The University Senate of Michigan Technological University

Proposal 7-12

(Voting Units: Academic)

"Master's Program in Biomedical Engineering"

Michigan Technological University
Department of Biomedical Engineering
August 2011

1. Introduction

This is a proposal to formally establish a Master's degree program in Biomedical Engineering (BME) within the Michigan Technological University's Department of Biomedical Engineering. This proposal will establish Plan A, Plan B and Plan D MS degree options. The mission of the proposed program is to create a pathway for students to further enhance their engineering and life science knowledge, gaining a competitive edge in an increasingly demanding job market.

The proposed Master's degree program in BME will be fully administered and maintained by the Department of Biomedical Engineering. The scope of the proposed program is similar to many existing programs at Michigan Tech as well as at other institutions. Engineering students with high academic standing can apply and be accepted for the program. Students without a Biomedical Engineering undergraduate degree are welcome into the program, but may be required to take additional life science courses to make up for deficiencies in life science training. Highly qualified non-engineering students are also welcome to apply, however, these individuals may be required to complete additional mathematical and/or engineering courses to make up for deficiencies.

Participating students are also required to maintain good standing after acceptance into the program.

Our specific objectives are to:

1) Offer a Master's degree beginning in the fall of 2012.
2) Initiate a recruiting effort to publicize the expanded graduate opportunities in BME at Michigan Tech.
3) Establish initial MS student enrollment at a level of 15 (including an estimated 12 from the accompanying proposal for an accelerated MS program).
4) Contribute to Michigan Tech's mission to be a nationally prominent and internationally recognized technological university that bridges technology and business and meets the needs of a global and technologically rich society through excellence in undergraduate and graduate education, scholarship, and research.

Note that an Accelerated Master's Degree Program proposal has been developed also and it will be submitted to the Graduate School for approval upon final approval of the present proposal.

2. Rationale

Biomedical Engineering is one of the fastest growing engineering specialties in the United States. The bachelor's degree program in biomedical engineering at Michigan Tech reflects this trend and has experienced steady growth in student numbers since the program was initiated in 1997. BME at Michigan Tech currently (Fall, 2011) enrolls approximately 272 undergraduate students. To prepare students for careers in biomedical engineering requiring advanced education beyond the bachelor's degree, the BME department established and offered a doctoral program in biomedical engineering starting 2005. BME currently has 12 doctoral students enrolled in the program.

At present, Michigan Tech has programs in biomedical engineering aimed at preparing students for both entry level (bachelor's degree) terminal level (Ph.D. degrees) positions. Nevertheless, there is still a strong need for master's

program that can provide training to students who are interested in mid-level entry positions, or who desire to have a competitive edge compared to students with a standard 4-year BME bachelor's degree.

There are many reasons to establish a master's program in biomedical engineering at Michigan Tech. First, at the national level, there is an increasing demand for master's degree level biomedical engineers. Without a master's degree program at Michigan Tech, Michigan Tech graduates will be forced to attend competitor institutions if they wish to continue beyond a 4-year bachelor's degree but do not want to commit at least 4 more years towards a Ph.D. degree.

Second, a master's program in biomedical engineering is a natural progression for the Biomedical Engineering Department at Michigan Tech. To be competitive nationally, the university recognizes that it is important to have strong graduate programs, in addition to undergraduate programs, to achieve the highest quality education at all levels. The small size of the BME graduate student population has restricted the department's efforts towards developing highly focused, advanced graduate-level courses. The establishment of a master's program is expected to increase the size of the graduate program and provide a large number of self-supporting students. This will allow the department to engage in activities that strengthen the overall graduate mission of the department and the university.

Third, a master's program in biomedical engineering will both directly and indirectly enhance the research efforts in the department. The proposed Plan A master's program is a traditional, hands-on master's degree that requires research leading to a thesis. The proposed Plan B requires a smaller project that results in a research paper. Finally the Plan D master's degree is purely ~~didactic~~ educational in nature preparing students to further continue their education, if desired. As a result, the Plan D master's program will allow the department to identify and recruit highly motivated and better prepared students into the department's Ph.D. program. We do not propose to develop a Plan C master's program which requires a small project and an final examination.

3. Related Programs

Related Programs at Michigan Tech

Currently, the BME department at Michigan Tech has an undergraduate program that awards graduating students a bachelor's of science in biomedical engineering, and a graduate program that awards students a Ph.D. in biomedical engineering. There are no master's programs in BME. Students who wish to pursue a master's degree in a biomedical engineering –related field at Michigan Technological University must pursue their degree from another engineering department, such as electrical, mechanical, materials science or chemical engineering.

Equivalent/Competitive Programs in the State of Michigan

University of Michigan

The Biomedical Engineering Department at the University of Michigan has a graduate program in the Horace Rackham School of Graduate Studies that grants M.S. and Ph.D. degrees in Biomedical Engineering. The department is jointly supported by the College of Engineering and the Medical School. In order to obtain an M.S. degree in Biomedical Engineering, students must satisfactorily complete (B or better for courses that are issued letter grades, and S for courses that are graded S/U) a minimum of 30 credits of graduate study beyond the bachelor's degree. Within this requirement, a group of core courses, or their equivalents in the biological sciences, as well as several graduate-level engineering and physical science courses, must be completed. Directed research work is required to familiarize the student with the unique problems associated with biological systems research.

Wayne State University

Wayne State University offers both the MS and Ph.D. degrees in Biomedical Engineering. The master's degree is offered in two options: Plan A, which requires a minimum of 34 credit hours in course-work including an eight-credit thesis and Plan C, which requires a minimum of 34 credits in course work. Wayne State does not offer an accelerated BS/MS program.

Michigan State University

Biomedical Engineering is not available as a major at Michigan State, but several MSU degree programs include an optional concentration for biomedical-related focused study, including Biosystems Engineering, Chemical

Engineering, Materials Science and Engineering, and Mechanical Engineering. The Electrical Engineering major includes a Biomedical Engineering major track.

Equivalent Programs Nationally

Nationally, master's programs in biomedical engineering at research-oriented universities are the norm. Certain BME programs, notably the Georgia Institute of Technology/Emory program restrict awarding MS degrees to those doctoral students who have met the minimum requirements for a MS degree, but fail to complete the Ph.D. program.

The table below lists a few of the top rated biomedical engineering programs, and their MS programs (if offered).

Top national undergraduate biomedical (bioengineering) programs	**MS or equivalent program?**
Johns Hopkins University	Yes
Georgia Institute of Technology/Emory	M.S. only for failing Ph.D. students
University of California – San Diego	Yes
Duke University (Pratt)	Yes
University of Washington	Yes
Massachusetts Institute of Technology	Yes
University of Pennsylvania	Yes
Boston University	Yes
Rice University	Yes (Master of Bioengineering – non-thesis)
Stanford University	Yes
University of Arizona	Yes

4. Projected Enrollment

We project our initial master's graduate enrollment to be 3, plus an additional 12 from the proposed accelerated program for a total of 15. The low numbers for the initial year are due to lack of time or advertising/recruitment. Our goal is to rapidly increase this number to 25 master's students (combined accelerated program and this program) in 5 years. The estimation is based on exit interviews and alumni surveys from past years. Recruitment plans include (1) advising our BME undergraduate majors of the potential for continuing at Michigan Tech obtain a master's degree in BME following one additional year of study, (2) working with Michigan Tech's Undergraduate Admissions/Recruitment Office along with the Graduate School to develop a BME brochure and a focused marketing plan, (3) updating the BME Department web page highlight the master's program.

5. Scheduling Plans

The master's program in BME will be offered at the beginning of Fall Semester 2012.

6. Curriculum Design

Admission Requirements:

1) Only students with a cumulative GPA of 3.0 or above are eligible to enter the BME master's program.
2) In general, all students who have a BS in an engineering discipline are eligible to apply. However, those students lacking undergraduate courses in the life sciences may be required to complete additional courses in the life sciences to correct for this deficiency.
3) Exceptional students with non-engineering BS degrees are also eligible to apply. However, these students may be required to complete additional courses in engineering and or mathematics to correct for this deficiency.
4) General GRE exam results are required to be submitted as part of the admissions process.
5) The standard Graduate School admissions process applies.

Program Requirements:

1) The number of credits required for the Master's degree is 30 credits
2) Students who are accepted into the program will not be allowed to continue if their cumulative GPA falls below a 3.0. A cumulative GPA of 3.0 will be required for graduation.

3) Due to the interdisciplinary nature of the biomedical engineering program, courses also will be taken outside of the Biomedical Engineering Department as determined by the student and his/her advisory committee and dependent on the student's area of emphasis. However, the students will need at least 12 credit hours (in addition to the 2, 1 cr seminar requirement – see #6, below) from the BME department.
4) Each student will have an academic/research advisor who is a member of the Biomedical Engineering faculty. The Advisor's primary responsibility will be supervising the student's academic and professional growth, as well as working with the student to develop an academic plan for enrolling in the appropriate courses for the student and program.
5) The academic plan developed by the student and academic advisor will need written approval from the faculty advisor and the departmental graduate coordinator.
6) Throughout their degree program, the graduate students will be required to attend the Graduate Seminar. During the first year of study, the students will receive one credit for each semester for participation. After the first year, attendance will still be mandatory, but the students will not receive credit.
7) All Graduate School residency and credit requirements must be met.

Typical Program of Study:

Other than the Graduate Seminar course requirements, ~~T~~there are no core required classes for the MS in Biomedical Engineering. Course plans will be developed by the student, the student's advisor and the BME graduate program coordinator. A minimum of 12 credits (of the minimum 30) must be taken from the BME Department.

Because of the breadth of the field of Biomedical Engineering, there is no single 'typical' program of study. However, Appendix II lists some appropriate existing courses that a BME MS student may take to fulfill course requirements.

7. New Course Descriptions

Three new faculty hires (already hired; will begin Fall 2011) will develop new graduate level courses as part of their regular teaching duties to supplement existing graduate level courses (for our existing Ph.D. Program). However, these courses will not be required courses for the degree.

8. Library and Other Learning Resources

No additional library or other learning resources are associated with this program. However, there will be a small increase in demand for library resources and resources.

9. Faculty Resumes

Biomedical Engineering faculty resumes can be found at http://www.biomed.mtu.edu/fac_CVs/ .

Participating Biomedical Engineering Faculty include:

Sean J. Kirkpatrick, Ph.D., Associate Professor & Chair
Michael Neuman, MD, Ph.D., Full Professor
Jeremy Goldman, Ph.D., Associate Professor
Keat Ghee Ong, Ph.D., Associate Professor
Megan Frost, Ph.D., Associate Professor
Rupak Rajachar, Ph.D., Associate Professor
Niloy Choudhury, Ph.D., Assistant Professor
Feng Zhao, Ph.D., Assistant Professor
Bruce Lee, Ph.D., Assistant Professor
Martyn Smith, Ph.D., Adjunct Professor
Qing-Hui Chen, Ph.D., Adjunct Assistant Professor
Karen Roemer, Ph.D., Adjunct Assistant Professor

10. Description of Available/Needed Equipment

Students will access the university-wide computing facilities already present.

11. Program Revenue & Costs

Presented below is a quick summary of the financial assessment of the proposed program. A more complete evaluation is given in Appendix I. The appended evaluation conforms to the proposal 51-04 of the University Senate of Michigan Technological University.

Revenue (Based on 2011-2012 Tuition & Student Voted Fees)

Graduate Resident and Non-Resident Per Credit Rate:	$702
Engineering tuition Fee Per Semester For Undergraduates Taking 6 Credits or more and Graduate Students Taking 5 Credits or More:	$705
Student activity Fee:	$44.30
Experience Tech Fee:	$69.00

Per Student (30 credits* $702)	$21,060
Engineering Tuition Semester Fee (4 semesters)	$ 2,820
Fees (4 semesters)	$ 453.20
Total per Student	**$24,333.20**
Based on Initial Enrollment of 3 Students:	**$72,999.60 (Initial class)**

*Note that we expect ~12 more paying students to be enrolled through our planned accelerated MS program which will be approved by the Graduate School immediately following approval of this program

New Costs

Student support: No financial support for MS students is required

Lab space: No new laboratory space is needed

New courses: BME already offers numerous graduate level courses as part of our Ph.D. degree program. We have also recently hired 3 new tenure-track faculty, each of whom will develop a graduate level course as part of their regular teaching assignment. Thus no new costs associated with new course development.

Student offices: BME has sufficient space to house the expected enrollment.

Student Advising: For the research MS students, much of the research advising will be completed during the usual weekly lab meetings that each of the BME faculty hold with their research groups. Course advising for the MS students will be minimal and the time required for this advising will be small as the BME faculty already perform these same advising tasks for BME Ph.D. students.

Other: There will be a slight increase in administrative costs, costs associated with student advising and supervision, library and computer usage, etc.

12. Space

No additional space is required to support this proposed program.

13. Policies, regulations and rules

Specific policies, regulations and rules for this program are stated in Section 6: Curriculum Design (above).

14. Accreditation Requirements

There are no further accreditation requirements for this proposed Master's program.

15. Internal Status of Proposal

This proposal for a master's program in Biomedical Engineering has been approved by the Faculty of the Department of Biomedical Engineering, by the Engineering Council, and by the Dean, College of Engineering.

16. Planned Implementation Date

This proposed master's program will be implemented in the Fall of 2012.

Appendix I

Criteria for Financial Evaluation of proposed Academic Programs
Senate proposal 51-04

I. Relation to University Strategic Plan

a. Relation of program to the University's educational and research goals:

The University and the College of Engineering both are striving to increase graduate enrollment. In this regard, the proposed MS program aligns with the University's research and educational goals. In addition, we expect the proposed MS Program to serve as a feeder program for the Department's Ph.D. program and thereby increase both the numbers of students and the quality of students in the Ph.D. Program.

b. Consistency with the University's resource allocation criteria:

No new resources are being requested at the Departmental level to support this proposed program.

II. Impact on University Enrollment

a. Projected number of students in the program:

We project our initial master's graduate enrollment to be 3, plus an additional 12 from the proposed accelerated program for a total of 15. Our goal is to increase this number to 25 master's students (combined accelerated program and this program) in 5 years. The estimation is based on exit interviews and alumni surveys from past years. Recruitment plans include (1) advising our BME undergraduate majors of the potential for continuing at Michigan Tech obtain a master's degree in BME following one additional year of study, (2) working with Michigan Tech's Undergraduate Admissions/Recruitment Office along with the Graduate School to develop a BME brochure and a focused marketing plan, (3) updating the BME Department web page highlight the master's program.

b. Source of new students:

Initially, we project that all new students will have earned their BS Degree from Michigan Tech. However, as the degree program matures, we project that we will draw students from other universities into the program.

c. What is the likely correlation between demand for the new program and existing enrollment patterns at Michigan Tech?:

We do not foresee any significant changes in the enrollment patterns at Michigan Tech as a result of this program. However, we do expect that students who are interested in obtaining an MS in BME will now do so through the Department of Biomedical Engineering as opposed to other Engineering Departments (e.g., MEEM, ECE).

d. What is the current enrollment in the unit?:

BME currently enrolls approximately 272 undergraduate students and 12 Ph.D. students.

III. Impact on Resources Required by Department in which the program is Housed

a. Faculty Lines: No new faculty lines are requested

b. Faculty and Student Labs: No new Laboratory space is requested. All faculty maintain and active research lab as part of our Ph.D. Program.

c. Advising: For the research MS students, much of the research advising will be completed during the usual weekly lab meetings that each of the BME faculty hold with their research groups. Course advising for the MS students will be minimal and the time required for this advising will be small as the BME faculty already perform these same advising tasks for BME Ph.D. students.

d. Assessment:

Faculty members will have to devote time to assessing the MS students. More students will enroll in our graduate courses and the work will need to be assessed. Faculty advisors and committee members will need to devote time to reviewing the student's research and reading/assessing MS theses.

IV. Impact on resources Required by Other Units Within the University

a. Other academic units with regard to faculty, labs, and assessment:

BME MS students may take courses from other Units on campus, if there is sufficient space in the courses. Faculty from other Units would have to assess the student's performance in these courses just as they would for any other graduate student.

b. Information Technology, Library, Central Administration etc.:

New students will, of course, increase the demands on IT, the Library, etc. However, it is within the University's goals to increase the number of graduate students enrolled. The students in the Program will pay the Engineering Tuition Fee which should, presumable, help to offset some of these costs.

V. Assessement of the Ability to Obtain the Necessary Resources Assuming Requested Funds are Obtained:

No new funds are requested; No new faculty lines are requested.

VI. Past proposals:

The Department has not initiated any other new degree programs in the past 5 years.

VII. Departmental Budget Contribution

a. What is the Department's total general fund budget? $1,127,115 (2011-20112 Budget Year)

b. How much tuition does the Department generate (approximate numbers)?

1. Credit hours taught by Department: 1321credit hours at $420.50/hour = $555,480.50 (+ fees)
(Undergraduate in FY10)
157 credit hours at $702/hour = $110,214 (+fees)
(Graduate in FY10)
Total: ~$555,480.50+$110,214 = $665,649.50

Note that these values will increase slightly due to increased enrollment this academic year.

2. Number of credit hours taken by BME majors:
Ave. of 16.38 cr hrs per student per semester * 240 students = 3,930 cr. hrs per semester (Undergraduate)
3,930cr hrs at $420.50/hr (in FY10) = $1,652,565
Ave of 9 cr hrs per student per semester * 12 Ph.D students = 108 cr. hrs per semester (Graduate)
108 cr hrs at $702/hr = $75,816
Total: $1,652,565+ $75,816 = $1,728,381

VIII. a. How do the benefits from this Program compare to other alternatives that are currently under consideration or development?

No alternatives are currently under consideration or development.

b. Will approval and allocation of resources to this program preclude the development of other programs?

No allocation of new general fund resources or space is requested, so other programs will not be precluded from being developed based on these considerations.

Appendix II
List of Appropriate Existing Courses
(not necessarily all inclusive; does not include research credits or special topics courses)

Department of Biomedical Engineering Courses

BE5100 Cell/Tissue mechanics	BE5200 Biology for Engineers II
BE5300 Polymeric Biomaterials	BE5510 Cardiovascular Engineering
BE5600 Active Implant. Dev.	BE5700 Biosensors
BE5940 Intro Tissue Eng.	BE5550 Biostatistics for Health Sciences
BE5990 Grad Seminar	BE5800 Adv. Biomaterials Interfaces
BE5880 Princ & Anal/Cell Proc.	BE5900 Biomedical Optics

(Note BME has recently hired 3 new faculty members into the Department. As part of their regularly assigned teaching duties, they will each develop a graduate-level course for the existing Ph.D. Program. These courses have yet to be defined, however, they will be added to this list as they are developed and offered.)

*Other College of Engineering Courses**

EE5440 The Laser
EE5540 Statistical Optics
EE5940 Electrophysics Seminar
EE5410 Engineering Electrodynamics
EE5500 Prob & Stoch P rocesses
MEEM5210 Adv. Fluid Mech
CM5900 Nanobiosensors
MEEM5150 Advanced Mechanics of Mats.
MEEM6110 Adv. Continuum Mech
MY5580 Atomic force Microscopy
EE5522 Digital Image Processing
EE5750 Dist Embedded Control Sys
EE5950 Signals and Systems Seminar
EE5520 Fourier Optics
MEEM5170 Finite Element Methods
MEEM5650 Adv. Quality Eng
MEEM5240 Comp. Fluid Dynamics
MEEM5700 Dynamic Meas/Signal Analysis
MY5260 Crystallography

*Courses Offered in the College of Science and Arts**

BL5340 General Immunology
BL5030 Molecular Biology
BL4840 Mol. Biol. Tech
CH6920 Adv. Mass Spectrometry
CH6790 Protein Folding
BL5502 Biological Sciences Seminar
BL5025 The Scientific Profession
CH5120 Pharm Chemistry: Drug Design
PH5410 Quantum Mechanics

*Based on availability

Introduced to Senate: 19 October 2011
Friendly Amendments in red: 19 October 2011
Approved by Senate: 02 November 2011
Approved by Administration: 11 November 2011
Approved by BOC: 09 December 2011
Approved by State: 20 January 2012