

Recommendation to the Board of Governors

**ESTABLISHMENT OF A BACHELOR OF SCIENCE IN BIOMEDICAL
ENGINEERING**

Recommendation

It is recommended that the Board of Governors approve the proposal from the College of Engineering and the Department of Biomedical Engineering (in collaboration with School of Medicine) to establish a Bachelor of Science in Biomedical Engineering effective Fall semester 2010.

Background

Wayne State University has one of the longest histories in the United States with respect to biomedical engineering research. In 1939, faculty from the College of Engineering and School of Medicine began collaborating to investigate the mechanisms of injuries to the human body. The injury biomechanics program at WSU has gained an international reputation for its work. The Graduate Program in Biomedical Engineering was established in 1998 and the Department formed four years later. The established faculty are now in a strong position serve as the foundation for an undergraduate degree program in biomedical engineering.

Biomedical engineering has become one of the fastest growing fields of engineering worldwide. There is tremendous student interest in the field, with biomedical engineering programs often becoming the largest undergraduate majors at the colleges that develop them. Even at Wayne State, many undergraduate students are interested in BME, as evidenced by the number of potential students who indicate a desire to pursue a major in biomedical engineering. Currently, undergraduates are advised to pursue a major in chemical, electrical, or mechanical engineering, taking technical electives in the BME area. However, a dedicated undergraduate program will allow this opportunity to be marketed to bring additional students to the College of Engineering.

Nationally, biomedical engineering students are some of the top students at their respective colleges of engineering. BME is a challenging program – integrating engineering and the biomedical sciences. Admission to the WSU BME program will be competitive, with limited enrollment due to limited resources. It is anticipated that such a program will attract outstanding students to Wayne State's College of Engineering.

The State of Michigan has identified biomedical sciences and technology as one of the new areas of economic development within the state during the transition from a reliance on the automotive industry. Biomedical engineers serve as key members of research, development, and manufacturing teams within this arena, translating ideas that grow from basic biomedical and clinical sciences into systems, devices, and techniques that can be patented, produced and marketed to improve health care outcomes. The need for biomedical engineers within the State of Michigan can be expected to grow substantially over the next 10 to 15 years. Nationally, biomedical engineering opportunities are expected to grow by 21% in the next 7 years, which is much higher than the overall average expected increase in job growth and 10 points higher than engineering in general.

Program Objectives

In the Accreditation Board for Engineering and Technology (ABET) terminology, program objectives are those things that graduates will be able to do 2-3 years after graduation. The objectives of the BSBME program are thus to develop graduates who can:

1. Work in multidisciplinary teams to translate biomedical science to application
2. Utilize engineering, mathematical, and biomedical tools to solve biomedical engineering problems and design biomedical engineering systems
3. Continue their education in engineering or biomedical fields based on a strong underlying foundation in both areas of study

Curriculum Requirements

The proposed undergraduate program has been developed with four underlying tenants:

1. The program shall have a strong foundation in engineering.
2. The program shall integrate engineering with biomedical science early and continuously within the course progression.
3. Traditional didactic lectures will be combined with problem-based and project-based learning to allow students to immediately apply their foundational knowledge to biomedical engineering challenges.
4. The program will leverage the resources of the College of Engineering and the University as a whole while taking into consideration the unique aspects of educating students in the field of biomedical engineering.

The outlined program includes 131 credits of required coursework that satisfy ABET and University requirements. The curriculum is divided into 8 parts, as outlined below. Courses that satisfy University General Education requirements are noted in brackets.

General Education (28 cr)

Open Electives

- AI course (3 cr)
- FC course (3 cr)
- HS course (3 cr)
- VP course (3 cr)

Specified Courses

- ECO 2010 or ECO 2020 (3 cr) [SS]
- ENG 1020 (4 cr) [BC]
- ENG 3050 (3 cr) [IC]
- ENG 3060 (3 cr) [OC]
- PHI 1120 – Professional Ethics (3 cr) [PL/EI]

Mathematics (16 cr)

- MAT 2010 – Calculus I (4 cr) [MC]
- MAT 2020 – Calculus II (4 cr)
- MAT 2030 – Calculus III (4 cr)
- MAT 2150 – Differential Equations and Matrix Algebra (4 cr)

Physical Sciences (16 cr)

- CHM 1225/1230 – General Chemistry and Lab (3 + 1 cr) [PS/Lab]
- CHM 1240 – Organic Chemistry I (4 cr)
- PHY 2175 – General Physics I (4 cr)
- PHY 2185 – General Physics II (4 cr)

Life Sciences (13 cr)

- BIO 1510 – Basic Life Functions + Lab (4 cr) [LS]
- BME 2005 – Introduction to Molecular and Cellular Biology (3 cr)
- BME 4010 – Engineering Physiology Laboratory (2 cr)
- BME 5010 – Engineering Physiology (4 cr)
- CMS 6010 – Research Ethics (1 cr)

Basic Engineering (13 cr)

- BE 1200 – Basic Engineering I: Introduction to Engineering Design (3 cr) [CL]
- BE 1300/1310 – Basic Engineering II: Materials Science for Engineering Applications + Lab (3 + 1 cr)
- BE 2100 – Basic Engineering III: Probability and Statistics for Engineering Applications (3 cr)
- BE 2550 – Basic Engineering IV: Numerical Methods and Computer Applications in Engineering (3 cr) [CP]

Core Engineering (14 cr)

- ME 2410 – Statics (3 cr)
- ME 2420 – Mechanics of Materials (3 cr)
- CHE 3200 – Fluid Flow and Heat Transfer (4 cr)
- ECE 3570 – Electronics (4 cr)

Core Biomedical Engineering Science and Design (15 cr)

- BME 2910 – Biomedical Design Laboratory I (1 cr)
- BME 2920 – Biomedical Design Laboratory II (1 cr)
- BME 3470 – Biomedical Signals and Systems (4 cr)
- BME 3910 – Biomedical Design Laboratory III (1 cr)
- BME 3920 – Biomedical Design Laboratory IV (2 cr)
- BME 4910 – Biomedical Capstone Design I (3 cr)
- BME 4920 – Biomedical Capstone Design II (3 cr) [WI/ST]

Biomedical Engineering Concentration (15 cr)

Introduction to Concentration Course (select one) (3 cr)

BME 4210 – Introduction to Biomechanics

BME 4310 – Introduction to Biomaterials

BME 4410 – Introduction to Biomedical Instrumentation

Concentration Courses (12 cr) from one of following groups of currently offered courses

Biomechanics

CHE 3300 – Thermodynamics: Chemical Equilibria (4 cr)

ME 3400 – Dynamics (3 cr)

BME 5130 – Vehicle Safety Engineering (3cr)

BME 5210 – Musculoskeletal Biomechanics (4 cr)

BME 5250 – Hip and Spine Fractures in the Elderly (2 cr)

BME 6500 – Enabling Technology (3 cr) (ECE 6100)

PT 5500 – Kinesiology and Biomechanics (3 cr)

PT 5660 – Pathokinesiology (2 cr)

Biomaterials

CHE 3300 – Thermodynamics: Chemical Equilibria (4 cr)

CHE 3800 – Separations (4 cr)

BME 5310 – Device and Drug Approval and the FDA (3 cr)

BME 5370 – Selection of Materials for Biomedical Implants (4 cr)

BME 5380 – Biocompatibility (4 cr)

MSE 5350 – Polymer Science (3 cr)

MSE 5650 – Surface Science (3 cr)

Biomedical Instrumentation

BME 5510 – Introduction to Clinical Engineering and Technology (2 cr)

BME 5570 – Mechatronic System Design I (4 cr) (ECE 5370)

BME 5580 – Mechatronic System Design II (4 cr) (ECE 5380)

BME 6480 – Biomedical Instrumentation (4 cr)

BME 6500 – Enabling Technology (3 cr) (ECE 6100)

BME 6470 – Smart Sensor Technology I (4 cr)

The program is designed to be completed in four years for students who place in MAT 2010. Those who do not place into MAT 2010 will need additional credits for prerequisite mathematics courses, depending on their placement. Students in the Honors Program can complete the University and Engineering Honors requirements without any additional required credits. Students wishing to attend medical school will need to complete an additional 9 credits of coursework to satisfy standard medical school admissions requirements.

In order to minimize required resources, a strict course progression will be followed, with most BME courses offered only once per academic year. Students may reduce their course load each term by deferring targeted courses to the spring/summer semester. Students who decide that they wish to attend university part-time will be allowed to work with their advisor to develop a plan of work that allows for continued progression through the courses.

Related Programs at Other Universities

Only three other undergraduate BME programs exist in Michigan. These are at the University of Michigan (Ann Arbor), Michigan Technological University, and Lawrence Technological University. Each school has differences in the emphasis of their programs. Of the other three, only the University of Michigan has an affiliated medical school. LTU has a new undergraduate program that was established in 4 or 5 years ago and does not offer graduate degrees. Michigan Tech focuses on undergraduate BME education, with only a small doctoral program. The University of Michigan offers BS, MS, MSE, and PhD programs in BME. Fall 2008 enrollments at these three institutions plus Wayne State were:

<u>University</u>	<u>BS.</u>	<u>MS.</u>	<u>PhD.</u>
University of Michigan	202	69	110
Michigan Technological Univ.	239	0	10
Lawrence Technological Univ.	52	0	0
Wayne State University	NA	124	30

Admissions Requirements

The size of the undergraduate BME program is limited by the availability of resources, in particular instructional personnel and laboratory space, required to support it. Based on the anticipated resources available, both from BME and from supporting departments, a class size limit of 40 students is proposed. This cohort size can be accommodated within current classrooms for design laboratories, can be scheduled for physiology laboratory with two class sections, and will not overtax currently offered courses in other engineering departments or the Basic Engineering course sequence. Admissions are therefore expected to be reasonably competitive in nature.

Admission to the BSBME program will be restricted to students who have demonstrated ability in math and science. Incoming freshmen will be expected to have completed at least the following courses with a minimum high school math and science gpa of 3.0:

- Precalculus – with WSU math placement into MAT 2010 or higher
- Chemistry – with placement into MAT 1225/1230 or higher
- Physics
- Biology

Demonstration of academic preparedness through a strong high school record and appropriate math and chemistry placement will guide admissions decisions. No strict ACT or SAT requirements will be set, but it is anticipated that students will have minimum math and science ACT scores of 26 (math SAT of 650).

Freshman will be admitted to the BME program at the start of their first semester, following confirmation of appropriate math and chemistry placement. Those students interested in BME will be invited to submit a simple application to trigger a review of their record by the BME

faculty and academic advisor. Outstanding prospects may be admitted on a rolling basis in the spring of their senior year of high school based on enrollment in advanced mathematics, prior Advanced Placement exam results, and/or dual enrollment in college-level courses.

Additional spots in the program are expected to become available through transfer of initially admitted BME students to other programs both within and outside the College of Engineering. Students will be considered for these spots from both inside WSU (internal transfers) and outside of the University (external transfers). Processes for these transfers are described below.

The department has created admission plans for both students who are entering in their second or third year.

Program Administration

The Chair of the Biomedical Engineering Department, Dr. Albert King, will have ultimate responsibility for the program. An Undergraduate Program Director will be named from within the BME faculty to oversee the program, decide on program policy waivers, and coordinate activities within the Department for accreditation.

The Department has a full-time academic services officer, Namrata Murthy, who will provide advising for the undergraduate students as she does currently for graduate students. She will also assist the department with program recruiting and outreach.

Budget and Resource Requirements

Personnel

As the program grows to full strength, a minimum of four new faculty will be required in order to maintain the graduate program, meet the teaching needs of the undergraduate program, and maintain the departmental research program. External reviewers have strongly recommended that the teaching load within the Department of Biomedical Engineering be kept at 8 credits per year due to the very high per faculty research productivity. During the transition, the following faculty will be required:

- Faculty member from Chemical Engineering and Materials Science to teach BME 4310 annually and alternating BME 5370 and BME 5380, each on a biannual basis
- Faculty member from Electrical and Computer Engineering to teach BME 3470 and BME 4410 annually
- Instructor to coordinate and teach the entire BME design sequence
- Faculty member (new – by first enrollment of juniors) to teach BME 4210 along with annualization of current 5000-level biomechanics offerings

It is anticipated that the new faculty member to be hired under the existing open search in Biomedical Engineering (through the Graduate Program Enhancement Program) will be able to fill one of these faculty slots, most likely in the area of biomechanics. The design instructor can begin in a part-time role as the program is established, building to a full-time annual teaching load of 17 credits (8 credits Fall, 7 credits Winter, 2 credits Spring/Summer). It is anticipated that

this will be a non-tenure track faculty member focused on teaching. The remaining two faculty positions can be sought once the program has been established and has demonstrated its financial benefit to the College and University in terms of tuition revenue. Additional GTA's will also be required in order to support laboratory and design course offerings.

Laboratory and Infrastructure

In addition to the offices and research laboratories that will be required for the new research-intensive faculty, space for undergraduate laboratories will be required. Expected laboratory resources are likely to include:

- Cell culture facilities
- Optical microscopes (teaching labs) and more advanced microscopes (AFM, SEM, confocal, etc in research labs)
- Mechanical testing system (teaching lab facility preferred)
- Instrumentation and electronic system design, fabrication, and analysis facility

Some of these systems are currently available for relocation to a BME teaching laboratory. Others may need to be acquired over the first years of the program and/or shared with current undergraduate teaching labs in other departments. Students would be expected to take advantage of the Engineering Machine Shop for assistance in development of their prototype systems as necessary.

Ideally, the capstone design students will need a space in which they can build and test their prototype systems that can be accessed outside of scheduled class time and in which team materials can be secured. Until such a time that a dedicated space can be developed, it may be possible to utilize a portion of the teaching laboratory facility. Physiology laboratory facilities will be required for BME 4010. This will include computer-based workstations that can utilize Biopac systems for physiological signal acquisition and analysis. If scheduling is coordinated appropriately, a single facility that includes physiological and other laboratory facilities can be used to support laboratory studies.

Accreditation

The College of Engineering plans to pursue accreditation for the BSBME program through ABET. This process will be pursued after the first class of students has graduated, per ABET policy. All procedures and practices required for accreditation will be implemented with the admission of the first class in order to support the accreditation process.

Approvals

The proposal for the Bachelor of Science in Biomedical Engineering in the Department of Biomedical Engineering was approved by the Chair and the faculty in the Department of Biomedical Engineering and the College of Engineering Faculty Council and dean.