The University Senate of Michigan Technological University

PROPOSAL 32-05

(Voting Units: Academic Senators)

Ph. D Program in Biomedical Engineering
Department of Biomedical Engineering

Proposal:

The University Senate recommends approval of the PhD Program in Biomedical Engineering described below.

Introduction, Mission and Objectives:

This is a proposal to formally establish an Ph.D. program in Biomedical Engineering (BME) within MTU's Department of Biomedical Engineering. The mission of the proposed graduate program is to train both engineers and life scientists in the science and technology of this field and to recognize their achievement by creating an advanced biomedical engineering degree at Michigan Technological University. Graduates of the program will have the necessary skills and will be highly qualified to perform scientific and technologically advanced research in solving problems of biological, clinical, technological and industrial relevance, both in the design, development, and manufacture of products and systems for understanding, maintaining and improving human health.

Biomedical engineering is a discipline that advances knowledge in engineering, biology and medicine, and improves human health through cross-disciplinary activities that integrate the engineering sciences with the biomedical sciences and clinical practice. [Whitaker Foundation] The proposed PhD program will emphasize research and education in biomaterials/tissue engineering and physiological measurements. Because biology will have increasing importance in all of engineering in the coming years, this Ph.D. program will have a strong life science component. Our goal is to prepare students at the doctoral level who can continue their research work in post doctoral training, assume positions in academia, industry, or governmental agencies and be prepared to grow into positions of leadership.

Our specific short-term (1 – 3) and long-term (4 – 5) objectives to achieve this mission are:

1. Return the Department of Biomedical Engineering to full-staffing with six full-time faculty and a Department Chair

2. Establish PhD student enrollment at a level of 1.5 – 2 per faculty member

3. Prepare a recruiting effort to publicize our program, identify promising potential students and encourage them to matriculate in our PhD program

4. Expand graduate course offerings in the Department by emphasizing our fields of specialization and the biological aspects of these fields

5. Increase external funding to an average level of $200,000 annual research expenditures per faculty member

6. Contribute to MTU'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.

1. Related Programs

Biomedical engineering is an interdisciplinary field. The study of biomedical engineering has been ongoing at MTU, but BME did not exist as a department or as a major until 1997. In fact, most current BME faculty do not have degrees in biomedical engineering. Their degrees are more likely to be in electrical or mechanical engineering or perhaps materials science or chemical engineering. These remain related programs. For example, here at MTU, without a graduate program in biomedical engineering, our current graduate students are enrolled in other departments (mechanical, electrical and chemical engineering, and materials science), and our BME faculty have adjunct appointments in those departments so they can serve as the research advisors and mentors for students in those other departments who are doing research in BME. The interdisciplinary nature of BME will not change with the addition of a Ph.D. program in BME. It is important to note, however, that while these other programs are related to BME, they are not BME programs.

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 Technological University reflects this trend and has experienced steady growth in student numbers since the program began in 1997.[1] Undergraduate education in biomedical engineering, however, is generally not sufficient for a BME program that will achieve national eminence in the field. Many of the jobs in biomedical engineering require advanced and continuing education beyond the bachelor's degree. In addition, a strong undergraduate program requires association with the leading-edge research related to masters and doctoral training programs. The biomedical engineering degree program at Michigan Technological University is incomplete without an accompanying graduate component. MTU has the competencies and resources to establish and offer a doctoral program in biomedical engineering.

There are many reasons to establish a doctoral program in biomedical engineering at MTU. First, there is an increasing demand for biomedical engineers at all levels. The biomedical engineering job market is growing at a rapid rate. The U.S. Department of Labor estimates that there will be a 31% increase in biomedical engineering jobs by the end of the decade, and many of these positions will require an advanced degree. [ftp://ftp.bls.gov/pub/special.requests/ep/ind-occ.matrix/occ_pdf/occ0135.pdf] The fundamental life sciences and biology are undergoing a major revolution that is changing these fields from qualitative, descriptive disciplines to quantitative, mathematically-based disciplines similar to the physical sciences. Applications of biology are increasing exponentially, and the biotechnology industry continues to grow. Engineers of all backgrounds are playing an increasing role in these areas, and biomedical engineers are well-positioned to be at the forefront of this expansion with their specialized training in the application of the fundamentals of the biological sciences to real-world problems using the techniques of traditional engineering, the physical sciences and mathematics.

As the world's population ages and the cost of health care rises, the demand for professionals trained in biomedical engineering will continue to increase The cost of health care will be an important factor in future years, and technology does and will represent a significant portion of these costs. Biomedical engineers can play an important role in containing these costs by being aware of the technological as well as medical issues involved in development and deployment of new technologies. Beside the cost of health care, quality of life will be a critical concern as aging baby-boomers look for ways to remain living independently. The solution to coming healthcare-related problems will require engineering methodologies from a broad, interdisciplinary approach that includes, not only engineering and the life sciences, but an understanding of social problems associated with aging. MTU is well positioned to contribute highly qualified candidates at both the undergraduate and graduate levels to meet this nationwide demand.

Second, a doctoral program in biomedical engineering is a natural progression for the Biomedical Engineering Department at MTU. The University's mission recognizes that it is important to couple research-oriented graduate training programs with undergraduate programs in order to achieve the highest quality education at all levels. Without question, a research-centered doctoral program in biomedical engineering will also strengthen MTU's undergraduate program. Demand for this program at MTU is evidenced by the twelve students who are currently enrolled in biomedical engineering graduate study and whose thesis and dissertation research is being supervised by biomedical engineering faculty. However, because MTU does not presently offer a Ph.D. in biomedical engineering, these students must enroll in other departments at MTU, such as Mechanical Engineering and Materials Science Engineering, in order to receive the training they want. By establishing a Ph.D. in biomedical

engineering, enrolled students can focus their research and education on this specialized field, and MTU can continue to build a solid reputation as a leader in the field of biomedical engineering education.

Third, by developing a first-rate biomedical engineering graduate program, MTU can compete for increasing funding opportunities. In response to the demand for biomedical engineering expertise, the Federal government established the National Institute of Biomedical Imaging and Bioengineering and several new study sections to review grant applications specifically in the area of biomedical engineering. The National Science Foundation, an agency in which MTU is very successful in securing research funding, has increased its support for biomedical engineering-related education and research activities. This support even extends to major programs such as NSF's Engineering Research Centers. By offering a Ph.D. in biomedical engineering and by developing a strong accompanying research program, MTU will be able to submit competitive proposals to research and funding agencies traditionally associated with the medical profession, such as the National Institutes of Health. These agencies help support our graduate degree programs by creating research opportunities and by providing financial support for graduate students.

Fourth, MTU is capable of delivering a nationally-recognized doctoral biomedical engineering program. MTU's Department of Biomedical Engineering has received solid support from The Whitaker Foundation, a leader in the support of research and education in biomedical engineering. Recently, MTU received another award from The Whitaker Foundation. This $180,000 award, which will help the Biomedical Engineering Department expand industrial co-ops and internships for biomedical engineering majors, evidences external confidence in MTU's ability to deliver a high-quality education founded in both theory and practice.

Biomedical engineering has a strong interdisciplinary component, and combines traditional engineering fields and the basic sciences. A graduate biomedical engineering program at MTU can and will take advantage of the strong engineering and science faculties at the University. A hallmark of the proposed program will be the close interaction with other science and engineering departments with particular emphasis on Biological Sciences, Materials Science and Engineering, and Chemical Engineering. The program will also be able to partner with local and regional health care facilities in order to provide our students with a comprehensive graduate education in biomedical engineering.

Finally, because the proposed program will attract students who have non-engineering undergraduate degrees or no previous life science courses, some students admitted to the program will find it necessary to take additional training to fill gaps in their background. Interaction between students in the biomedical engineering graduate program who have diverse undergraduate backgrounds will provide many informal educational opportunities for this interdisciplinary field.

3. Curriculum Design

Admission Requirements: Students with a B.S. or M.S. degree in engineering, mathematical sciences, the physical sciences and biological sciences from an accredited college or university will be eligible for admission to the Ph.D. program. Students who have a baccalaureate or Master's degree from a non-engineering discipline (e.g. life science) will be considered for admission to the program on a case by case basis and will be eligible for provisional admission. Students with non-engineering degrees will be required to complete the following pre-requisite courses or BME faculty approved equivalent courses prior to full admission into the Graduate program:

1. BL 1020, General Biology
2. Math courses through Differential Equations
3. MY 2100, Materials Science
4. MEEM 2120, Statics and Mechanics of Materials
5. EE 3010 Electrical/Electronic Circuits

Optional:

1. MEEM 3210 Fluids Mechanics
2. MEEM 3230 Heat Transfer
3. MEEM 2700, Dynamics
4. MEEM 2200, Thermodynamics

Curriculum: A minimum of sixty credits after a B.S are required for the Ph.D. degree. These credits are distributed as follows:

14 credits of core courses,
25 credits of research,
21 committee approved thrust area credits.

The number of credits for the Ph.D. degree after a Master's degree is 30 credits. The courses these students will need will be determined on a case-by-case basis. Common to each field at the Ph.D. level are the following core courses:

Core course	Credits
Life Science	6
Graduate Seminar	2
Advanced Math	3
Statistics	3
Total Core Credits	**14**

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.

The student will have the option to take at least one of the following advanced math courses to satisfy the core math requirement:

Course Number	**Course Title**	**Credits**
MA4515	Intro. Partial Diff. Eqns.	3 credits
MA4520	Integral Trans & Series Methods	3 credits
MA4610	Numerical Linear Algerba	3 credits
MA4620	Finite Difference Methods & PDEs	3 credits
MA4635	Numerical Methods for Integral Eqations	3 credits
MA4710	Regression Analysis	3 credits
MA4720	Design/Analysis of Exp.	3 credits

The following is the proposed list of biomedical engineering courses to be offered, including the number of credits and the frequency with which the course will be offered.

Course Number	**Course Title**	**Frequency**	**Credits**
BE4930	Graduate Seminar	Semester	2
BE4930	Advanced Physiology	annually	3
BE5500	Advanced Biomaterials	annually	3
BE4930	Advanced Biomechanics	annually	3
BE4210	Exercise Physiology	annually	3
BE5600	Laser, Optics, and Biosensors	alternate years	3
BE5930	Biomaterial Interfaces	alternate years	3
BE5940	Implantable Devices	alternate years	3
BE5930	Genetic Engineering	alternate years	3
BE5930	Advanced Polymeric Materials	annually	3
BE6930	Special Topics in Biomedical Eng.	varies	Variable
BE9990	Ph.D. Dissertation	Semester	Variable

Each of the above courses is presently offered at MTU. As faculty are added to the BME Department, additional courses will be developed based on the interests and expertise of the new faculty, and the listed courses may undergo revision as they are taught by new faculty.

Due to the interdisciplinary nature of the biomedical engineering program, courses also will be taken outside the Biomedical Engineering Department as determined by the student and his/her advisory committee and dependent on the student's area of emphasis.

Academic advancement by the student is measured in terms of semester hour credits or, simply, credits. One credit should average three hours of a student's time per week for one semester. Depending on the course requirements, these three hours may be spent in the classroom, laboratory, or may be divided between home study, class or laboratory attendance. One hour in class and three hours of individual study is a typical division.

Courses numbered in the 3000 and 4000 series are intended primarily for upper-division undergraduate students but are available to graduate students for graduate credit with approval by the Department of Biomedical Engineering. Courses of the 5000 level are intended primarily for graduate students, but senior level undergraduates that have at least a 3.0 G.P.A. can also take these courses. Courses numbered in the 6000 and above series are available only to advanced graduate students.

Typical Program of Study: Below are lists of example curricula for the Ph.D. degree in each of the areas of concentration, Biomaterials/Tissue Engineering, and Physiological Measurement:

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Biomaterials /Tissue Engineering

BE4930 Advanced Physiology
BE4930 Graduate Seminar
---------- Advanced Math Course (as appropriate to each student)
MA5701 Statistical Methods
MY 5000 Materials Science and Engineering
BU------- Entrepreneur/Industrial Modules (under development)

Suggested Electives:

BL4010 Biochemistry I
BL4020 Biochemistry II
BL4820 Biochem. Techniques I
BL4830 Biochem. Techniques II
BL5350 Special Topics Physiol.
BL5360 Special Topics Biochem.
BL4320 Histology
BL4470 Analysis of Biological Data
CM5620 Advanced Biochemical Eng.
CM5640 Advanced Polymer Engineering
CH5530 Molecular Spectroscopy
CH5570 Biophysical Chemistry
BE5500 Advanced Biomaterials
BE5930 Biomaterials Interfaces
BL4030 Molecular Biology
MY 5100 Thermodynamics and Kinetics I
MY 5110 Thermodynamics and Kinetics II
MY 5200 Scanning Electron Microscopy
MY 5250 Practical Transmission Electron Microscopy
MY 5400 Mechanical Behavior of Materials
MY 5540 Surface Chemistry I
MY 5550 Surface Chemistry II

Physiological Measurement

BE4930 Advanced Physiology
BE4930 Graduate Seminar
MA------- Advanced Math Course (as appropriate to each student)
MA5701 Statistical Methods
BE5940 Implantable Devices
BU------- Entrepreneur/Industrial Modules (under development)

Suggested Electives:

MY 5000	Materials Science and Engineering
BE5500	Advanced Biomaterials
BE5930	Biomaterials Interfaces
BE5600	Lasers, Optics, and Biosensors
BE4930	Advanced Polymeric Materials
BE5930	Genetic Engineering
BL4010	Biochemistry I
BL4030	Molecular Biology
BL4080	Cardiopulmonary Physiology
EE 4211	Computer-Aided Circuit Design
EE 4231	Physical Electronics
EE 4232	Electronic Applications
EE4252	Two-Dimensional Signal and Image Processing
EE4253	Real Time Signal Processing
EE4255	Wireless Communications
EE4261	Classical Control Systems
EE 5430	Electronic Materials
EE 5450	Modeling of IC Interconnects
EE 5460	Solid State Devices
EE 5530	Wireless Digital Communication
EE 5580	Wavelet and Spectral Analysis
EE 5900	Introduction to MEMS
EE6470	Thin Films
MY5200	Scanning Electron Microscopy
MY 5540	Surface Chemistry I
MY 5550	Surface Chemistry II

Each plan of work must be approved the Graduate Program committee.

Enrollment and Credit Requirements: Full-time and part-time students will be permitted to enroll in the program. Full-time students not supported by GRA or GTA appointments are required to take a minimum of 9 credits per semester at the Doctoral level. All graduate students using University Services must be enrolled for at least one course or at least one credit of graduate research. The maximum is 16 credits per semester, though supported graduate students should generally plan to take 9-11 credits per semester. Graduate students supported by a GRA or GTA appointments or fellowships may not drop below the minimum number of credit hours as described above. GRA and GTA students are required to register for and complete a certain number of credit hours, depending on their level of support, in each semester in which they receive support. In the Doctoral programs, research credits may be included for the purpose of determining whether the minimum and maximum enrollment criteria have been met. GRAs and GTAs who are enrolled for the minimum of credits are considered to be full-time students.

Appointment levels shall be as follows:

Quarter time (10 hours per week)	9 credit minimum,
Half time (20 hours per week)	9 credit minimum,
Three quarter time (30 hours per week)	9 credits minimum,
Summer enrollment	1 credit or 1 course

Unless the fellowship carries other requirements for determining eligibility, fellowship students must be enrolled full time (9 credit minimum Ph.D. level).

Grade Requirements: Students must maintain a minimum grade point average of 3.0 in order to complete and graduate from the program. A ‘C’ earned in one course may be counted towards graduation requirements, provided that it is offset by an equivalent number of ‘A’ credits to allow at least a 3.0 grade point average to be maintained. Also, if a student receives a ‘C’ in two of his/her classes, the classes can be repeated with permission from the student’s advisor and the Graduate Program Committee.

Time to Degree Requirements: Ph.D. students must complete the doctoral degree within eight years from the time of a student’s first enrollment in the doctoral program by the Dean of the Graduate School. In addition, the comprehensive examinations must be taken within three years of enrollment. Time

extensions beyond these may be authorized by the Dean of the Graduate School only for conditions that are clearly beyond the student's control.

Other Degree Requirements: The degree requirements for a Ph.D. in Biomedical Engineering will adhere to the general rules and requirements established by the MTU Graduate School. This Ph.D. is a research degree, with the coursework designed to prepare students for comprehensive examinations in the two designated primary fields. The Department will prepare and adopt formal requirements concerning each of the following upon acceptance of this degree program:

Advisory Committee - Each student will have an Advisor who is a member of the Biomedical Engineering faculty. Approval by the Department chairperson will be required. The Advisor's primary responsibility will be supervising the student's research project and directing the student's academic and professional growth. Adjunct faculty can serve as a student's research advisor, but the Department chairman may choose to appoint an academic advisor in those cases where the adjunct faculty may not be familiar with the Department's rules and requirements.

An Advisory Committee for each student will be comprised of the student's advisor plus 4 additional members. Two of the four may be from the same department as the Advisor while the other two will come from members of the Graduate Faculty outside the Department of Biomedical Engineering. At least one of the Committee members must be an engineer as defined by holding a doctorate in an engineering discipline. Since biomedical engineering is an interdisciplinary field, it will be imperative that the Advisory Committee play an active role in the research project. Therefore, it will be critical that the Advisory Committee members be appointed during the student's first academic year in the BME Ph.D. program. Also, the Advisory Committee must meet at least twice a year with the advisor and the student to discuss progress. A brief written and oral report on the research will be expected from the student at these meetings. It is expected that the student and advisor will meet on a regular basis.

Comprehensive Examination - Advancement to doctoral candidacy is contingent upon successful completion of a comprehensive written and oral examination. All Ph.D. students will be expected to take the examination no later than three years after enrollment. However, students will be encouraged to take the examination after completion of the core courses. The exam will be offered twice a year depending upon need. Each student will take a comprehensive written examination composed of two core areas (Math and BME Core Courses: Biomaterials, Biomechanics, Life Sciences Bioinstrumentation) and one area of specialization (which will cover material relevant to the candidate's research focus).

Students must pass the written examination before the oral examination may be scheduled. Students will pass each portion of the written examination with a score of 70% or better. If a student fails one section, she/he must re-take all sections for which scores were less than 70 percent. Students will not be required to re-take sections for which scores were 70 percent or greater. In the event a student must re-take any portion or each portion of the written test, she/he must wait until the next scheduled examination date (approximately 6 months). Students will be allowed to take each section of the written examination a maximum of two times unless special circumstances arise. Failure on the second attempt may result in dismissal from the program after a complete review of the student's records.

An oral examination will also be administered. Students may schedule the oral examination, which will be administered by the student's advisory committee members, following successful completion of the written examination. The decision to pass or fail a student will be made by the committee, and criteria may vary on an individual basis. Students will be allowed to take the oral examination a maximum of two times. Failure on the second attempt may result in dismissal from the program. Following successful completion of the oral examination, the student is admitted to candidacy for the doctoral degree.

Research Dissertation Proposal - Before accumulating more than 10 semester credits of BE 9990 Doctoral Dissertation Research, each student is required to successfully pass an oral defense of the research dissertation proposal. This examination shall be a presentation of the proposal for the dissertation research, and is to be administered by the student's doctoral committee.

4. New Course Descriptions

No new courses are planned. However, as BME faculty are added, we anticipate that they will develop new courses in their areas of interest and expertise and that they will revise existing courses to suit their teaching methods student needs.

5. Projected Enrollment

We project our initial Ph.D. graduate enrollment to be 1.5 graduate students per BME faculty member. Our goal is to increase this number to 2.0 graduate students per BME faculty member. Upon approval of the proposed Ph.D. program in biomedical engineering, the department will offer the biomedical students currently enrolled in other departments the opportunity to transfer to BME. The department's immediate plan is to increase our current size from 5 faculty (including department chair) to 7 faculty (including department chair). These positions are included in the Department's budget and do not require new funding authorizations. The department is on track to meet this staffing goal. A new faculty member will begin at MTU on February 1, 2004, and we are actively recruiting to fill the two remaining BME faculty positions. As BME research funding increases, the BME program will grow, resulting in increased numbers of both faculty and graduate students.

Recruitment plans include (1) carefully screening our BME undergraduate majors for potential graduate school candidates, (2) working with MTU's Graduate School to develop a BME brochure and a focused marketing plan, (3) updating the BME Department web page to include the Ph.D. program.

6. Scheduling Plans

The Ph.D. program in BME will be offered at the beginning of Fall Semester 2005, although students already enrolled in other departments who are studying biomedical engineering will be invited to transfer into the program sooner. The number of BME faculty will be at the projected and budgeted number of 7 (including department chair) by the beginning of Fall Semester 2005. Student recruitment will begin upon approval of this proposed Ph.D. program.

7. Administration of Degree Program

Even though the proposed PhD degree program is within the College of Engineering, it is recognized that biomedical engineering is an interdisciplinary field that involves many disciplines beyond engineering as well as within it. For this reason oversight of the program will go beyond the boundaries of the Department of Biomedical Engineering. An Advisory Committee made up of the Chair and Graduate Coordinator in the Department of Biomedical Engineering and representatives from at least three other departments in the University that are involved in Biomedical Engineering will be formed upon establishment of the PhD degree program in Biomedical Engineering. This committee will meet at least once per academic semester to review the program. The chair of this committee will be appointed by the Dean of the Graduate School in consultation with the Chairman of Biomedical Engineering and will serve for one year with reappointment possible and likely for subsequent years. A secretary will be appointed by the chair and will be responsible for documenting all committee activities. An Administrative Committee consisting of all full-time members of the Graduate Faculty in the Department of Biomedical Engineering will be responsible for the day-to-day operation of the degree program. The Graduate Coordinator will chair this committee.

8. Program Costs (Years 1, 2, and 3)

Estimated program budgets for Years 1, 2, and 3 are attached to this proposal as Attachment A.

9. Description of Available/Needed Equipment

Graduate students in the BME Department will require computing resources in or near their workspace. The current BME computing labs are located in the West Computing facilities in the ME-EM Building, which is acceptable for our undergraduates who take most of their courses in the general location. It is planned that the computing facilities of the Department of Biomedical Engineering will be transferred to the East Computing Network during the summer of 2005. An undergraduate computer laboratory will be located near the BME area of the M&M Building. Some of the current graduate students associated with the Department already have computing facilities though their research support, but others and new students will require additional facilities. Other than computing resources, no new equipment is needed to support this proposed Ph.D. program.

10. Faculty Resumes

Current CVs for each BME faculty member are attached t this proposal as Attachment B.

11. PRR (if planned) – NA to this proposal.

12. Internal Status of Proposal

This proposal for a Ph.D. in Biomedical Engineering has the support of the entire BME faculty, and a letter indicating this signed by all BME faculty members is attached to the original copy of this proposal. The proposal has been reviewed and approved by the Dean of MTU's Graduate School. It was presented to the MTU Graduate Faculty Council on February 3, 2004, and will proceed through the University Senate review procedures.

13. Planned Implementation Date

This proposed Ph.D. program will be implemented upon final approval at all required levels.

14. Library and Other Learning Resources

We have requested an allowance in our budget for library acquisition of books and journals relevant to the biomedical engineering field. The library's present collection of biomedical engineering resources is not adequate to support a graduate program in BME. There are a number of professional journals and books that are essential library resources for BME graduate students.

15. Space

No additional space is required to support this proposed Ph.D. program.

16. Accreditation Requirements

There are no further accreditation requirements for this proposed Ph.D. program. The BME Department will be seeking ABET accreditation for its undergraduate BME program in the fall of 2004.

Revised 4/20/05

Ph.D. Program in
Biomedical Engineering
Attachment A
Estimated Budget and Justification for Years 1 – 3

Budget Item	Year 1	Year 2	Year 3	Total
Faculty	NA	NA	NA	NA
Graduate Support (Stipend, Tuition, Fees)	$120,000	$120,000	$120,000	$360,000
Equipment (Computers and support for added grad students)	$ 8,000 (4 computers and support)	$ 8,000 (4 computers and support)	$ 4,000 (2 computers and support)	$ 20,000
Library Resources	$ 4,000	$ 4,000	$ 4,000	$ 12,000
Travel	NA	NA	NA	NA
Additional Space or Renovations	NA	NA	NA	NA
Totals	**$132,000**	**$132,000**	**$128,000**	**$392,000**

Budget Justification:
Faculty salaries are already included in the existing BME budget, and no new funding authorization is required at this time.

This estimated budget assumes continuing graduate student support at current levels, which includes 6 graduate teaching assistants supported by MTU and 5 graduate students supported by external research funding. For the first 3 years of the new Ph.D. program, the Department requests support from MTU for 4 additional Ph.D. graduate students. This assumes an annual stipend of $20,000 and tuition and fees of $10,000 per student. When the Ph.D. program is well-established, the Department anticipates increased external research funding to support more graduate students.

Graduate students in the BME Department will require computing resources in or near their workspace. Some of the current graduate students associated with the Department already have computing facilities though their research support, but others and new students will require additional facilities. Other than computing resources, no new equipment is needed to support this proposed Ph.D. program

The Department requests $4,000 per year for library acquisition of books and journals relevant to the biomedical engineering field. The library's present collection of biomedical engineering resources is not adequate to support a graduate program in BME. There are a number of professional journals, such as *Physiological Measurement*, and books that are essential library resources for BME graduate students. $4,000 per year will allow for annual subscriptions to 4 professional journal subscriptions and acquisition of several books

20 April 2005: Adopted by the Senate
28 April 2005: Approved by President Mroz
24 June 2005: Approved by Board of Control

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[1] In the Fall Semester of 1997, there were 38 students enrolled in MTU's BME undergraduate program. There are presently, in 2003-2004, 165 students enrolled in MTU's BME undergraduate program. In the spring of 2000, 9 B.S. degrees in BME were awarded. In the spring of 2003, 38 degrees were awarded. These BME undergraduates also provide MTU with a pool of potential BME graduate school candidates.