

BOARD OF HIGHER EDUCATION

REQUEST FOR COMMITTEE AND BOARD ACTION

COMMITTEE: Academic Affairs

NO: AAC 17-20

COMMITTEE DATE: June 13, 2017

BOARD DATE: June 20, 2017

APPLICATION OF THE UNIVERSITY OF MASSACHUSETTS AMHERST TO AWARD THE BACHELOR OF SCIENCE, MASTER OF SCIENCE, AND DOCTOR OF PHILOSOPHY IN BIOMEDICAL ENGINEERING

MOVED: The Board of Higher Education hereby approves the application of the **University of Massachusetts Amherst** to award the **Bachelor of Science, Master of Science, and Doctor of Philosophy in Biomedical Engineering**.

Upon graduating the first class for these programs, the University shall submit to the Board a status report addressing its success in reaching program goals as stated in the application and in the areas of enrollment, curriculum, faculty resources, and program effectiveness.

Authority: Massachusetts General Laws Chapter 15A, Section 9(b)

Contact: Winifred M. Hagan, Ed.D., Associate Commissioner for Academic Affairs and Student Success

BOARD OF HIGHER EDUCATION
June 2017
Bachelor of Science, Master of Science, Doctor of Philosophy
in Biomedical Engineering.

INTENT AND MISSION

The University of Massachusetts Amherst (UMA) reports that in the April 2014 report of the University of Massachusetts' Joint Task Force on Strategic Oversight Subcommittee on Research and Graduate Education identified areas of existing intersection between campus strengths and state, regional or national priorities. The field of applied life sciences, was identified as one such area and because of this UMA recognizes the proposed programs as well-aligned with the university's mission.

UMA intends that the proposed B.S. program in Biomedical Engineering (BME) will be a foundational undergraduate degree program through which, students learn the knowledge and skills to solve engineering problems in biology and medicine. It is intended that students will be able to apply knowledge of mathematics, science, and engineering, to identify, formulate, and solve engineering problems, to design and conduct experiments, design systems, components, or processes to meet needs, to work in teams, to communicate effectively, to conduct themselves professionally and ethically, and to understand the need for life-long learning. It is expected that graduates of the proposed undergraduate program will be prepared for a broad range of careers, including those in medical equipment and supply manufacturing, scientific research and development services, pharmaceutical and medicine manufacturing, and for work with medical professionals. In all cases, it is intended that students have a rigorous foundation in math, sciences, information technology, and engineering that ensures that they are competitive in the labor market.

The proposed M.S. and Ph.D. BME programs are intended to be graduate degree program in which students learn the knowledge and skills to conduct research at the intersection of biology, medicine, and engineering. UMA expects that graduates of the master's program will be prepared for occupations in the life science industry and for graduate studies in biomedical engineering and related fields. UMA anticipates that graduates of the Ph.D. program will be prepared for occupations in the life science industry, research labs, and academia with state-of-the-art knowledge in math, sciences, information technology, and engineering, including research in industry, postdoctoral research positions, and academic positions.

The proposed programs obtained all necessary governance approvals on campus and were approved by the University of Massachusetts' Board of Trustees on April 12, 2017. The required letter of intent was circulated on September 14, 2016. No comments were received.

NEED AND DEMAND

National and State Labor Market Outlook

UMA cites a U.S. Bureau of Labor Statistics prediction that there will be a 23.1% job growth for biomedical engineers between 2014 and 2024. This growth reflects the increased medical demands of an aging population and increased awareness of biomedical engineering advances. UMA also cites Occupational Network data indicating that 45% of engineering jobs will require a baccalaureate degree, 35% will require a master's and 20% will require a doctorate. The National Institute of Health has called for future US competitiveness and innovation in biomedical research by creating pathways through undergraduate, graduate and postdoctoral training to participate in a broad-based and evolving economy¹.

The MA Executive Office of Labor and Workforce Development's long-term industry projections show an increase in employment demands in BME of 27.3% between 2012 and 2022. The proposed program is aligned with ongoing efforts to expand advanced manufacturing efforts in western Massachusetts, including health-related industries. The MA life sciences sector has risen to number one in the nation with the per capita employment close to 14,300 jobs for every one million residents. The new jobs being created in the life sciences require diverse skills and educational attainment².

Student Demand

UMA reports that, in response to the need for BME graduates at all levels, numerous universities have started offering such degrees, and students have responded by enrolling in these programs in record numbers. Enrollment in biomedical engineering, which increased by 7.5% between 2009 and 2010, continues to be one of the fastest growing science and engineering fields and has experienced rapid growth over the last decade from approximately 3,200 graduate students in 2000 to 8,500 students in 2010³. UMA expects that there is a large number of potential students who would enroll in the proposed program.

OVERVIEW OF PROPOSED PROGRAM

Program Overview

The proposed B.S., M.S., and Ph.D. in BME degrees are intended to be the core educational offering of a new, to-be-established department of BME in the College of Engineering. It is envisioned that the program will be administered by appointed staff. The current proposal was developed by a faculty advisory committee from various departments. UMA expects that this committee will provide guidance to the program's development until the new department is established and ready.

¹ *Biomedical Research Workforce Working Group. (NIH) June, 2012*

² *Annual Report by the Massachusetts Life Science Center (2013)*

³ *A report by the National Center for Science and Engineering Statistics of the National Science Foundation May, 2012*

Duplication

BME programs are offered at a variety of universities in the region including UMass Lowell, Boston, and Dartmouth. The proposed biomedical engineering department and degree programs are different from the others being offered and represent a difference in that they provide more depth for a career in the biomedical field. There will be opportunities for collaboration and UMA expects to work closely with other campuses to identify and expand them.

BME degrees are also offered by Boston University, Harvard University, the Massachusetts Institute of Technology, Northeastern University, Tufts University, and Worcester Polytechnic Institute, Brown University, Cornell University, Dartmouth College, the University of Connecticut, and Yale University.

The *Engineering by the Numbers 2014* report by the American Society for Engineering Education listed 20 schools with the highest numbers of B.S. degrees awarded in BME. Among the top 20 in New England were Boston University, Worcester Polytechnic Institute and University of Connecticut with 122, 113, and 62 graduates, respectively. UMA holds that these numbers and those from smaller programs in the region are not sufficient to meet the needs for a strong BME workforce. UMA expects the proposed program to augment workforce development in the region.

ACADEMIC AND RELATED MATTERS

Admission

College of Engineering BME admissions for the B.S. degree are expected to be handled through the UMA Admissions office using the same criteria as for other students who are admitted to the University and the College of Engineering. Students who transfer into the proposed B.S. BME program will be advised individually by college and departmental advisors. College of Engineering BME admissions for the M.S. and Ph.D. degrees will be handled through the Graduate School using the same criteria as for other students who are admitted to the University and the College of Engineering. The BME department will select among the qualified applicants based on qualifications, match of research interests with those of BME faculty, and available funding as applicable. The proposed M.S. and Ph.D. programs are not designed to accept transfer students, however up to 6 credits may be transferred on the recommendation of the department.

Program Enrollment
Baccalaureate Program

| | Year 1 | Year 2 | Year 3 | Year 4 |
|----------------------|---------------|---------------|---------------|---------------|
| New Full-Time | 45 | 55 | 60 | 60 |
| Continuing Full-Time | | 43 | 94 | 148 |
| New Part-Time | | | | |
| Continuing Part-Time | | | | |
| Totals | 45 | 98 | 154 | 208 |

Master's Program

| | Year 1 | Year 2 | Year 3 | Year 4 |
|----------------------|---------------|---------------|---------------|---------------|
| New Full-Time | 0 | 0 | 2 | 2 |
| Continuing Full-Time | | 0 | 0 | 2 |
| New Part-Time | | | | |
| Continuing Part-Time | | | | |
| Totals | 0 | 0 | 2 | 4 |

Doctoral Program

| | Year 1 | Year 2 | Year 3 | Year 4 |
|----------------------|---------------|---------------|---------------|---------------|
| New Full-Time | 1 | 2 | 6 | 9 |
| Continuing Full-Time | | 1 | 3 | 11 |
| New Part-Time | | | | |
| Continuing Part-Time | | | | |
| Totals | 1 | 3 | 11 | 22 |

Curriculum (Attachment A)

It is expected that the proposed B.S. degree program will be accredited by the Accreditation Board for Engineering and Technology (ABET). All undergraduate degree programs in the College of Engineering are regularly reviewed and accredited by ABET. The expertise available within the college for successful accreditation will be used to provide guidance for the BME program. Accreditation is earned after the first student has been graduated. Thus, formal accreditation is not expected until 2020. The process of preparing for accreditation (e.g., implement assessment process for program educational objectives and student outcomes, improvement loop, collection of student work examples, etc.) will begin at the outset of the proposed degree program. UMA expects that this will synchronize with the accreditation cycle of other B.S. degree programs.

There are no plans to seek accreditation for the M.S. and Ph.D. program. UMA reports that ABET accreditation is not typical for graduate degree programs. The ABET database of accredited programs lists only two ABET-accredited graduate programs in Massachusetts (UMass Lowell M.S. in Occupational and Environmental Hygiene and M.A. in Radiological Sciences and Protection). In the Biomedical Engineering area, ABET lists only one graduate program with accreditation in the United States (University of Louisville, M.E. in Bioengineering).

Internships or Field Studies

UMA plans that internships and experiential learning will be optional for students. It is planned that the College of Engineering Career Services office can provide interested students with opportunities upon request.

RESOURCES AND BUDGET

Fiscal (Attachment B)

UMA plans that the new programs will be offered by a new department of BME within the College of Engineering. Faculty members with the necessary expertise in BME are expected to be hired on a gradual schedule as the programs are developed. Space for new hires is planned to be available both on the UMA campus as well as at the UMass Medical School in Worcester.

UMA expects to admit 60 new B.S. students (45 students, in-state, 15 students out-of-state) per year. A stable undergraduate population of around 225 undergraduate students is planned from year 6. The graduate program is expected to grow proportionate to the faculty and growth in research activity. The faculty is expected to reach full size in year 6 to educate a full complement of undergraduate students as well as a robust graduate research program. The tuition and fee revenues are sufficient to offset the costs of implementing these programs.

A calculation of the necessary budget is based on that of other engineering departments, using the same proportions of salaries, student support, and operations expenses.

UMA's budget analysis indicates that after an initial investment by the college or campus, the department can sustain itself with the numbers of students projected for the three degree programs. In addition, UMA expects the faculty members in the new BME department to be research-active. Thus, additional resources may be available through research funding and overhead return.

Faculty and Administration (Attachment C)

The proposed program is part of a strategic effort by the College of Engineering to create a new department of BME that offers undergraduate and graduate programs. UMA plans to hire 12 full-time, tenure track faculty members, one instructor, and support staff in order to realize a new BME department and programs.

Facilities, Library and Information Technologies

Limited office and research lab space is available in the College of Engineering and UMA plans that an expansion by 12 faculty members will require additional space dedicated to this effort. Collaboration with the University of Massachusetts Medical School is expected to help establish some research labs for new faculty. All educational activities in the undergraduate program will be offered at the Amherst campus. UMA is in the process of renovations to accommodate the proposed undergraduate laboratories as well as allow shared common areas. Students in the proposed M.S. and Ph.D. programs are expected to work in the research lab spaces that will become available as faculty members are hired in the baccalaureate program.

The library has a large set of resources available for biomedical engineering as the institution is a land grant university with a mission in the life sciences. In addition, the Institute for Applied Life Sciences supports active research in this area with considerable resources for both the educational and research programs in Biomedical Engineering.

Technology resources are provided at the University level by the office of Information Technology (IT) and by the College through Engineering Computer Services (ECS). Information technology resources include network access, software packages, and computer labs (which also provide access to software with licensing restrictions). The Office of Information Technology Instructional Technologies Department provides support to faculty related to a wide variety of classroom and instructional support technologies, and it supports the research and instructional computing needs of the College of Engineering.

Affiliations and Partnerships

UMA plans that an external advisory board and the accreditation agency for the proposed B.S. degree will provide guidance on the program's future development. A core principle of ABET accreditation is continued assessment and improvement. Since the proposed B.S. program will seek ABET accreditation, a continued review process will be implemented for that program. As part of this process, an external advisory board with members from local and regional industry and academia will provide external input and help guide the graduate programs.

PROGRAM EFFECTIVENESS

| Goal | Measurable Objective | Strategy for Achievement | Timetable |
|--------------------------------------|---|---|---|
| Critical mass of BME faculty members | Hire 12 tenure-track and 1 non-tenure-track faculty member in BME Department to teach all 27 BME courses that are offered annually. This goal will be reached in steps over 6 years | Hire BME faculty members | Hiring schedule: 1 starting Fall 2017 1 starting Fall 2018 3+1 starting Fall 2019 3 starting Fall 2020 2 starting Fall 2021 2 starting Fall 2022 Teaching schedule: 1 course in 2017/18 6 courses in 2018/19 13 courses in 2019/20 25 courses in 2020/21 27 courses in 2021/22 and thereafter |
| Critical mass of BME B.S. students | Have sufficient number of students (60 incoming undergraduate students per year) to sustain program financially. | Admit students to BME program, advertise program regionally | Fall 2016: advertising campaign Spring 2017: admit first class of 45 students for Fall 2017 Fall 2018: admit 55 students Fall 2019 and thereafter: admit 60 students |
| High quality of BME B.S. students | Maintain or exceed quality of students at current level of College of Engineering by admitting students with equal or better GPA and SAT scores than previous years. | Select best applicants | |
| High quality education | Achieve ABET accreditation for B.S. program by meeting ABET student outcomes (a)-(k) and program-specific outcomes. Conduct AQAD assessment for graduate program. | Prepare for ABET review, collect evidence of improvement | Fall 2016 start assessment and improvements Spring 2021 request review when first students graduate |

| | | | |
|--------------------------------------|--|---|---|
| Successful career start for students | Collect data on student job placement or pursuing post-graduate degrees using the nationally accepted 6-month post-graduation cutoff date. | Track student placement through survey, emails, phone calls and other methods. The College of Engineering's Career Services office has an existing process for collecting data that has proven to be effective. | Fall 2017 begin promoting and assisting students to find experiential learning opportunities including but not limited to internships, co-ops, service learning, research experiences for undergraduates, and Engineers without Borders. In the senior year (Fall 2020 work with student (resume building, interview skills, placement counseling), to identify, contact and interview prospective employers. This includes conducting a career fair attended by prospective employers. |
|--------------------------------------|--|---|---|

EXTERNAL REVIEW AND INSTITUTIONAL RESPONSE

The proposed program was reviewed by Kristen Billiar, Ph.D., Department Head and professor, Department of Biomedical Engineering at Worcester Polytechnic Institute; Christina DeMur, M.S., Vice President of Digital Health at Redpine Signals, Inc. in San Jose, CA; Larry McIntire, Ph.D., Wallace Coulter Chair Emeritus at the Georgia Institute of Technology; and William Olbricht, Ph.D., Deputy Division Director of CBET, National Science Foundation, and professor in the departments of Chemical and Biomolecular Engineering, and Biomedical Engineering, at Cornell University in Ithaca, New York.

The team found that the proposed degree program is well designed, and that the University and state can expect that it will become a valuable addition to the educational offerings of UMA. The proposed curriculum was determined to be consistent with the stated goals. The team suggested that while sequence of courses and research is appropriate, moving the lab rotation to the first semester would help students choose research topics and advisors. The team indicated that BME has the advantage of being able to recruit students from a wide range of academic disciplines, but the curriculum must be sufficiently flexible to accommodate students from diverse backgrounds. To this end, it recommended making tracks optional to allow more room

for students to gain concentrated expertise in areas that will complement their research activities. The reviewers also suggested that students should be encouraged to take advantage of professional development opportunities available on campus.

The renovated facilities for research labs were found to be adequate for the Amherst-based faculty, as were the agreements in place for lab and office space for the faculty who will be located in Worcester. The reviewers indicated that the advisory board and regularly scheduled program reviews will ensure quality assessment and that students graduating from the program with an M.S. will be adequately prepared for the rapidly expanding BME workforce. The team questioned whether the facilities, equipment and library resources would be adequate to support the programs. It also questioned whether an adequate process had been established to assess the effectiveness of the programs.

In response, UMA cited the renovation of the Goessmann Laboratory on campus, the rental laboratory space at the medical school, core equipment at the Institute for Applied Life Sciences, and existing library resources as sufficient. Regarding program effectiveness UMA offered that the external advisory board comprised of local and regional industry experts and academics, as well as job placement data and regular reviews of the program would be adequate measures in addition to ABET accreditation for the undergraduate program.

STAFF ANALYSIS AND RECOMMENDATION

Staff thoroughly reviewed all documentation submitted by the University of **Massachusetts Amherst** and the external reviewers. Staff recommendation is for approval of the proposed **Bachelor of Science, Master of Science, and Doctor of Philosophy in Biomedical Engineering** programs.

ATTACHMENT A: CURRICULUM**B.S. Program Curriculum Outline**

| <i>Major Required (Core) Courses (# Total courses required = 8)</i> | | |
|---|---|--------------|
| <i>Course Number</i> | Course Title | Credit Hours |
| BME 210 | Bioengineering | 3 |
| BME 230 | Statics & Dynamics | 4 |
| BME 310 | Introduction to Laboratory Techniques | 3 |
| BME 320 | Bioinstrumentation I | 3 |
| BME 330 | Quantitative Physiology | 3 |
| BME 415 | Capstone Project | 4 |
| BME 430 | Systems Biology | 3 |
| BME 470 | Ethics and Regulations | 3 |
| | <i>Sub-Total Core Credits</i> | 26 |
| <i>Other Required Courses in Related Subject Areas (# Total courses required = 17)</i> | | |
| <i>Course Number</i> | Course Title | Credit Hours |
| CHEM 111 | Chemistry I | 4 |
| CHEM 112 | Chemistry II | 4 |
| CHEM-ENG 226 | Thermodynamics I | 3 |
| E&C-ENG 122 / CS 121 | Intro to ECE II / Intro. Problem Solving w/Comp | 4 |
| ENGIN 114 | Introduction to Biomedical Engineering | 4 |
| ENGIN 191ENG | Freshman Seminar | 1 |
| ENGIN 351 | Writing in Engineering | 3 |
| ENGLWRIT 112 | College Writing | 3 |
| KIN 270 | Anatomy & Physiology I | 4 |
| MATH 131 | Calculus I | 4 |
| MATH 132 | Calculus II | 4 |
| MATH 233 | Multivariate Calculus | 3 |
| MATH 331 | Differential Equations | 3 |
| MIE 211 | Strength of Materials I | 3 |
| PHYSICS 151 | Gen. Physics I – Mechanics | 4 |
| PHYSICS 152 | Gen. Physics II – Thermo., E&M | 4 |
| STAT 515 | Statistics I | 3 |
| | <i>Sub-Total Related Credits</i> | 58 |

| <i>Elective Courses (# Total courses required = 8)</i> | | |
|--|---|---------------------|
| <i>Course Number</i> | <i>Course Title</i> | <i>Credit Hours</i> |
| BIOCHEM 420 | Elementary Biochemistry | 3 |
| CHEM 261 | Organic Chemistry I | 3 |
| CHEM 262 | Organic Chemistry II | 3 |
| BME 235 | Introduction to Biomedical Devices | 3 |
| BME 296/396/496 | Research | 3 |
| BME 520 | Bioinstrumentation II | 3 |
| BME 521 | Biomedical Devices | 3 |
| BME 522 | Biosensors | 3 |
| BME 530 | Cell & Matrix Mechanics | 3 |
| BME 540 | Drug Delivery and Design | 3 |
| BME 541 | Immunology | 3 |
| BME 543 | Pathophysiology | 3 |
| BME 550 | Experimental Techniques in Genetics | 3 |
| E&C-ENG 211 | Circuit Analysis I | 3 |
| E&C-ENG 212 | Circuit Analysis II | 3 |
| E&C-ENG 242 | Data Structures and Algorithms | 3 |
| E&C-ENG 313 | Signals and Systems | 3 |
| E&C-ENG 580 / MIE 444 | Feedback Control | 3 |
| KIN 272 | Anatomy & Physiology II | 3 |
| KIN 530 | Mechanical Analysis of Human Motion | 3 |
| KIN 535 | Muscle Mechanics and Modeling | 3 |
| MICROBIO 255 | Introduction to Medical Microbiology | 3 |
| MICROBIO 310 | General Microbiology | 3 |
| MICROBIO 390B | Introduction to Microbiology Laboratory | 3 |
| MICROBIO 680 | Advanced Microbial Physiology | 3 |
| MIE 201 | Introduction to Materials Science | 3 |
| MIE 340 | Fluid Mechanics I | 3 |
| MIE 397B | System Dynamics | 3 |
| MIE 597 | Finite Element Analysis | 3 |
| MIE 597R | Biorobotics | 3 |
| MIE 597SM | Soft Tissue Biomechanics | 3 |

| | | |
|----------|--|----|
| MIE 597T | Orthopedic Biomechanics | 3 |
| | <i>Sub-Total Elective Credits</i> | 24 |

| <i>Distribution of General Education Requirements</i> | | # of Credits |
|--|-----|--------------|
| 4 Social World Electives (One course (AL/AT), one course (HS), one course (SB), and one course (AL, AT, SB, I, or SI); these courses should also meet the 2-course cultural diversity requirements: One course focusing on UNITED STATES diversity (U, ALU, ATU, HSU, IU, or SBU) and one course focusing on GLOBAL diversity (G, ALG, ATG, HSG, IG, or SBG)) | | 4 |
| <i>Sub-Total General Education Credits</i> | | 16 |
| <i>Curriculum Summary</i> | | |
| Total number of courses required for the degree | 37 | |
| Total credit hours required for degree | 124 | |
| <i>Prerequisite or Other Additional Requirements:</i> | | |
| Notes: | | |
| General Education requirements are met as follows: | | |
| <ul style="list-style-type: none"> • Writing: ENGLWRIT 112, ENGIN 351 • Basic Mathematics and Analytic Reasoning: MATH 131 • Biological and Physical World: BME 210, PHYSICS 151 • Social World and Social & Cultural Diversity: 4 Social World Electives (see above) • Integrative Experience: BME 415 | | |
| Elective Courses are grouped into “tracks.” | | |

M.S. Program Curriculum Outline

| <i>Major Required (Core) Courses (Total courses required = 4)</i> | | |
|---|---|---------------------|
| <i>Course Number</i> | <i>Course Title</i> | <i>Credit Hours</i> |
| BME 601 | Biomedical Engineering Core I | 3 |
| BME 602 | Biomedical Engineering Core II | 3 |
| BME 610 | Advanced Math and Analysis | 3 |
| BME 680 | Biomedical Lab Rotation | 3 |
| | SubTotal # Core Credits Required | 12 |
| <i>Concentration Course Choices (Total courses required = 6)</i> | | |
| BME 622 | Biosensors | 3 |
| BME 623 | Biosensor Fabrication | 3 |
| BME 631 | Skeletal and Tissue Biomechanics | 3 |
| BME 632 | Biorobotics | 3 |
| BME 644 | Pharmacokinetics and Pharmacodynamics | 3 |
| BME 645 | Therapeutic Design | 3 |
| | SubTotal # Concentration Credits Required | 18 |
| <i>Other/Elective Course Choices (Total courses required = 0)</i> | | |
| BME 699 | Masters Thesis | 9 |
| | SubTotal # Elective Credits Required | 0 |
| <i>Curriculum Summary</i> | | |
| Total number of courses required for the degree | 10 | |
| Total credit hours required for degree | 30 | |
| <i>Prerequisite or Other Additional Requirements:</i> | | |
| Masters thesis is optional and replaces 3 courses (9 credits) of electives. | | |

Ph.D. Program Curriculum Outline

| <i>Major Required (Core) Courses (Total courses required = 4)</i> | | |
|--|---|---------------------|
| <i>Course Number</i> | <i>Course Title</i> | <i>Credit Hours</i> |
| BME 601 | Biomedical Engineering Core I | 3 |
| BME 602 | Biomedical Engineering Core II | 3 |
| BME 610 | Advanced Math and Analysis | 3 |
| BME 680 | Biomedical Lab Rotation | 3 |
| BME 899 | PhD Dissertation | 18 |
| | SubTotal # Core Credits Required | 33 |
| <i>Concentration Course Choices (Total courses required = 2)</i> | | |
| BME 622 | Biosensors | 3 |
| BME 623 | Biosensor Fabrication | 3 |
| BME 631 | Skeletal and Tissue Biomechanics | 3 |
| BME 632 | Biorobotics | 3 |
| BME 644 | Pharmacokinetics and Pharmacodynamics | 3 |
| BME 645 | Therapeutic Design | 3 |
| | SubTotal # Concentration Credits Required | 6 |
| <i>Other/Elective Course Choices (Total courses required = 0)</i> | | |
| None | | |
| | SubTotal # Elective Credits Required | |
| <i>Curriculum Summary</i> | | |
| Total number of courses required for the degree | 6 | |
| Total credit hours required for degree | 39 | |
| <i>Prerequisite or Other Additional Requirements:</i> | | |

ATTACHMENT B: BUDGET

Program: B.S., M.S., Ph.D. in Biomedical

| REVENUE ESTIMATES | | | | | | | | | | |
|---|-------------------------|--------------------------------|-------------------------|--------------------------------|-------------------------|--------------------------------|-------------------------|--------------------------------|-------------------------|--------------------------------|
| | Year 1 | | Year 2 | | Year 3 | | Year 4 | | Year 5 | |
| UNDERGRADUATE | 2017 | | 2018 | | 2019 | | 2020 | | 2021 | |
| <i>Full-Time Tuition Rate: In-State</i> | \$1,714 | | \$1,800 | | \$1,890 | | \$1,984 | | \$2,083 | |
| <i>Full-Time Tuition Rate: Out-State</i> | \$9,937 | | \$10,434 | | \$10,956 | | \$11,503 | | \$12,078 | |
| <i>Mandatory Fees per Student (In-state)</i> | \$12,457 | | \$13,080 | | \$13,734 | | \$14,421 | | \$15,142 | |
| <i>Mandatory Fees per Student (out-state)</i> | \$20,567 | | \$21,595 | | \$22,675 | | \$23,809 | | \$24,999 | |
| <i>FTE # of New Students: In-State</i> | 40 | | 45 | | 45 | | 45 | | 45 | |
| <i>FTE # of New Students: Out-State</i> | 5 | | 10 | | 15 | | 15 | | 15 | |
| <i># of In-State FTE Students transferring in from the institution's existing programs</i> | | | | | | | | | | |
| <i># of Out-State FTE Students transferring in from the institution's existing programs</i> | | | | | | | | | | |
| Tuition and Fees | Newly Generated Revenue | Revenue from existing programs | Newly Generated Revenue | Revenue from existing programs | Newly Generated Revenue | Revenue from existing programs | Newly Generated Revenue | Revenue from existing programs | Newly Generated Revenue | Revenue from existing programs |
| First Year Students | | | | | | | | | | |
| Tuition | | | | | | | | | | |
| In-State | \$68,560 | \$0 | \$80,987 | \$0 | \$85,036 | \$0 | \$89,288 | \$0 | \$93,752 | \$0 |
| Out-of-State | \$49,600 | \$0 | \$104,330 | \$0 | \$164,333 | \$0 | \$172,550 | \$0 | \$181,177 | \$0 |

| | | | | | | | | | | |
|------------------------------------|-----------|-----|-----------|-----|-----------|-----|-------------|-----|-------------|-----|
| | 85 | | 9 | | | | | | | |
| Mandatory Fees | \$601,115 | \$0 | \$804,547 | \$0 | \$958,150 | \$0 | \$1,006,057 | \$0 | \$1,056,360 | \$0 |
| <u>Second Year Students</u> | | | | | | | | | | |
| Tuition | | | | | | | | | | |
| In-State | | | \$71,988 | \$0 | \$85,036 | \$0 | \$89,288 | \$0 | \$93,752 | \$0 |
| Out-of-State | | | \$52,169 | \$0 | \$109,555 | \$0 | \$172,550 | \$0 | \$181,177 | \$0 |
| Mandatory Fees | | | \$631,171 | \$0 | \$844,774 | \$0 | \$1,006,057 | \$0 | \$1,056,360 | \$0 |
| <u>Third Year Students</u> | | | | | | | | | | |
| Tuition | | | | | | | | | | |
| In-State | | | | | \$75,587 | \$0 | \$89,288 | \$0 | \$93,752 | \$0 |
| Out-of-State | | | | | \$54,778 | \$0 | \$115,033 | \$0 | \$181,177 | \$0 |
| Mandatory Fees | | | | | \$662,729 | \$0 | \$887,013 | \$0 | \$1,056,360 | \$0 |
| <u>Fourth Year Students</u> | | | | | | | | | | |
| Tuition | | | | | | | | | | |
| In-State | | | | | | | \$79,367 | \$0 | \$93,752 | \$0 |
| Out-of-State | | | | | | | \$57,517 | \$0 | \$120,785 | \$0 |
| Mandatory Fees | | | | | | | \$695,866 | \$0 | \$931,363 | \$0 |
| <u>Fifth Year Students</u> | | | | | | | | | | |
| Tuition | | | | | | | | | | |
| In-State | | | | | | | | | \$0 | \$0 |
| Out-of-State | | | | | | | | | \$0 | \$0 |
| Mandatory Fees | | | | | | | | | \$0 | \$0 |

GRADUATE

| | | | | | |
|---|----------|----------|----------|----------|----------|
| <i>Full-Time Tuition Rate: In-State</i> | \$2,640 | \$2,772 | \$2,911 | \$3,056 | \$3,209 |
| <i>Full-Time Tuition Rate: Out-State</i> | \$9,937 | \$10,434 | \$10,956 | \$11,503 | \$12,078 |
| <i>Mandatory Fees per Student (In-state)</i> | \$12,114 | \$12,720 | \$13,356 | \$14,023 | \$14,725 |

| | | | | | | | | | | |
|---|--------------------------------|---------------------------------------|--------------------------------|---------------------------------------|--------------------------------|---------------------------------------|--------------------------------|---------------------------------------|--------------------------------|---------------------------------------|
| Mandatory Fees per Student (out-state) | \$20,037 | | \$21,039 | | \$22,091 | | \$23,195 | | \$24,355 | |
| FTE # of New Students: In-State | 0 | | 0 | | 2 | | 3 | | 4 | |
| FTE # of New Students: Out-State | 1 | | 2 | | 6 | | 8 | | 11 | |
| # of In-State FTE Students transferring in from the institution's existing programs | | | | | | | | | | |
| # of Out-State FTE Students transferring in from the institution's existing programs | | | | | | | | | | |
| | Newly Generated Revenue | Revenue from existing programs | Newly Generated Revenue | Revenue from existing programs | Newly Generated Revenue | Revenue from existing programs | Newly Generated Revenue | Revenue from existing programs | Newly Generated Revenue | Revenue from existing programs |
| Tuition and Fees | | | | | | | | | | |
| First Year Students | | | | | | | | | | |
| Tuition | | | | | | | | | | |
| In-State | \$0 | \$0 | \$0 | \$0 | \$5,821 | \$0 | \$9,168 | \$0 | \$12,836 | \$0 |
| Out-of-State | \$9,937 | \$0 | \$20,868 | \$0 | \$65,733 | \$0 | \$92,027 | \$0 | \$132,863 | \$0 |
| Mandatory Fees | \$20,037 | \$0 | \$42,078 | \$0 | \$159,256 | \$0 | \$227,633 | \$0 | \$326,805 | \$0 |
| Second Year Students | | | | | | | | | | |
| Tuition | | | | | | | | | | |
| In-State | | | \$0 | \$0 | \$0 | \$0 | \$6,112 | \$0 | \$9,627 | \$0 |
| Out-of-State | | | \$10,434 | \$0 | \$21,911 | \$0 | \$69,020 | \$0 | \$96,628 | \$0 |
| Mandatory Fees | | | \$21,039 | \$0 | \$44,182 | \$0 | \$167,219 | \$0 | \$239,015 | \$0 |
| Third Year Students | | | | | | | | | | |
| Tuition | | | | | | | | | | |
| In-State | | | | | \$0 | \$0 | \$0 | \$0 | \$6,418 | \$0 |

| | | | | | | | | | | |
|--|-----------|-----|-------------|-----|-------------|-----|-------------|-----|-------------|-----|
| Out-of-State | | | | | \$10,956 | \$0 | \$23,007 | \$0 | \$72,471 | \$0 |
| Mandatory Fees | | | | | \$22,091 | \$0 | \$46,391 | \$0 | \$175,580 | \$0 |
| Fourth Year Students | | | | | | | | | | |
| Tuition | | | | | | | | | | |
| In-State | | | | | | | \$0 | \$0 | \$0 | \$0 |
| Out-of-State | | | | | | | \$11,503 | \$0 | \$24,157 | \$0 |
| Mandatory Fees | | | | | | | \$23,195 | \$0 | \$48,710 | \$0 |
| Fifth Year Students | | | | | | | | | | |
| Tuition | | | | | | | | | | |
| In-State | | | | | | | | | \$0 | \$0 |
| Out-of-State | | | | | | | | | \$12,078 | \$0 |
| Mandatory Fees | | | | | | | | | \$24,355 | \$0 |
| Gross Tuition and Fees | \$749,334 | \$0 | \$1,839,618 | \$0 | \$3,369,928 | \$0 | \$5,135,147 | \$0 | \$6,321,311 | \$0 |
| Grants | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Contracts | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Campus budget allocation | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Other Revenues (specify in cell 54) | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Total | \$749,334 | \$0 | \$1,839,618 | \$0 | \$3,369,928 | \$0 | \$5,135,147 | \$0 | \$6,321,311 | \$0 |

| | Year 1 2016 | | Year 2 2017 | | Year 3 2018 | | Year 4 2019 | | Year 5 2020 | |
|---------------------------|---------------------------------------|-------------------------------------|---------------------------------------|-------------------------------------|---------------------------------------|-------------------------------------|---------------------------------------|-------------------------------------|---------------------------------------|-------------------------------------|
| | New Expenditures required for Program | Expenditures from current resources | New Expenditures required for Program | Expenditures from current resources | New Expenditures required for Program | Expenditures from current resources | New Expenditures required for Program | Expenditures from current resources | New Expenditures required for Program | Expenditures from current resources |
| Personnel Services | | | | | | | | | | |
| Faculty | \$144,2 | \$0 | \$275,2 | \$0 | \$655,6 | \$0 | \$1,031 | \$0 | \$1,250 | \$0 |

| | | | | | | | | | | |
|---------------------------------|------------------|------------|--------------------|------------|--------------------|------------|--------------------|------------|--------------------|------------|
| | 00 | | 25 | | 36 | | ,703 | | ,423 | |
| Administrators | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Support Staff | \$82,400 | \$0 | \$148,526 | \$0 | \$273,182 | \$0 | \$281,377 | \$0 | \$359,375 | \$0 |
| Others | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Fringe Benefits 29.13% | \$66,009 | \$0 | \$123,439 | \$0 | \$270,565 | \$0 | \$382,500 | \$0 | \$468,934 | \$0 |
| Total Personnel | \$292,609 | \$0 | \$547,190 | \$0 | \$1,199,383 | \$0 | \$1,695,580 | \$0 | \$2,078,732 | \$0 |
| Operating Expenses | | | | | | | | | | |
| Supplies | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Library Resources | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Marketing/Promotional Expenses | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Laboratory Expenses | \$20,600 | \$0 | \$21,218 | \$0 | \$37,967 | \$0 | \$41,181 | \$0 | \$42,416 | \$0 |
| General Administrative Overhead | \$9,064 | \$0 | \$16,950 | \$0 | \$37,153 | \$0 | \$52,523 | \$0 | \$64,392 | \$0 |
| Other (specify): startup | \$350,000 | \$0 | \$175,000 | \$0 | \$1,075,000 | \$0 | \$1,050,000 | \$0 | \$1,350,000 | \$0 |
| Total Operating Expenses | \$379,664 | \$0 | \$213,168 | \$0 | \$1,150,120 | \$0 | \$1,143,704 | \$0 | \$1,456,808 | \$0 |
| Net Student Assistance | | | | | | | | | | |
| Assistantships | \$32,250 | \$0 | \$33,217 | \$0 | \$102,641 | \$0 | \$140,960 | \$0 | \$145,189 | \$0 |
| Fellowships | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Stipends/Scholarships | \$200,054 | \$0 | \$467,977 | \$0 | \$783,614 | \$0 | \$1,109,155 | \$0 | \$1,246,102 | \$0 |
| Total Student Assistance | \$232,304 | \$0 | \$501,194 | \$0 | \$886,254 | \$0 | \$1,250,114 | \$0 | \$1,391,291 | \$0 |
| Capital | | | | | | | | | | |
| Facilities / Campus recharges | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Equipment | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Other | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Total Capital | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 | \$0 |
| Total Expenditures | \$904,576 | \$0 | \$1,261,552 | \$0 | \$3,235,757 | \$0 | \$4,089,399 | \$0 | \$4,926,832 | \$0 |

BUDGET SUMMARY OF NEW PROGRAM ONLY

| | Year 1 2016 | Year 2 2017 | Year 3 2018 | Year 4 2019 | Year 5 2020 |
|---|----------------|----------------|----------------|----------------|----------------|
| Total of newly generated revenue | \$749,334 | \$1,839,618 | \$3,369,928 | \$5,135,147 | \$6,321,311 |
| Total of additional resources required for program | \$904,576 | \$1,261,552 | \$3,235,757 | \$4,089,399 | \$4,926,832 |
| Excess/ (Deficiency) | (\$155,242) | \$578,066 | \$134,171 | \$1,045,748 | \$1,394,479 |

Justification of Financial Projections: Faculty salaries assumed at \$90k (except for founding department head at \$120k); Administrative staff consists of business manager, undergraduate program manager, and graduate program manager (latter two hired in Year 2); operating expenses are assumed to be 3% of budget (which is comparable to other departments in the College of Engineering) - no detailed breakdown by expense category is possible at this point; TAs are approximately 4% of budget; a COLA is assumed to be 5%; startup-costs, facilities, lab setup, equipment are one-time costs that are *not* considered.

ATTACHMENT C: FACULTY

| Name of faculty member (Name, Degree and Field, Title) | Tenured Y/N | Courses Taught Put (C) to indicate core course. Put (OL) next to any course currently taught online. | # of sections | Division or College of Employment | Full- or Part-time in Program | Full- or part-time in other department or program (Please specify) | Sites where individual will teach program courses |
|---|--------------------|---|----------------------|--|--------------------------------------|---|--|
| Maureen Lynch, Ph.D. in Mechanical Engineering, Assistant Professor | N | Orthopaedic Biomechanics | | Engineering | Full | Full-time in Mechanical Engineering | Amherst |
| Frank C. Sup IV, Ph.D. in Mechanical Engineering, Assistant Professor | N | Mechatronic Systems, Biorobotics | | Engineering | Full | Full-time in Mechanical Engineering | Amherst |
| Yubing Sun, Ph.D. in Mechanical Engineering, Assistant Professor | N | Molecular, Cellular and Tissue Biomechanics | | Engineering | Full | Full-time in Mechanical Engineering | Amherst |
| Yossi Chait, Ph.D. in Mechanical Engineering, Professor | Y | Systems Dynamics | | Engineering | Full | Full-time in Mechanical Engineering | Amherst |
| Guangyu Xu, Ph.D. in Electrical Engineering, Assistant Professor | N | Introduction to Biosensors and Bioelectronics | | Engineering | Full | Full-time in Electrical and Computer Engineering | Amherst |
| Juan M. Jiménez, Ph.D. in Mechanical and Aerospace Engineering, Assistant Professor | N | Connections in Medicine, Biology and Engineering | | Engineering | Full | Full-time in Mechanical Engineering | Amherst |

| | | | | | | | |
|---|---|--|--|-------------|------|--|---------|
| Ian R. Grosse, Ph.D. in Mechanical Engineering, Professor | Y | The Design of Biological Systems & Inspirations for Engineering Design | | Engineering | Full | Full-time in Mechanical Engineering | Amherst |
| Qiangfei Xia, Ph.D. in Electrical Engineering, Associate Professor | Y | Semiconductor Devices, Microelectronic Fabrication, Nanostructure Engineering | | Engineering | Full | Full-time in Electrical and Computer Engineering | Amherst |
| Shelly Peyton, Ph.D. in Chemical Engineering, Associate Professor | Y | Chemical Engineering Principles for Biological Systems | | Engineering | Full | Full-time in Chemical Engineering | Amherst |