New Degree Proposal

Professional Master’s Degree in Biomedical Engineering

Graduate Center for Biomedical Engineering
The Graduate School
University of Kentucky
Executive Summary

The profession of engineering has two distinct but interrelated career paths: one technical and the other managerial. The University’s existing Master of Science Degree in Biomedical Engineering prepares students for the former: the proposed degree program will prepare students for the latter. Previously, management and leadership skills in biomedical engineering have typically been acquired by experience in industry; however, rapid changes in technology, healthcare cost containment initiatives, and a short-term (next-quarter) corporate emphasis have rendered this process inefficient. There exists a societal need, and unmet educational market potential for, degree programs designed to educate individuals who can capitalize upon “America’s second gold rush” in technology. Specifically, there exists an opportunity to formally train students in engineering leadership skills to meet the emerging demands of rapidly changing, cost-conscious 21st Century biomedical technology. A few leading academic institutions have already recognized this opportunity and developed this type of “professional” biomedical engineering educational program. The proposed degree program seeks to catapult the University of Kentucky into this emerging trend of graduate biomedical engineering education, compete for the nations very best students and shape them into the technological leaders of tomorrow, while simultaneously helping to create new technologies and bring new biomedical technology-based businesses to Kentucky.

The proposed Professional Master’s of Biomedical Engineering degree seeks to develop a unique combination of managerial, technical, and leadership skills for those who will direct the future course of biomedical technology. The proposed program is a supplement to, not a replacement for, the existing Masters Degree Program in Biomedical Engineering at the University of Kentucky. This program consists of a three semester, 14-course curriculum. Eleven of these are taken from existing courses: five from Biomedical engineering, five in management and administration from the Martin School of Public Policy, and one course from the Gatton Business School. Three new Biomedical engineering courses will be developed specifically for the proposed program. Choices and timing of these courses are specifically intended to develop the student’s ability to think critically and quantitatively on the multiple levels of technology, business, clinical practice, administration, science, economics, law, etc. that are required of the successful professional biomedical engineer who has chosen for his or her practice of engineering the management career alternative. The capstone course of the program, the Advanced Study Project, is an intensive student-team effort based upon a real-world biomedical technology problem that requires students to use all the skills learned in the program and provide a timely, well-studied solution.

The selection, timing, mission, and execution of the courses in the proposed program will differentiate this degree from virtually all other graduate biomedical educational programs in schools of engineering or business. The proposed program has been developed over the past several years and incorporates ideas and suggestions from a variety of faculty within the University of Kentucky as well as from
leaders in industry. The initiator, author, and prime mover of the proposed program, the proposed Program Director, is an existing tenured faculty member with graduate degrees in biomedical engineering and business, as well as industrial experience in the both the benchtop and the managerial career paths of the biomedical engineering profession.

The long-term goals of the proposed Professional Master's Degree in Biomedical Engineering are to: 1) strengthen the teaching mission of the University of Kentucky by producing top-quality graduate engineers who have leadership skills in the rapidly changing field of biomedical technology, 2) broaden the academic diversity of UK's graduate biomedical engineering program, 3) enhance the national prominence of the graduate school in biomedical engineering education, 4) enhance our research mission and develop new funding opportunities for research by increasing the visibility of the University to industrial organizations, 5) enhance the number and successfulness of our biomedical engineering alumni, 6) enhance the University's public service mission by offering an engineering education that has for too long been relegated to industry, 7) provide a competitive response to the profession-oriented biomedical engineering education programs that are beginning to emerge at other leading academic institutions, and 8) create or attract new upstart biomedical engineering companies within the State of Kentucky that will result from new interactions among students, faculty, and industry.

The proposed program is inexpensive to launch. Average annual expenses are approximately $60,000 for the first five years of the program. Excluding any grant monies or industrial contributions received for the program, projected tuition payments will generate sufficient revenue to make the program cash neutral in its second or third year. Beginning with the second and no later than the third year of the program, the Professional Masters Degree in Biomedical Engineering offers the University of Kentucky the potential to generate substantial revenue surpluses.
### Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive Summary</td>
<td>3</td>
</tr>
<tr>
<td>I. Mission, Influence, Organization</td>
<td></td>
</tr>
<tr>
<td>1.01 Consistency with Mission</td>
<td>7</td>
</tr>
<tr>
<td>1.02 Internal/External Influences</td>
<td>8</td>
</tr>
<tr>
<td>1.03 Relationship to University Organizational Structure</td>
<td>12</td>
</tr>
<tr>
<td>II. Program Description</td>
<td></td>
</tr>
<tr>
<td>2.01 Curriculum</td>
<td>12</td>
</tr>
<tr>
<td>2.02 Didactic Clinical Relationship</td>
<td>13</td>
</tr>
<tr>
<td>2.03 Accreditation/Certification</td>
<td>15</td>
</tr>
<tr>
<td>2.04 Admission Criteria/Standards/Procedures</td>
<td>15</td>
</tr>
<tr>
<td>2.05 Objectives/Evaluation Scheme</td>
<td>16</td>
</tr>
<tr>
<td>2.06 Advisory Committee</td>
<td>17</td>
</tr>
<tr>
<td>2.07 Plans for Articulation/Transfer/Cooperation</td>
<td>18</td>
</tr>
<tr>
<td>III. Supportive Data</td>
<td></td>
</tr>
<tr>
<td>3.01 Personnel Requirements</td>
<td>18</td>
</tr>
<tr>
<td>3.02 Similar Programs in Kentucky</td>
<td>19</td>
</tr>
<tr>
<td>3.03 Comparative Programs in Other States</td>
<td>19</td>
</tr>
<tr>
<td>3.04 Student Demand</td>
<td>20</td>
</tr>
<tr>
<td>3.05 Evaluation of Related Programs</td>
<td>20</td>
</tr>
<tr>
<td>3.06 Anticipated Issues/Trends</td>
<td>21</td>
</tr>
<tr>
<td>IV. Resources</td>
<td></td>
</tr>
<tr>
<td>4.01 Resources Required</td>
<td>21</td>
</tr>
<tr>
<td>4.02 Expenditures</td>
<td>22</td>
</tr>
<tr>
<td>4.03 Sources of Revenue</td>
<td>24</td>
</tr>
<tr>
<td>V. Forms</td>
<td></td>
</tr>
<tr>
<td>Form 1</td>
<td></td>
</tr>
<tr>
<td>Form 2</td>
<td></td>
</tr>
<tr>
<td>Form 2A</td>
<td></td>
</tr>
<tr>
<td>Form 3 – Amount and Sources of Revenue</td>
<td></td>
</tr>
<tr>
<td>Form 3A - Revenue</td>
<td></td>
</tr>
</tbody>
</table>
Appendices

Appendix A
Curriculum Vitae of the Proposed Director of the Professional Master’s Degree in Biomedical Engineering

Appendix B
Curriculum for the Proposed Professional Master’s Degree in Biomedical Engineering (presented in general and track-specific configurations)

Appendix C
Competing Professional Biomedical Engineering Programs

Appendix D
Tables 1 – 4: Spreadsheet files listing projected annual: Student Enrollments, Expenditures, Revenues, and Net Revenues accompanying the Proposed Professional Master’s Degree in Biomedical Engineering

Appendix E
New course request forms for BME 642, BME 767, and BME 777. These new courses are needed for implementation of the proposed Professional Masters Degree in Biomedical Engineering.
I. Mission, Influence, Organization

1.01 Consistency with Mission

The goal of the Professional Master of Biomedical Engineering (PBME) program is to offer a professional level, practice-oriented educational program that is capable of training a new breed of engineer who prefers the management, instead of the “benchtop,” career route in industrial biomedical engineering. This program attempts to bridge the wide gap between the educational curriculum offered by the research-oriented Master’s Degree in Biomedical Engineering and the administration-oriented Masters of Business Administration programs. The Professional Master of Biomedical Engineering degree program, in conjunction with our existing research oriented program, seeks to provide highly qualified students the option of choosing an educational program that will lead them to either of two viable career alternatives. For those who seeking research excellence in biomedical engineering, the current Master’s of Science in Biomedical Engineering is the degree of choice. However, for those who seek technical and administrative excellence in biomedical engineering, the proposed PBME program is believed to be a superior alternative to conventional management programs.

The proposed Professional Master’s Degree in Biomedical Engineering is an innovative new degree program designed to teach the biomedical engineer how to manage and successfully direct rapidly evolving biomedical technologies. The long term goals of this program are to: 1) strengthen the teaching mission of the University of Kentucky by producing top-quality graduate engineers who have leadership skills in the rapidly changing field of biomedical technology, 2) broaden the academic diversity of UK’s graduate biomedical engineering program, 3) enhance the national prominence of the graduate school in biomedical engineering education, 4) enhance our research mission and develop new funding opportunities for research by increasing the visibility of the University to industrial organizations, 5) enhance the number and successfulness of our biomedical engineering alumni, 6) enhance the University’s public service mission by offering an engineering education that has for too long been relegated to industry, 7) provide a competitive response to the profession-oriented biomedical engineering education programs that are beginning to emerge at other leading academic institutions, and 8) create or attract new upstart biomedical engineering companies within the State of Kentucky that will result from new interactions among students, faculty, and industry. The new interactions among students, faculty, and industry that will occur as a result of this program offer the potential to create or attract new upstart biomedical engineering companies within the State of Kentucky.

This program is distinctive in its goals and curriculum. The 14 courses in this program are based upon specific selections of three of the 13 eligible existing biomedical engineering courses, three new courses in Biomedical Engineering (BME) developed specifically for this program, six existing courses from the Martin School, one existing course from the business school and one existing course from the medical school. During each of the three semesters of the program, students are exposed to
advanced biomedical engineering courses, management and administration courses, and a course that links the former with the latter. The program also includes an Advanced Study Project in the final semester. The Advanced Study Project requires a team effort to use all the material learned in the program to solve an actual problem that was developed in consultation with industry. This arrangement of courses and the incorporation of the Advanced Study Project, are designed to develop the student’s ability to think critically, and concurrently in all of the multiple areas that comprise the professional practice of biomedical engineering. The selection and arrangement of courses, in addition to the Advanced Study Project, differentiate the proposed program from similar programs at other institutions.

This new degree program will help place the University of Kentucky at the forefront of what is becoming an important trend in biomedical engineering education. This program has the potential to catapult UK to national prominence as an innovator in biomedical engineering education and to draw upon the nation’s top undergraduate student population. The proposed program is consistent with UK’s educational mission and also has the potential to benefit it’s research mission through the increased interaction with a wide variety of industrial organizations that will result from students interactions with these businesses during the course of their Advanced Study Project.

1.02 Internal/External Influences

External Influences

It has long been recognized that the profession of biomedical engineering has two distinct but interrelated tracks: one technical (commonly referred to as “benchtop” engineering) and one managerial. Successful creation and efficient implementation of technology relies upon the successful performance of talented individuals in both of these tracks. We, as an institution of higher learning, have for too long been focused exclusively upon training the “benchtop” route of tomorrow’s engineers. As an institution of higher learning, we have ignored the important educational needs of those engineers who choose to excel in their profession by taking the management route. Duties required of those who choose the management route include: developing corporate, product and technical goals; developing technological forecasting abilities to be in the “right” technology at the right time; clearly understanding the lifecycle of technology and providing their organization with a blend of technologies of various maturation levels; establishing budgets and timelines; and managing teams of “benchtop” engineers to achieve these goals.

There exists a clear need for the nations leading academic institutions to educate its students in the technological leadership skills, i.e., the “other track” in biomedical engineering. The proposed program has been planned, discussed, and refined for approximately the past five years. A wide variety of UK faculty and leaders from industry have offered suggestions and the proposed degree program reflects the best-combined effort offered by our combined talents.
Other academic institutions have also recognized this opportunity for graduate engineering education and taken the lead by implementing technology leadership programs in biomedical engineering as well as other engineering disciplines. Noteworthy examples of this include Rensselaer Polytechnic Institute, the University of Pennsylvania, the University of St. Thomas (St. Paul, MN), and others (Appendix C). At the present time, the University of Kentucky is only one of a handful of academic institutions offering this type of a degree. As a result, the University of Kentucky has the potential benefits afforded to early market entrants and the ability to achieve distinction as an institution offering a novel educational product that attracts considerable attention from students, their parents, as well as the future employers of graduates from this program. Delay in implementation of this program will result in a “me-too” status as a follower instead of a leader in biomedical engineering education.

Modern society has become increasingly dependant upon technological solutions to complex problems, especially those pertaining to healthcare. Explosive growth in new biomedical knowledge and capabilities will occur in the 21st Century, but successful development and efficient implementation of these technologies will not occur in the absence of individuals with the capabilities to direct their development and implementation. The need for these individuals will increase as our ability to create new technologies grows, while our ability to chose which technologies to develop, and how to do it efficiently (so that these technologies are not the exclusive province of a few) will decrease.

The need for change is brought on by several external changes. First, the recession of the early 1990’s brought a drastic change in industrial America. Gone are the days of lifetime employment and widespread long-term research efforts. Much of what now occurs in private industry is focused on the sales performance of the next quarter. Short-term thinking also predominates innovation, research, and product development. In the biomedical industry, new developments in genetic engineering, medical imaging, sensors and devices, and computer modeling of biological processes began to unveil the dawn of a new generation of healthcare technology. Simultaneously with these technological advances came restrictions on how much resources would be spent to pay for such state of the art healthcare technology. As a result, the biomedical engineering profession was forced to contend with this explosive new capabilities, but limited resources in which to implement such technologies. The rate and extent of biomedical engineering innovation is not shaped solely by technological considerations or the limits imposed by physics, chemistry, and biology, but is also constrained by federal regulations governing the safety and efficacy trials of medical devices and drugs, the growing threat of device/drug malperformance litigation, intellectual property protection and patent infringement concerns, the ability to raise funds for technology development, the rise in power of the third-party payer and their ability to promote or impede a technology based solely upon their reimbursement policies, and the emergence of the a global marketplace with a differing set of technical and clinical performance standards. In short, successful development and efficient implementation of new biomedical technology is no longer the province of the “benchtop” engineer, but
requires the participation of talented engineering leadership. The decade of the 1990s clearly proved the validity of the aphorism “...it’s more important to be in the right technology than to do the technology right...” While the benchtop engineer is trained to do the technology right, successful technology leadership requires that the biomedical engineer be directed towards the right technology that the organization should be pursuing. This is a part of the contribution to successful technological innovation made by the biomedical engineer who chooses the management route.

The advent of the Internet, and the educational opportunities afforded by this mode of communication, also offers opportunities for learning as well as threats to academic institution’s role as the sole providers of learning and instruction. The professional practice of engineering provides skills needed by engineers to take ideas to the marketplace and thus create personal and societal wealth. This is a powerful motivating factor, which if not addressed by academic institutions, can have substantial long-term consequences. Consider the advent of firms such as Hungry Minds. Given their potential, the proposed Professional Master’s Degree in Biomedical Engineering can also be considered a pre-emptive response to ensuring that education remains the province of the academic institution, not that which will be usurped by internet based educators (see Appendix C – hungryminds.com).

Internal Influences

The proposed Professional Master's Degree in Biomedical Engineering is a response, not only to the needs of the external biomedical engineering community, but is also reflective of the career achievements and needs of our graduates. Since the formal creation of our program in 1988, approximately half (27 of 56) of our biomedical engineering graduates have chosen a career in industry. Most of our graduates begin their careers by doing benchtop engineering, but many (an estimated 40-50% of these) will change their career focus from the benchtop to the management route. While our program does well in preparing them for the former, it is lacking in preparing our students for the latter, and this is one of the motivations for the proposed Professional Master's of Biomedical Engineering Degree program.

Most of UK’s engineering alumni, who are nominated and elected into the Hall of Distinction, are done so not because of their benchtop engineering prowess, but because of their excellence in engineering management. It is ironic that Universities clearly recognize the value of engineers who succeed in the management route, as clearly evidenced by the awards given to such individuals, yet fail to implement the educational programs which enable these individuals to achieve the goals for which they are awarding them. Instead, engineering schools have relegated the continuing education of these “managerial” engineers to business schools or to education from within industrial organizations. Neither of these educational methods is optimal for meeting the future needs of a society in which biomedical technology, and the constraints under which such technology are developed and utilized, are changing so rapidly.
The need for, and curriculum of, the proposed program is motivated and influenced by its prime mover, the proposed Program Director, David Pienkowski, Ph.D., M.B.A., Associate Professor of Biomedical Engineering and Orthopaedic Surgery. Dr. Pienkowski has more than eight years of experience in the biomedical industry serving in both the technical and the managerial career paths. This experience, in conjunction with his MBA degree from the Wharton School of Business, and his involvement with related programs at another institution, have aided him in shaping the proposed degree program. The proposed Program Director has maintained many of his former contacts in the biomedical industry. These relationships, along with new ones to be developed, will be invaluable in the procurement of start up funds for the program as well as to provide an ongoing supply of topics, collaboration, and experiences for students in the Advanced Study Project course. These relationships may also have longer-term benefits such as enhanced collaboration between the University’s existing research endeavors as well as the formation of new biomedical engineering corporate entities in the State of Kentucky.

External and internal factors have also had a key role in deciding the program’s name. Considerable efforts were expended to properly and descriptively name the proposed degree. Titles included for consideration were: Master’s of Biomedical Engineering Management, Master’s of Biomedical Engineering Management and Administration, Master’s of Biomedical Technology Management and Administration, and Professional Master’s of Biomedical Engineering. The first title was rejected because it appears to most as a degree focused primarily upon management and ignores the heavy emphasis upon engineering. The second was rejected because it is excessively lengthy and appears to some like it belongs in a school of business, not a school of engineering. The third name was not only lengthy but appeared to many like a program offered by a technical institute, not a university. Furthermore, all three of these names are used for similar or related programs at institutions that the University of Kentucky would not consider to be one of its peer academic institutions (e.g. St. Thomas University). The last name was selected because it reflects the practicing profession-oriented aspects of the proposed program. It is simple, different, and is consistent with the titles offered by its nearest competitors, the Professional Master’s Degrees of Biomedical Engineering recently offered by Rensselaer Polytechnic Institute and the University of Pennsylvania. This latter point is considered especially important for readily communicating the identity and goals of the program and to enhance the marketability of the proposed program to prospective candidates.
1.03 Relationship to University Organizational Structure

The proposed new Master’s Degree Program in Biomedical Engineering will be based at the Graduate Center for Biomedical Engineering. The Center currently offers the Master of Science and Doctor of Philosophy Degrees in Biomedical Engineering. It is located administratively under the Office of the Chancellor of the Medical Center (Figures 1 and 2). The Director of the Center reports to the Dean of the Graduate School who in turn, reports to the Chancellor of the Medical Center. There are currently nine tenure-track faculty appointments in the Center. As mentioned earlier, the Director of the proposed program will be Dr. David Pienkowski who is a full time tenured faculty member in the Center. In addition to his graduate degree in Biomedical engineering, he also has an MBA degree in Management from the Wharton School and has more than eight years experience working full time in the biomedical industry. He will guide the direction of the new program and will be primary supervisor of the students.

II. Program Description

2.01 Curriculum

The curriculum of the proposed Professional Master of Biomedical Engineering, shown in generic form on the next page, is unique because it is designed to develop critical thinking and quantitative analytical skills on both the biomedical engineering and management levels, and to do this concurrently over a wide variety of subjects that influence the development of biomedical technology. Simultaneously, the program seeks to develop the student’s competency in the quantitative Advanced Study Projects of biomedical engineering management and administration fundamentals, e.g., managing technical people, marketing of medical devices and drugs, constraints on technology development and implementation due to patent concerns, ethical considerations, reimbursement policies, government safety and efficacy regulations, clinical practice and usage, etc. Options to select various subspecialty areas of biomedical engineering (see Appendix B) allow the student to advance their engineering competency in a variety of biomedical engineering sub-disciplines (e.g., biofluids, biomaterials, biosignals and controls, and biomechanics). Flexibility in the business component of the curriculum allows the student to concentrate on either management or finance, depending upon the career goals of the student. A general curriculum (next page) also exists for the student who seeks a broad education in biomedical engineering pursuant to a career as a management or technology consultant, venture capital associate, or industry analyst.

Bridge courses in each semester link the biomedical engineering components of the program to the management and administration components. These bridge courses, e.g., BME 642: Constraints in Biomedical Engineering (ethics, patent law for biomedical engineers, medical device regulations, etc.), HA 601: Healthcare System Overview, and BME 767: Management of Technology, emulate important real-world relationships between the technical opportunities and limitations inherent in the
fundamental science of the technology and the constraints and opportunities posed by
the administrative aspects of biomedical engineering.

The engineering component of the proposed curriculum is only one or two
courses shy of the course work required for the existing research-oriented Master of
Science degree in Biomedical Engineering. However, Instead of performing a thesis-
based research project, the Advanced Study Project associated with the proposed
degree requires in-depth use of the student’s newly acquired skills to prepare, or
properly critique (as in a venture capital related due-diligence analysis) a business plan
for the development of a new medical device or technology. The written component of
the Advanced Study Project will be completed by a group effort of three-to-five students
and it will reflect the level of effort needed to write an actual business plan, industry
analysis, or due diligence analysis of an emerging medical device or a new biomedical
technology.

2.02 Didactic Clinical Relationship

An important educational component of the proposed new Master’s Program in
Biomedical Engineering is the summer internship /Advanced Study Project experience.
This segment of the program is designed to help the student implement much of his or
her newly gained knowledge by working with a variety of outside organizations, e.g., a
venture capital firm, a manufacturer of medical devices, a technology analyst group of a
brokerage house, etc. to perform a needed real-world assessment of an existing or
emerging technology or to quantitatively forecast the rate of technological change in a
specific field of endeavor, etc. The Program Director will consult with groups of
students regarding the selection of the Advanced Study Project. These consultations
will occur during the later portion of the Fall semester of the first year of the student’s
program. Unlike conventional engineering programs where students work as
individuals, students working on their project will function in a team setting. Since the
Advanced Study Project will be based upon one of several existing “real world industry
based problems,” participation of the students at the sponsoring organizations facilities
is strongly recommended as part of their performance on the Advanced Study Project.
Students will be expected to travel to the participating organization’s place of business
and work with the organization’s own personnel in the formulation of the problem,
developing the method of attack, solving the problem, and implementation of the
solution. The Advanced Study Project will culminate in the preparation of both a formal
written report (which will be provided to the participating organization) as well as an oral
presentation delivered on campus via a special one-day biomedical engineering forum
to which all engineering students are invited. This report will describe in detail the
assessment of a technology, present a business plan and describe the strategy for an R
& D effort, etc. and how it was needed and used by the participating organization. The
evaluation of the Advanced Study Project will be conducted with the same rigor and
according to the same rules as are ordinarily applied to the final examination process of
students pursuing a traditional masters degree in engineering.
One of the existing Advanced Study Projects that await student involvement concerns the need to develop a strategic plan for a major manufacturer of orthopaedic implant devices. This manufacturer seeks to develop a succession of new products in the field of tissue engineering. The students would be required to travel to the manufacturers place of business, obtain information about the company’s existing business (history, philosophy, product lines, technical competencies, equipment and physical plant, etc.), perform a technological assessment of the need and market potential (based upon demographic and economic changes) for new materials replacing worn or diseased bone and cartilage, make an assessment of the current state of the technology as well as its direction and rate of change, etc. This information would be assimilated by the students (using the materials learned in the program) and formally delivered in a written plan and then presented orally to the faculty, the sponsor and their representatives, and other students in the program. The sponsor would benefit from a plan for developing a viable stream of new innovations in the field of tissue engineering that is consistent with their corporate mission and capabilities.

It is expected that initially, only partial support for this effort will be obtained from the sponsoring extramural organization, but as the successfulness of the program develops, it is expected that all of the support for the Advanced Study Project portion of the proposed program will be received from extramural sources.

The student faculty ratio for the didactic component of the program is estimated to be 15-20 students per faculty member, while the student faculty ratio for the Advanced Study Project is estimated to be five students per faculty member.

There are few opportunities for students of the program to actively engage in an Advanced Study Project with companies that are presently located in Kentucky (except for MedVenture, Inc. in Louisville, KY). It is likely that for the conceivable future of the program, most students will be required to travel out of state and work with a manufacturer (e.g., Ethicon, Inc. in Cincinnati, OH, DePuy Orthopaedics, Inc. in Warsaw, IN; Smith and Nephew Richards, Inc. in Memphis, TN), a venture capital or brokerage house firm (Viscogliosi Brothers, Inc., in New York, NY or SenMed Ventures, Inc. in Cincinnati, OH) or a small upstart manufacturer (typically located in the “medical alley” regions of Minneapolis, MN or San Diego, CA) to accomplish their Advanced Study Project. The Director of the Program will create the opportunities for student involvement with the Advanced Study Projects. Although several project opportunities already exist, the subject of and need for these opportunities continues to change. Identification, cultivation, establishment of industrial liaisons which lead to such projects will require a substantial effort in the first year or two of the program, but the effort required will decrease as the program, and its results, become known and appreciated. That is, industrial concerns will also come to the program seeking help and offering opportunity. Furthermore, the project choices available to the students will increase as a result of anticipated growth of the biomedical industry in Kentucky.
2.03 Accreditation/Certification

As with most graduate programs in traditional engineering and biomedical engineering, accreditation is neither sought nor considered necessary. Therefore, accreditation will not be sought for the proposed program, however, most students in the program will have a degree from an ABET accredited program in a traditional or a biomedical engineering major.

2.04 Admission Criteria/Standards/Procedures

For the first three years of this new program, applicants will be considered who: 1) are graduates of accredited undergraduate biomedical engineering programs (and in special circumstances, other undergraduate engineering majors), 2) who have high grade point averages (GPA of 3.2 or greater), and 3) have competitive Graduate Record Examination (and possibly, equally competitive Graduate Management Aptitude Test) scores. In the event of applicants with equivalent objective credentials, preference will be given to those with promising prior work experience or those with exceptional letters of recommendation.

In addition to the customary University of Kentucky graduate admissions procedures, admission to the program will require students complete an essay on their career aspirations and why the completion of the proposed program will help them reach these goals, as well as other essay questions designed to identify applicants with exceptional critical thinking and communication skills. All applications will be screened by the Program Director. Acceptance or rejection of each candidate will be performed by an admissions committee composed of a small group of faculty from the College of Engineering, the Center for Biomedical Engineering, and the Martin School of Public Policy and Administration.

Recruiting for PBME students will begin in the Fall semester of 2000 for a program start date of 2001 if this proposal is approved. Applications for the program will be accepted in the Spring semester and will continue until the class size targets have been achieved. Decisions will be made regarding admission beginning May 1. Applicants lacking the needed prerequisite course work may be accepted on a conditional basis, pending satisfactory completion of the prerequisite courses. Invited candidates will be notified by telephone, email, and first class mail.

Student enrollment in the first few years of the program will be encouraged by full or partial tuition assistance, depending upon program funding resources. Students in traditional engineering departments will also be recruited provided that they have also fulfilled the required prerequisites. At this time, all students must be required to take the courses listed in the program and no students will be excused from any of these courses based upon prior course work in the past, unless these courses were taken at the University of Kentucky within two years prior to admission to the program. There are no provisions for advanced placement at this time.
It is anticipated that approximately five students will enroll in the first year of this program, and seven in the second year (Table 1A, Appendix D). The entering class size will grow by two and three students, respectively, for each of the next two years of the program (years three and four). Beginning with the fifth year of the program, the entering class size will expand to an estimated 13 students. These projections will result in a total class size (both years of the program) of approximately 30 students. At the present time, it is expected that the total class size will remain at this (30 students total) level pending future review and analysis of the program.

2.05 Objectives/Evaluation Scheme

The objective of the Professional Master of Biomedical Engineering educational program is to prepare students for a professional level, practice-oriented career in the technical and managerial aspects of the biomedical engineering industry. The curriculum of this program attempts to develop in the student the ability to analyze real problems from the wide variety of perspectives required of professional managers of biomedical engineering technology. All of the courses listed in the proposed curriculum, see generic curriculum shown previously, are essential components of developing the intended critical thinking and analytical skills that the program is designed to teach. Specific examples of the various subspecialty areas of study are shown in Appendix B. Simultaneous use of these skills will be put to the test during the last semester when the Advanced Study Project requires the solution of an actual problem. All Biomedical Engineering faculty will evaluate course-related performance of individual students during the normal biannual student review session conducted by the Center for Biomedical Engineering. For their Advanced Study Project, the performance of each group of students will be graded as an entity by the Program Director. This grading process will also be assisted by the recommendations of personnel from the organization with whom the students have worked. Individual performance of the students within their group will also be evaluated by their teammates, in addition to the Program director and the personnel from the collaborating organization. This evaluation process will be conducted with the same rigor and analogous rules that are applied to the final examinations that are administered to graduate students pursuing a traditional masters degree in engineering at the University of Kentucky.

We will quantify the effectiveness of the Professional Masters Degree in Biomedical Engineering program by measuring the:

1) GPA, GRE (and GMAT) scores or percentiles of the entering candidates: (and will compare these values to entering candidates in other graduate and professional programs in UK, its peer schools, and nationally),
2) number of applications per class position (a clear measure of success would be to have 10 applicants per each class seat available),
3) perceived value of the program to industry as measured by the:
- dollars of industry support contributed to the program,
- number of firms participating in the advanced study projects,
- number of job offers and starting salaries offered to program graduates,
4) evaluations from graduates of the program who have worked for two or more years in the practice of biomedical engineering, and
5) number of start-up commercial enterprises in the State of Kentucky that is attributed to the Professional Masters of Biomedical Engineering Program.

2.06 Advisory Committee

The following Internal Advisory committee at the University of Kentucky has developed the proposed Master’s program:

David Pienkowski, Associate Professor of Biomedical Engineering and proposed Program Director
Charles Knapp, Director, Center for Biomedical Engineering
Thomas Lester, Dean Engineering School
Michael Nietzel, Dean, Graduate School
Gina Toma, Dean, Martin School of Public Policy and Administration
Faculty, Center for Biomedical Engineering

Subsequent to the implementation of this new degree, an External Advisory committee will be formed to guide the continuing development of this program and to assist the internal advisory committee members. Although no external advisory members have been formally invited to participate in the proposed program, potential candidates for this Committee include:

Dr. Jonathan Black, Principal, IMN Biomaterials, King of Prussia, PA
Ms. Elaine Duncan, Principal, Paladin Medical, Sweetwater, MN
Mr. Richard Tarr, Director of Research in Orthopaedics and Orthobiologics, DePuy Orthopaedics, Inc.
Dr. Robert J. Morff, Associate Director, Medical Technology, Senmed Medical Ventures, Cincinnati, OH
Mr. Dave Phelps, President, MedVentures, Louisville, KY
Dr. Kenneth Taylor, Director, Technology & Product Development, Arthur D. Little Inc., Cambridge, MA
Mr. Marc Viscogliosi, Viscogliosi Brothers LLC, New York, NY
Other potential advisors may be recruited from Stryker Inc., Baxter Inc., and US Surgical Inc.
2.07 Plans for Articulation/Transfer/Cooperation

This program will be complimentary to the University’s existing Master of Science Degree program in Biomedical Engineering. It will also interact with the Master’s of Public Policy and Administration Program at the Martin School through the sharing of classes. Students in the program will also take one course (Marketing 601) from the Gatton School of Business and Economics and one course from the Medical School (Physiology 412-G). Physiology is required of all graduate biomedical engineering students regardless of whether they choose the existing traditional degree or the proposed new degree program. All applications will be screened by the Program Director. Acceptance or rejection of each candidate will be performed by an admissions committee composed of a small group of faculty from the College of Engineering, the Center for Biomedical Engineering, and the Martin School of Public Policy and Administration.

The proposed program will recruit top caliber students from within the State of Kentucky as well as nationwide, but no other relationships with other academic institutions within Kentucky are foreseen at this time.

All students will be considered for admission to the program solely upon the basis of undergraduate grades, letters of recommendation, objective test criteria (i.e. Graduate Record Examination and possibly the Graduate Management Aptitude Test), caliber of undergraduate institution, and prior professional experience. Current students (or recent graduates) of the University of Kentucky, who satisfy the prerequisites for admission, will be considered on an equal basis with all other applicants for admission to the program.

Due to the almost unique nature of the program, there are no plans at present for student mid-program student transfers.

III. Supportive Data

3.01 Manpower Requirements

The following is a summary of the personnel requirements that are needed to implement this program. Since the program has been developed around curricula already in place and operational at the University of Kentucky, additional personnel needs are minimal. These requirements consist of: 1) Program Director (David Pienkowski, full-time tenured faculty member in the Center for Biomedical Engineering, 50% effort), 2) one-half time administrative assistant (to be hired), and 3) three part-time visiting faculty.

It is anticipated that the administrative assistant will only be needed on a 50% full time equivalent basis during the first year of the program. Other tasks, e.g., application forms receipt and processing, applicant interview arrangements, etc., will be performed by existing Center for Biomedical Engineering administrative personnel. The anticipated growth of the program will require an increase of 20% more time of this
administrative assistant each year of the program until, by approximately year five of the program, the administrative assistant will be needed on a full-time basis. Additional tasks required of the administrative assistant for year five and following would be cost allocated on an as needed FTE equivalent fractional basis. Much of the administrative assistants time will be needed for coordinating the campus trips of the visiting faculty, ordering supplies and educational materials, and interacting with the organizations which sponsor the Advanced Study Projects.

Each of the visiting faculty is needed to teach the equivalent of a 1-credit course in their fields of expertise (patent law for engineers, standards and government regulation of drugs and medical devices, and ethics in biomedical engineering). The intended visiting faculty in consultation with the proposed program director has developed preliminary curricula for these courses. These curricula have been presented to biomedical engineering students on a trial-basis, and preliminary results indicate wide student acceptance of the material. Formalized incorporation of these course materials into BME 642 awaits approval of the proposed Professional Master’s Degree of Biomedical Engineering degree program.

3.02 Similar Programs in Kentucky

There are no programs in Kentucky that are similar to the one being proposed. In fact, there are only two known other programs outside of Kentucky that have implemented a program in Graduate Biomedical Engineering education similar to that proposed. See Section 3.03 for additional details.

3.03 Comparative Programs in Other States

Professional engineering education programs have begun to emerge at other academic institutions. These programs are a response to the growing recognition that engineers create invaluable new technologies that society increasingly relies upon and for which there is no substitute. This increasing dependence upon technology has brought concomitant rewards and respect for engineers, which in turn has fueled the perception of engineering as a profession. Profession oriented educational programs, however, unlike those of medicine, law, and business, has been slow in coming to engineering until the last five years. Recently, professional-oriented engineering educational programs have emerged at the following academic institutions:

- Dartmouth University
- Penn State University
- Rensselaer Polytechnic Institute (offers Professional MS in BME)
- Syracuse University
- St. Thomas University
- University of Illinois at Chicago
- University of Pennsylvania (offers Professional MS in BME)
While all of these institutions offer professional graduate education programs in traditional engineering disciplines, only Rensselaer Polytechnic Institute and University of Pennsylvania have professional graduate biomedical engineering educational programs. Specific information based upon their website published materials, is contained in Appendix C.

Also, the concept of professional oriented degrees in other disciplines (distinct from medicine, law, dentistry, etc.) is also beginning to emerge at other universities. Washington University in St. Louis has recently instituted a Professional Master’s of Business Administration degree program. In addition to differentiating their program from all other MBA programs, it claims to provide their graduates with better preparation for the practice of business than traditional MBA programs (Appendix C).

3.04 Student Demand

While it is difficult to gauge the student demand for a program that is not widely known, two observations suggest that the prospective student population will eagerly receive the program. First, admission to similar or related programs at other institutions, like the one proposed, has been oversubscribed. Admission to these programs is limited by class size and is very competitive. The fact that competition for admission to these programs is substantial (and becoming more so with time as the popularity of the program, and its effect on the career of the graduates, becomes known) suggests that the program, once advertised, will attract a significant number of students. Second, casual mention of the program and its intended goals to several students, faculty, and employers, as done during the development of this program, has also been met with considerable enthusiasm. The enthusiasm shown by students for programs of similar names at other institutions is a motivating reason for adopting the name “Professional Master’s of Biomedical Engineering” for the proposed degree program.

As stated in section 2.04, it is anticipated that approximately five students will enroll in the first year of this program, and seven in the second year (Table 1A, Appendix D). The entering class size will grow by two and three students, respectively, for each of the next two years of the program (years three and four). Beginning with the fifth year of the program, the entering class size will expand to an estimated 13 students. These projections will result in a total class size (both years of the program) of approximately 30 students. At the present time, it is expected that the total class size will remain at this (30 students total) level pending future review and analysis of the program.

3.05 Evaluation of Related Programs

While the proposed Professional Master’s Degree in Biomedical Engineering shares courses from existing graduate biomedical engineering, public policy and administration, and business educational curriculums, it does not articulate as a degree entity with any other existing degree programs at the University of Kentucky. The proposed degree creates a new degree entity by a careful selection and arrangement of
existing courses in these programs, plus three new courses developed specifically for the proposed program.

3.06 Anticipated Issues/Trends

Several trends have emerged which place the proposed Professional Master’s Degree in Biomedical Engineering in a favorable light. As noted earlier, our societal reliance upon technology has created an increasing demand for engineers. As a profession, engineers create value for society and this value is slowly, but inexorably, becoming recognized and rewarded. Particular rewards are being offered to those who steer their organization towards “...the right technology,” and it is in this spirit that the Professional Master’s Degree in Biomedical Engineering intends to educate its students.

The growing rewards offered to managers of technology, coupled with the decline in income and status of health and legal professions has increased the desirableness of the program to the best and brightest that would otherwise seek a career in medicine and law. This has been the experience of the program at the University of Pennsylvania. Growth in their program is limited by faculty size and time commitment to the effort, but not by student interest in the program.

Thus, it is anticipated that as the attractiveness of careers in biomedical technology continues, while simultaneously the attractiveness of other traditional high end careers decreases, the interest in profession-oriented programs like that proposed will increase. If the program is marketed and conducted properly, it is conceivable that this program could have a 10 to 1 applicant/admission ratio and thus it could become one of the leading academic and income producing graduate programs of the University of Kentucky.

IV. Resources

4.01 Resources Required

Resources required to implement this program consist of modest reassignment of one faculty member’s distribution of effort (the Program Director) and the hiring of a half-time (initially) administrative assistant. All but three of the courses needed in the curriculum of this program are extant within the graduate school, and the program director will be responsible for creating these three additional courses.

Relatively minor expenditures are needed for new teaching materials, program advertising, and visiting faculty expenses. Otherwise, no major alterations to any program are required, nor are there any substantial capital equipment or building renovation/construction requirements.
4.02 Expenditures

This is an inexpensive program to implement. Summarized program expenditure estimates are presented in Table 2 (Appendix D) and are justified below. Most of the modest expenses required derive from a half-time executive administrative assistant, expenses for three visiting faculty, and program advertising expenses, and other minor miscellaneous expenses. The attached budget, and accompanying budget justification, lists these expenses and their need in detail.

An administrative assistant will be needed at the outset of the program to help with the review of applicants, maintain contact lists of inquiring students and their parents, procure educational materials for this curriculum, and orchestrate the orderly visitation of the visiting faculty needed for teaching BME 642. This person will also participate in maintain records and correspondence with all private sector contacts, facilitating visits by representatives from these organizations, and assisting the Program Director in procuring financial support for the program as well as assistance with the recruitment of subjects and sponsors for the student’s Advanced Study Projects. Initially, it is estimated that this person will only be needed on a 50% FTE basis, but this need will grow at an estimated 20% per year until year four when it is anticipated that the need will be for a full time (100% FTE) administrative assistant.

Three visiting faculty will be needed to teach the curricula of BME 642. Costs associated with these faculty are minimal and their educational materials have already been developed and presented to students at UK and other institutions. The first of this visiting faculty will be Mr. Sam Smith, J.D., a retired patent attorney with experience in government and the private sector. He will teach the first one-third of BME 642. Mr. Smith and the Program Director have already developed the curriculum for this component of the course, and this material has already been presented to BME students on a trial basis during the BME 772 seminar series. Highly favorable student evaluations were received regarding the lectures accompanying this curriculum. Mr. Smith is a Lexington resident who is enthusiastically committed to teaching this material in the proposed PBME program. His participation in the teaching effort will require only an honorarium. No travel or housing expenses will be needed.

The second visiting faculty will be P. Elaine Duncan. Ms. Duncan is a graduate of UK’s program in Mechanical Engineering and she has considerable experience in the medical device industry. For the last 12 years, Ms. Duncan has been the founder and President of Paladin Medical, Inc., a private consulting group providing advice regarding quality assurance, standards compliance, and regulatory affairs to small and medium sized companies in the medical products industry. Ms. Duncan is also a 2000 inductee into the UK Engineering Alumni Hall of Distinction. For the last five years, Ms. Duncan has regularly lectured to UK’s biomedical engineering students. Her topics have covered the role of standards and government regulations on the engineering constraints and design implications of medical devices. Her family lives in Lawrenceburg, KY and she regularly travels to Kentucky to visit them throughout the
year. Ms. Duncan will require modest travel support and an honorarium, but no housing expenses are anticipated.

The third visiting faculty will be John Fielder, Ph.D. Dr. Fielder is Professor of Philosophy at Villanova University and is known nationwide for his long involvement in the study of ethics in engineering. Representatives from the biomedical industry and the Food and Drug Administration (FDA) regularly consult Dr. Fielder regarding ethical issues in drug and medical device development. Dr. Fielder has also developed several well-researched case studies involving a variety engineering efforts including the Shiley heart valve, the DC-10 airframe, and the Brooklyn Bridge. He also has a video teaching series that will supplement his on-campus lectures. Dr. Fielder will require airfare, housing, meals, and honoraria payments ($500 per day) for his contributions to the teaching of BME 642.

The PBME program must be made known if it is to succeed in its goal of attracting the adequate numbers of the best and brightest future leaders and shapers of biomedical technological innovation. To do this, considerable advertising efforts must be expended to make the customer population aware of its existence and how it can jumpstart their career. Owing to the computer literacy of contemporary undergraduates and the pervasive influence of the internet, most of the promotional expenses incurred with advertising the program will be focused upon developing an informative, attractive, well-linked website that provides information about the program and what it can do for the potential applicants career. Most of these expenses will be incurred in the initial years of the program, and only modest funds will be requested as the program continues for refinement of the initial efforts and refocusing of the website based upon student evaluation and feedback. The website will be designed, researched, and implemented by In Situ, Inc., a Lexington-based company. The Program Director has considerable experience with In Situ website development and has worked with the principals of this organization to develop other websites. He will actively participate in the design and implementation of this degree-program promotional website and is confident that In Situ Inc. can provide an effective recruiting and promotional tool that is so essential to the success of the PBME program.

Modest additional funds are also requested for the development of posters (to be displayed outside of undergraduate Biomedical Engineering administrative offices at institutions in the US and Canada. Brochures will also be prepared for mailing to undergraduate biomedical engineering students, as well as for distribution at conferences attended by prospective students. It is also anticipated that the program director will personally meet and recruit highly qualified applicants to the program. Specifically, he will travel to nearby academic institutions (Vanderbilt University, Purdue University, University of Cincinnati, etc.) to speak to undergraduate students regarding new career opportunities that will become available to graduates of the PBME program.
4.03 Sources of Revenue

Most of the revenue derived from the PBME program will come from tuition paid by students. Estimates of the number of new students entering the program in each year of the program’s existence are shown in Table 1A (Appendix D). Based upon these estimates and the assumption that all these students will be from out-of-state (hence an upper level estimate for revenue), projected program income from tuition is shown in Table 3 (Appendix D). The upper and lower enrollment estimates, as well as revenue estimates, are labeled “high” and “low” in these tables.

The Program Director will also seek additional sources of revenue from government agency grants and private sector donations to offset the negative cash flows that accompany the initial years of the program. Due to the sporadic, likely nonrecurring, and uncertainty of these contributions, no revenue contributions to the program are shown in Tables 1 – 4 (Appendix D). Table 4 summarizes the net cash flows (program revenues less expenditures) generated by this program, given the previously stated assumptions.

It is worthy to note that, based upon conservative estimates of student enrollment and tuition growth, this program offers the opportunity to generate considerable excesses of revenue over expenses (Table 4, Appendix D). Thus the Professional Masters Degree in Biomedical Engineering has the potential to be a substantial revenue (profit) generator for the University of Kentucky.
Appendix A

Curriculum Vitae of Proposed Director of the Professional Master’s Degree in Biomedical Engineering
Appendix B

Curriculum of the Proposed Professional Master’s Degree in Biomedical Engineering (presented in general and track-specific configurations)
Appendix C

Competing Professional Biomedical Engineering Programs
Appendix D

Tables 1 - 4

Spreadsheet files listing projected annual: Student Enrollments, Expenditures, Revenues, and Net Revenues accompanying the Proposed Professional Master’s Degree in Biomedical Engineering
Appendix E

New course request forms
New Course Request
Proposed Course number: BME 642

Course Title: Constraints in Biomedical Engineering

Teaching Objectives

the purpose of this course is to:

1. to present to biomedical engineering students enrolled in the proposed Professional Masters Degree in Biomedical Engineering the constraints that limit the scope or utilization of medical technology,

2. to develop the students ability to maintain current with changing legal, regulator, environmental, standards, etc. conditions that alter the rate and extent of biomedical technological development,

3. to explore, via case studies, how these constraints have affected the development or utilization of medical devices in the past.

Reference List:

1. Fundamentals of Patent Law for Engineers
2. Food and Drug Administration Regulation of Drugs and Medical Devices
3. Ethical Considerations for Engineering Design
4. Medical Device Quality Assurance and Regulatory Compliance

Specific texts and journal readings for this course will be developed in consultation with the three visiting faculty who will be teaching components of this course. Video taped case studies and lectures will also be used to supplement this reference list.
New Course Request
Proposed Course number: BME 767

Course Title: Management of Technology

Teaching Objectives

the purpose of this course is to:

1. to become familiar with the innovation process that occurs within technology-based organizations,

2. to understand how to find the scientific limitations affecting the nature and rate of technological innovation,

3. to develop an understanding of the strategic implications of technological change,

4. to develop an ability to make forecasts of the rate and extent of technological evolution,

5. to develop an ability to compare and contrast emerging versus established technologies, and

6. to understand the role of technological innovation as a strategic resource of the practicing engineer.

Reference List


Suggested Readings:

Journals:

- Harvard Business Review
- Inventing Tomorrow
- R&D
- Technology

Reading and study will also be required of selected Harvard Case Studies and articles taken from other journals (copied (with permission) and placed in a bulkpack for student purchase at the University Bookstore).
New Course Request
Proposed Course number: BME 777

Course Title: Advanced Study Project in Biomedical Engineering

Teaching Objectives

the purpose of this course is to:

1. learn how to work in groups of three-to five people on an assignment,

2. perform this group work activity while focused (as a group) on solving an actual problem provided by an industrial organization engaged in some aspect of biomedical engineering,

3. utilize all of the materials learned in the course work of the Professional Masters Degree in Biomedical Engineering towards the solution of this problem,

4. to make an effect presentation to the faculty and students of biomedical engineering. This presentation will present the: problem addressed, reason for its importance, approach taken to solving the problem, methods used, constraints and problems encountered, results obtained, conclusions drawn, and action recommended be taken by the participating industrial organization.

Reference List

There are no required readings for this course: all readings are on an as-needed basis.