments. Emphasis is placed on complete case studies of medical instrument design based on high technology components such as microcomputers, data conversion modules, and complex sensor systems. Biopotential amplifier design is also included. Students design, build and test medical instrumentation systems. Lecture three hours. **Prerequisites:** BME 120; CPE 184 or equivalent. 3 units.

230. Engineering Applied to Bioelectric Phenomena. In-depth study of engineering techniques applied to modeling, information acquisition, and control of bioelectric phenomena. Coverage includes electrode physical chemistry, electrical properties of muscle and nerve, volume conductor fields, bioelectric generators, diagnostic and therapeutic instrumentation, information processing, and electrical safety. Lecture two hours, laboratory three hours. **Prerequisites:** BIO 131; EEE 180 or equivalent. 3 units.

231. Engineering Applied to Homeostatic Transport Systems. Biomedical engineering applications to the systems responsible for homeostasis in the living organism. System structure and function. Diagnostic instrumentation and techniques. Therapeutic methods for replacing inadequate function and for driving the system to desired states. Applications to the mammalian respiratory, fluid balance, and thermoregulatory systems. Lecture two hours, laboratory three hours. **Prerequisites:** BIO 131 or equivalent; BME 210. 3 units.

260. Biomedical Engineering Practice. Issues relating to the practice of biomedical engineering in clinical engineering (management of medical technology) and medical device development/manufacturing environments. Topics include overview of the health care environment, federal and state regulations, example applications and processes used, project and business management techniques, legal and professional issues, impact of computer systems in clinical information systems, medical devices, imaging and telepresence, and future directions. Lecture three hours. **Prerequisite:** Graduate standing or permission of instructor. 3 units.

261. Human Factors in the Design of Medical and Assistive Technology. Discussion and analysis of human factors in the design of medical and assistive technology. Includes human performance models, characteristics (physical and cognitive), and performance limits, including disability. Specific issues related to the design of safe and effective medical devices, design of clinical application environments (e.g., anesthesia and surgery stations), and design of assistive technology for the disabled and aging populations are presented. Laboratory exercises focus on human performance measurement techniques and tools and the use of computer simulations in the design and analysis of human-machine interfaces. Lecture two hours, laboratory three hours. **Prerequisites:** BIO 131, EEE 180; or equivalents. 3 units.

262. Rehabilitation Engineering Design. Develops advanced methods for designing and testing assistive technology for persons with disabilities. The primary topic areas are wheeled mobility, personal transportation, recreational equipment, accessibility, orthotics and prosthetics, and robotics. The proper application of assistive devices, their design and testing are discussed. Material from current literature is used extensively throughout the course. Methods of modern manufacturing are introduced and applied in the laboratories. There is substantial hands-on experience with assistive technology. The course includes discussion of current laws, regulations and standards related to the design of assistive technology. Lecture two hours, laboratory three hours. **Prerequisite:** EEE 180. **Corequisite:** BME 280. 3 units.

270. Engineering Applied to Medical Imaging. Biomedical engineering aspects of instrumentation and devices utilized for diagnosis of many organ systems. Radiation biophysics with application in radiology and nuclear medicine. Imaging in medicine using ionizing radiation and ultrasound. **Prerequisite:** EEE 180. 2 units.

280. Engineering Applied to Body Materials and Fluids. An in-depth engineering analysis of selected mechanical systems in the human body with emphasis on cardiovascular applications. Topics covered include biocompatibility of materials, design of prosthetics, hemodynamics, and measurement of clinical parameters. Lecture one hour, laboratory three hours. **Prerequisites:** BIO 131 or equivalent; ENGR 45. 2 units.

295. Fieldwork in Biomedical Engineering. Supervised work experience in an area of biomedical engineering. **Prerequisite:** permission of instructor and advisor. Graded Credit/No Credit. 1-6 units.

296. Experimental Offerings in Biomedical Engineering. When a sufficient number of qualified students are interested, one of the staff will conduct a seminar in some advanced topic in biomedical engineering. May be repeated for credit with permission of advisor. 1-4 units.

299. Special Problems. Graduate research. **Note:** approval must be obtained from the faculty member under whom the work is to be conducted and from the student's advisor. 1-3 units.

500. Master's Thesis. Credit given upon successful completion of a thesis approved for the master's degree. **Note:** Open only to graduate students who have advanced to candidacy for the master's degree and who secures the permission of the chair of his/her thesis committee. Should be taken in final two semesters prior to completion of all requirements for the degree. Graded Credit/No Credit. 1-6 units.