University of Wisconsin-Milwaukee
College of Engineering & Applied Science

Request for Authorization to Implement a Bachelor of Science
in Biomedical Engineering

A. ABSTRACT:

The proposed Bachelor of Science (B.S.) in Biomedical Engineering will be offered by the Biomedical Engineering Program Department-like Body, within the College of Engineering & Applied Science. The program will require 120 credits of coursework that includes 16 credits of elective courses in a specialize track of the student's choice.

B. PROGRAM IDENTIFICATION:

Institution Name
University of Wisconsin-Milwaukee

Title of Proposed Program
Biomedical Engineering

Degree/major Designation
B.S. Engineering/Biomedical Engineering

Mode of Delivery
Primarily face-to-face classroom- and laboratory-based instruction

Single Institution or Collaboration
Single institution

Projected Enrollment by Year Five
250-300 students

Tuition Structure
Engineering undergraduate differential tuition

Department or Functional Equivalent
Biomedical Engineering Program Department-like Body

College, School or Functional Equivalent
College of Engineering & Applied Science

Proposed Date of Implementation
January 2, 2016
C. INTRODUCTION:

1. Why is the program being proposed? What is its relation to the institution's mission?

Biomedical engineering is a cross-disciplinary program that applies principles and methods from engineering, science, and technology to understand, define, and solve problems of life and medical sciences. Biomedical engineers design and manufacture devices and instrumentation, such as electrocardiography systems, electroencephalography, blood-flow monitoring, electrical stimulators for muscles and nerves, to assist medical specialists with diagnosis and treatment of patients. They design therapeutic and prosthetic devices to improve the quality of life. These include cochlear and visual prosthesis, prosthetic fingers, joints, and limbs. Biomedical engineers are also involved in development of artificial/bionic pancreas, heart, eyes, and other human organs.

Biomedical engineering is expected to play an important role in the economic development of Wisconsin and the region. The median annual pay in 2012 was $86,960 and, according to Forbes, biomedical engineering is ranked No. 1 in the major most worth tuition, time and effort, using a rubric of starting pay, median mid-career pay, growth in salary and wealth of job opportunities\(^1\). It has been ranked not only “one of the highest-paid engineering jobs,” but also an immensely rewarding profession because “it is a career that gives back to society by helping improve world health.”\(^2\)

The mission statement of the University of Wisconsin-Milwaukee includes the development of high quality undergraduate programs appropriate to a major urban doctoral university, including developing and extending academic and professional opportunities for minority students. National trends indicate biomedical engineering is more attractive among under-represented groups. Since Southeast Wisconsin is home to a number of biomedical related industries, there are internship and job opportunities for the graduates. Furthermore, since it is a growing area, there is a strong possibility of entrepreneurship that will help with new economic development in the region.

2. How does it fit into the institution's overall strategic plan?

The proposed B.S. in Biomedical Engineering will complement the existing program array at UWM. Since the proposed program is of interdisciplinary nature, this will build upon several science and engineering courses already offered in our six ABET accredited B.S. degrees. The College of Engineering & Applied Science (CEAS) currently has over twelve faculty members with research and teaching interests in this area and offers a Master of Science in Engineering degree with Biomedical Engineering as one of the areas of concentration.

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\(^1\) http://whatisbiomedicalengineering.net/Factors-That-Affect-Biomedical-Engineering-Salaries.html
\(^2\) http://money.cnn.com/pf/best-jobs/2012/snapshots/
Further, the College leads a doctoral program in Biomedical and Health Informatics that is offered in collaboration with the following five units of the University and the Medical College of Wisconsin:

1. College of Health Sciences  
2. College of Nursing  
3. Lubar School of Business  
4. School of Information Studies  
5. Zilber School of Public Health  

The proposed B.S. program will complement these graduate programs. Students in this program will have ample opportunities for research experience. Our partnership with the Medical College of Wisconsin will provide opportunities for hands-on experience to students. Also, biomedical engineering is one of the four areas of research concentrations with new investment by the College and therefore, such opportunities for students are expected to grow significantly.

3. Do current students need or want the program?

Many students are aware of potential growth of biomedical engineering area. As a result, institutions with this program have exceptionally high enrollments. We have received enquiries from prospective students for quite some time about the availability of biomedical engineering program at UWM. Since our intent to plan was circulated, student requests for the date of availability of this program have been continuous, including many enquiries from students belonging to underrepresented groups. Some of the students have interests in engineering as well as in medicine and this program fits in their plans. Others find it appealing because of entrepreneurship or research interests.

4. Does market research indicate demand?

According to the U.S. Department of Labor, employment of biomedical engineers will grow 27 percent over the period of 2012 to 2022. This growth is at a much faster rate than the average for all occupations\(^3\). Since an aging population will need more medical care, demand for biomedical engineers is expected to continue to be strong. National trends show there will be a growing market for new and improved assistive devices for the aging population.

The proposed program has potential for an increased entrepreneurial activity in the region because of the availability of trained professionals in biomedical engineering.

5. How does the program represent emerging knowledge, or new directions in professions and disciplines?

It is a cross-disciplinary program that prepares students to apply basic science and engineering analysis and design techniques to the medical area. This requires basic understanding of the human body functions to design diagnostic and therapeutic devices. Thus, this brings a diverse group of professionals together than in turn benefits

\(^3\) [http://www.bls.gov/ooh/architecture-and-engineering/biomedical-engineers.htm](http://www.bls.gov/ooh/architecture-and-engineering/biomedical-engineers.htm)
engineering designs as well. A number of biological phenomena have recently led to new engineering approaches. Against the backdrop of healthcare reform, an aging national populace\(^4\), and innovations in medicine and engineering, biomedical engineering is emerging as a field of significant potential.

D. DESCRIPTION OF PROGRAM:

General Structure of the Program

Institutional Program Array
In keeping with its interdisciplinary nature, the program combines several disciplines of the College of Engineering & Applied Science, College of Letters and Sciences, College of Health Sciences, School of Nursing, and Zilber School of Public Health. The proposed program is designed on the basis of selected courses from engineering, biological sciences and other basic sciences. Only a few new courses will be needed for this program.

Other Programs in the University of Wisconsin System
Only University of Wisconsin-Madison currently offers this kind of program within the UW-System. The proposed program is not expected to significantly affect students' enrollment there. When fully implemented, we expect a total of about 300 students enrolling in this program.

Collaborative Nature of the Program
We have established strong relationships with the Medical College of Wisconsin as well as with GE Healthcare for research and graduate education in biomedical engineering. GE Healthcare has sponsored a Center for Computational Imaging at the College and a number of their engineers attend our classes for advanced degrees. Several senior engineers also teach as adjunct faculty at the College. Our newly built Innovation Campus is close to the Medical College of Wisconsin to facilitate collaborative activities. We have a strong support for the proposed program from the Medical College of Wisconsin that also sees it as a potential feeder into their graduate medical program.

Diversity
The mission statement of the University of Wisconsin-Milwaukee includes furthering academic and professional opportunities for women and minority students. National trends indicate that biomedical engineering is more attractive among the under-represented groups.

Student Learning Outcomes
Upon the completion of the program, a student will be able to:

a) Apply principles of engineering, biology, human physiology, basic science, mathematics (through differential equations), and statistics;

b) Solve biomedical engineering problems, including those associated with the interaction between living and non-living systems;
c) Analyze, model, design and realize biomedical engineering devices, systems, components, or processes; and making measurements on and interpreting data from living systems;
d) 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;
e) Demonstrate an understanding of professional and ethical responsibility;
f) Demonstrate the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
g) Demonstrate an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Accreditation of engineering program requires a continuous assessment of the learning outcomes. Similar to existing engineering programs, this program will also be assessed in order to receive accreditation.

**Programmatic Curriculum**

Students will be required to take 120 credits to fulfill the requirements of the program. As indicated in the table below, this includes 26 credits in engineering core courses, 37 credits in the biomedical engineering major, up to 16 credits in mathematics, 10 credits in physics, and 15 in GER courses. Remaining 16 credits are assigned to several specialized tracks that students may select according to their interests. Some of these students may select a track in higher education while some other may select a broader spectrum and entrepreneurial emphasis. There will be more courses added to this group as the program expands.

<table>
<thead>
<tr>
<th>Engineering core courses (26 credits)</th>
<th>BME 101 Fundamentals of Biomedical Engineering (3)*</th>
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<tbody>
<tr>
<td></td>
<td>MechEng 101 Computational Tools for Engineers (2)</td>
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<td></td>
<td>EAS 200 Professional Seminar(1)</td>
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<td></td>
<td>CivEng 201 Statics (3)</td>
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<td></td>
<td>CivEng 202 Dynamics (3)</td>
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<td>MatlEng 201 Engineering Materials (4)</td>
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<td></td>
<td>ElecEng 301 Electrical Circuits I (3)</td>
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<td></td>
<td>MechEng 301 Basic Engineering Thermodynamic (3)</td>
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<td></td>
<td>ElecEng 305 Electrical Circuits II (4)</td>
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<tr>
<th>Biomedical Engineering Major (37 credits)</th>
<th>BioSci 202 Anatomy and Physiology I (4)</th>
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<tr>
<td></td>
<td>BioSci 203 Anatomy and Physiology II (4)</td>
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<tr>
<td></td>
<td>ElecEng 310 Signals and Systems (3)</td>
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<td></td>
<td>ElecEng 436 Introduction of Medical</td>
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<td>Course</td>
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<tr>
<td>Instrumentation</td>
<td>MechEng 469 Introduction to Biomechanical Engineering (3)</td>
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<td>MechEng 474 Introduction to Control Systems (4)</td>
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<td></td>
<td>MechEng 479 Control and Design of Mechatronic Systems (3)</td>
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<td></td>
<td>MatEng 485 Introduction to Biomaterials (3)</td>
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<td></td>
<td>BME 495 Biomedical Instrumentation Lab/Senior Lab (3)*</td>
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<td></td>
<td>BME 595 Capstone Design Project (4)*</td>
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<td></td>
<td>BioSci 465 Biostatistics OR IndEng 467 Introductory Statistics for Physical Science and Engineering Students (3)</td>
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<td>Mathematics</td>
<td>One of the following Calculus sequences must be completed Math 231-232-233 (12) OR Math 221-222(Honors) (10), AND ElecEng 234 Analytical Methods in Engineering (4)</td>
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<tr>
<td>Physics</td>
<td>Physics 209 &amp; 214 (Lab)</td>
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<td></td>
<td>Physics 210 &amp; 215 (Lab)</td>
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<td>GER courses</td>
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<td>Elective tracks</td>
<td>Students will select a track of their choice, such as (i) rehabilitation and bio-robotics, (ii) imaging, or (iii) general biomedical engineering and will be advised to enroll in courses from the list of electives. This list (and hence the tracks) is expected to grow as the faculty expands.</td>
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* Note: New course (CAR form) to follow

**Electives (16)**
- EAS 001 Co-op Work Period
- EAS 497 Study Abroad
- CivEng 303 Strength of Materials
- ElecEng 361 Electromagnetic Fields
- ElecEng 410 Principles of Discrete Systems & Digital Signal Processing
- ElecEng 437 Introduction to Biomedical Imaging
- ElecEng 438 Bioanalytics and Biomedical Diagnostics
- ElecEng 537 Fundamentals of Neuroimaging Technology
- ElecEng 539 Introduction to Magnetic Resonance Imaging
IndEng 584 Biodynamics of Human Motion
IndEng 360 Engineering Economic Analysis
MechEng 320 Introduction to Fluid Mechanics
MechEng 370 Computer Aided Engineering Laboratory
BusAdm 447 Entrepreneurship
BioSci 354 Introduction to Neuroscience I
BioSci 355 Introduction to Neuroscience II
Psych 254 Physiological Psychology
Chem 102 General Chemistry
Chem 104 General Chemistry and Quantitative Analysis
Chem 343 Organic Chemistry
Chem 344 Organic Chemistry Laboratory
Chem 345 Organic Chemistry
CompSci 250 Introductory Computer Programming
Physics 305 Medical Physics
Physics 306 Introduction to Biophysics
BioSci 150 Foundations of Biological Sciences I
BioSci 152 Foundation of Biological Sciences II

**Time to Degree**
Students taking 15 credits per semester can finish the requirements in eight semesters. Students taking 12 credits per semester can finish the requirements in 10 semesters. Since engineering students are encouraged to co-op, this may add another year to their graduation time.

**Program Review Process**
Academic Planning and Curriculum Committee reviews all undergraduate programs at the University of Wisconsin-Milwaukee. The details may be found at the following site. http://www4.uwm.edu/secu/faculty/standing/apcc/upload/UWM-Program-Review-Schedule-2030-3.pdf

Also, all existing engineering programs are accredited by ABET (Accreditation Board for Engineering and Technology). They have set eight criteria for such reviews: students, program educational objectives, student outcomes, continuous improvement, curriculum, faculty, facility and institutional support. The requirements include monitoring of student progress in attaining 11 outcomes, documenting processes for assessing and evaluating the extent to which student outcomes are being attained, and using this evaluation for continuous improvement. Students, alumni, and employers are included in the assessment process. An industrial advisory committee is involved for each engineering program. The proposed program will also have these assessments in order to have ABET accreditation.

**E. Institutional Commitment:** attached separately.