New Program Proposal
Master of Engineering in Biomedical Engineering
University of South Carolina Columbia

Summary

The University of South Carolina requests approval to offer a program leading to the Master of Engineering in Biomedical Engineering to be implemented in Fall 2014. The proposed program is to be offered through traditional instruction on campus. The following chart outlines the stages for approval of the proposal; the Advisory Committee on Academic Programs (ACAP) voted to recommend approval of the proposal to the Committee on Academic Affairs and Licensing (CAAL). The full program proposal is attached.

Stages of Consideration	Date	Comments
Program Planning Summary received and posted for comment	6/14/2013	
Program Planning Summary considered by ACAP through electronic review	7/30/2013	The representative from Clemson University stated that Clemson would hold its proposal so that both proposals could be considered simultaneously. The representative also stated that the two programs will mirror expertise at the undergraduate level and complement each other. CHE staff requested that the proposal include current data to support the industry demand and employment projections for post-baccalaureate training in this area as well as describe the collaboration between USC and Clemson in more detail. CHE staff also questioned whether this program would incur costs associated with graduate assistantships.
Program Proposal Received	1/15/2014	
ACAP Consideration	2/20/2014	Both Clemson and USC representatives discussed the collaborative nature of their two programs. Both representatives stated that the two programs are designed to complement each other to address the biochemical and biomechanical needs of the state and that the programs were designed in consultation with SCBIO[1] and local industry boards. ACAP also discussed the need for professional practitioners of this applied engineering program. In addition, ACAP members noted that MUSC, USC, and Clemson formed a bioengineering alliance focused on economic development.

[1] SCBIO unites the industry's major leaders, research institutions, and smaller organizations and individuals in a common vision for healing, feeding and fueling the world through life sciences. See www.scbio.org.

Stages of Consideration	Date	Comments
Comments and suggestions from CHE staff to the institution	2/21/2014	Staff requested the proposal be revised to include the following: • a detailed summary of the collaboration with Clemson • more information about employment opportunities in the state • a clearer description of the assessment plan, including specific examples of the data to be collected for programmatic assessment; and • a corrected "Estimated Costs and Sources of Financing" chart showing total costs, not just new costs.
Revised Program Proposal Received	3/24/2014	

Recommendation

The staff recommends that the Committee on Academic Affairs and Licensing commend favorably to the Commission the program leading to the Master of Engineering in Biomedical Engineering at the University of South Carolina to be implemented in Fall 2014.

UNIVERSITY OF SOUTH CAROLINA

COLUMBIA CAMPUS

NEW PROGRAM PROPOSAL

Master of Engineering in Biomedical Engineering

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Date of Submission

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Harris Pastides, President

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2. CLASSIFICATION

A. Program Title	Master of Engineering in Biomedical Engineering
B. Concentrations	None
C. Academic Unit in which Program Resides	College of Engineering and Computing, University of South Carolina
D. Designation of Degree	Master of Engineering (M.E.)
E. Proposed Date of Implementation	Fall 2014
F. Proposed CIP Code	140501
G. Site	Columbia Campus
H. Qualifies for supplemental Palmetto/LIFE Scholarship?	No
I. Delivery Mode	Traditional face-to-face

3. INSTITUTIONAL APPROVAL

Unit approval	February 21, 2013
Graduate Council approval	May 20, 2013
Provost approval	November 4, 2013
Board of Trustees approval	December 17, 2013

4. PURPOSE

The multidisciplinary field of Biomedical Engineering incorporates life sciences, engineering sciences, design, manufacturing and operation of biomedical processes and devices. Biomedical engineering is one of the fastest growing engineering areas in terms of student enrollment, graduate employment and research funding. The objectives of the proposed Master of Engineering in Biomedical Engineering (M.E. in BME) are to:

1. Prepare graduates of the program to meet the growing demands for continued development of and entrepreneurship in the biomedical industry.
2. Respond to the rapidly growing national demand for new biomedical technologies and provide opportunities for economic development and entrepreneurial growth for the State of South Carolina.
3. Meet the goals of the University of South Carolina in its emphasis area of biomedical sciences.
4. Provide an alternate mechanism for students to increase their competitiveness in attaining admission for further graduate studies, including Ph.D. programs in biomedical engineering and medical school.

The proposed Master of Engineering degree program will offer intensive, focused training in the professional practice of biomedical engineering. The program will be beneficial to students who plan to pursue industrial careers, as a graduate degree will enhance their job application, yield a higher starting salary, and enable rapid promotion within many corporate structures. Moreover, the program will provide students who plan to pursue further graduate education a means to distinguish themselves from typical candidates for M.S./Ph.D./M.D. programs, i.e. those with a B.S. degree only, and insomuch facilitate admission to leading Biomedical Engineering graduate programs and medical schools nationwide.

Our Program Educational Objectives are consistent with the University of South Carolina vision, as graduates who are capable of continuing to develop their technical and professional careers, and able to continue to learn and adapt to constantly evolving technology will contribute to the economic future of the state, nation and world.

In order to achieve these objectives, the Master of Engineering in Biomedical Engineering has the following student learning outcomes (SLO) set for its graduates. All M.E. in BME graduates will demonstrate:

- An ability to apply Mathematics, Life Sciences, Physical Sciences, and Engineering to advanced biomedical engineering problems. (SLO1)
- An ability to proficiently design and evaluate experiments, systems, components, or processes to meet desired needs. (SLO2)
- An ability to proficiently identify, formulate, and solve advanced biomedical engineering problems. (SLO3)
- An ability for proficient contemporary technical and scientific comprehension and lifelong learning. (SLO4)
- An ability for proficient technical and scientific communication. (SLO5)

- An ability to use advanced techniques, skills, and modern engineering tools necessary for biomedical engineering practice. (SLO6)

5. JUSTIFICATION

(a) Need for program in the state

Industry demand for post-baccalaureate training remains high, while reductions in federal research support have reduced the availability of assistantships for traditional M.S.-seeking students. Although absent in South Carolina, programs that are analogous to the proposed M.E. in BME have recently been introduced at top Universities both nationwide and at our peer institutions within the Southeast. In addition to meeting a local and national market demand, this degree program is designed to support economic development in the healthcare field, contributing to the advancement of a knowledge-based economy in South Carolina. We have recently observed strong growth in the relocation or opening of new facilities by healthcare companies in the State, as well as the formation of new start-up businesses. According to the Bureau of Labor Statistics, employment of biomedical engineers is projected to grow by 62% from 2010 to 2020, much faster than the average for all occupations (14%) and the fastest among engineering disciplines (11%) – The Whitaker Foundation (http://www.whitaker.org/glance/outlook2012.html). Moreover, the latest report (period of May 2012) from the Bureau of Labor Statistics indicates that Biomedical Engineers (occupation code 172031) in the state have an annual mean wage of $74,030, and those in the 90th percentile have an average annual earnings of $104,640 (http://data.bls.gov/oes/datatype.do). The aging baby-boom generation is expected to increase demand for a variety of biomedical devices and procedures, as it seeks to maintain healthy and active lifestyles. The surge in biomedical engineering demand is thus due to the range of industries which seek this particular expertise. The Bureau of Labor Statistics reports the following industries are employing the largest number of biomedical engineers, with mean salaries indicated in brackets:

- Scientific research and development services [$88,330]
- Pharmaceutical and medicine manufacturing [$82,820]
- Medical equipment and supplies manufacturing [$81,150]
- Colleges, universities, and professional schools [$68,070]
- General medical and surgical hospitals [$59,010]

Additionally, via intensive advertising campaigns from industrial leaders, the public has become aware of recent medical advances and procedures that are dependent on biomedical technologies. As a direct result, there are an increasing number of people who are inquiring and demanding new treatments from their physicians. Professional biomedical engineers will likely experience more demand for their services because of their central role in product development and evaluation coupled with the breadth of activities they are prepared to engage in. The high-value and in-demand attributes of biomedical engineers are made possible by the diverse nature of their training. Program administrators are working hard with biomedical engineering companies such as Rhythmlink, Selah Clinical, Stryker, and GE Health, locally and across the State, to enhance program diversity. Mechanisms such as our BME Advisory Board, Capstone Design Projects, collaboration with SC medical schools. and active participation in organizations like the SCBIO-SC Biomedical Engineering Companies Consortium, all contribute to enriching the opportunities that will be available to students in the program.

(b) Centrality of the program to the Commission-approved mission of the institution

As noted on the University website,

> The primary mission of the University of South Carolina is the education of the state's diverse citizens through teaching, research, creative activity and service…
>
> …With a flagship campus recognized by the Carnegie Foundation as a top research and service institution and nationally ranked in startup businesses and an eight-campus system that confers nearly 40 percent of all bachelor's and graduate degrees awarded at public institutions in South Carolina, the university has a profound relevance, reach and impact on the people of the state. The University of South Carolina provides all students with the highest-quality education, including the knowledge, skills and values necessary for success and responsible citizenship in a complex and changing world through engagement in nationally and internationally ranked research, scholarship, service and artistic creation. (http://ipr.sc.edu/mission/system_ms.htm)

The proposed M.E. in Biomedical Engineering degree program is directly related to the core USC mission, particularly the focus on education and the granting of terminal degrees, and is thus central to the continued evolution of our institution and in-line with the overarching goals delineated in the mission statement. The program will contribute in a substantial way to strengthening the economic and medical well-being of South Carolinians.

(c) Relationship of the proposed program to related programs within the institution

The University of South Carolina offers a Master of Science (M.S.) degree in Biomedical Engineering, but not a professional degree for the practice of biomedical engineering at the advanced level. The 30 credit hour M.E. in Biomedical Engineering degree program has been developed by the Biomedical Engineering Program at USC to meet the needs of students who desire to embrace a biomedical engineering industrial career in product and technology development or other related fields. Based on industrial career interest, students will be advised to select courses from an approved list of existing graduate level courses with the majority offered by the Biomedical Engineering Program at USC. Currently, the Biomedical Engineering Interdisciplinary program at USC offers a total of 36 graduate level courses in three colleges (Engineering and Computing, Arts and Sciences and the School of Medicine). Advising will be managed by the Biomedical Engineering Graduate Committee along with the assigned advisor of each student.

(d) Comprehensive list of similar programs in the state:

Clemson University and The University of South Carolina are concurrently requesting approval for a Master of Engineering Degree in Biomedical Engineering. Even though offering the same terminal degree, these institutions are proposing different curricula that will result in engineers with different skills sets. Together these programs will diversify the workforce as needed to attract and retain biomedical and biotechnology industry in South Carolina. Clemson University focused its M.E. in BME curriculum on current faculty expertise and physical resources for biomaterials engineering and bioelectrical engineering, both approved concentrations for the B.S. degree in Bioengineering. The former addresses medical device and technology design through new materials synthesis, characterization and simulation. The latter includes medical imaging engineering, bioinstrumentation (pacemakers, biosignal processing and acquisition), and surgical robotics. The engineering graduates from this program will be employed by medical device manufacturers and imaging companies. The M.E. in BME program at The University of South Carolina is aligned with the B.S. degree in Biomedical Engineering and with faculty expertise and strengths focusing on biochemical engineering and biomechanical engineering.

Both fields are highly conducive to generate a workforce that will address regenerative medicine challenges, meet the needs of the pharmaceutical industry, and propose advanced technology for functional devices and therapy. Both programs offer different fundamental training that jointly addresses the needs incurred by initiatives for biomedical engineering economic development in the state.

The proposed programs have been discussed and planned by both institutions. The department chairs, Dr. LaBerge and Dr. Bayoumi, and the faculty members at both institutions have synergistically developed the curriculum to address workforce gaps through their unique expertise. Since 1985, through the Bioengineering Alliance of South Carolina and more recently through the South Carolina Medical Translational Technology Program instigated in 2010, Clemson University and the University of South Carolina are partners in research, education, and economic development. From a research perspective, their students and faculty collaborate on numerous joint projects including extensive efforts such as NIH COBRE, SCBioMAT, NSF RII, and INBRE.

Overall, by both offering M.E. in degrees in Biomedical Engineering, Clemson University and the University of South Carolina will be central and pivotal in developing the workforce to secure a market advantage in this economic sector for South Carolina. M.E. in Biomedical Engineering graduates are highly sought out by industries surrounding medical imaging, medical devices, bioinstrumentation, software, orthopedics, tissue & cell engineering, diagnostics, drug discovery, pharmaceuticals, genomics, bioinformatics and more. This includes large pharmaceutical and medical device manufacturers like Roche, Sanofi, Pfizer, Novartis, AstraZeneca and GE, as well as Bioscience start-up companies or Testing and Medical Laboratories. Pharmaceutical and medical device companies are continuing to have a bigger impact in South Carolina's industry with a selection of companies listed in *Table 1*. The medical device industry in South Carolina has steadily grown over the last decade, despite an overall economic slowdown in the last years. [4] Both Clemson Bioengineering and USC Biomedical Engineering programs engage these companies for co-op, internship, and employment opportunities for their graduates.

Table 1: Selected Pharmaceutical and Medical Device companies in South Carolina

Company Name	**Company Name**
AAIPharma	Nephron Pharmaceuticals
BASF	Resmed
Bausch & Lomb	Roche
Becton Dickinson	Rockwell Medical
Cell and Tissue Systems	Rhythmlink
Charles River Laboratories	SensorTech, LLC
Covidien	St. Jude Medical
CreatiVasc Medical, LLC	The Rite Dose Corporation
Deltex Medical	ToxStrategies
Kiyatec	Trumpf Medical Systems
Medtronic	Varian Medical Systems

Currently, there is no similar program at a public or private university in South Carolina. Both Clemson University and the University of South Carolina offer Master of Science (M.S.) degrees in Bioengineering/Biomedical Engineering, but do not offer a professional degree for the practice of biomedical engineering at the advanced level. The M.S. degree is a research-focused advanced degree intended to prepare students for a research career. The new M.E. in BME program will provide an integrated education and internship experience preparing students for product and technology development. It is considered a professional terminal degree.

a) Similarities and differences between the proposed program and those with similar objectives offered at other institutions in the state, the region, and the nation:

Similar M.E. in BME programs are offered at other universities in the United States (Table 2). The closest universities to South Carolina are Vanderbilt University (Tennessee) and Duke University (North Carolina), both of which are private institutions.

***Table 2: Master of Engineering Programs in Biomedical Engineering and Bioengineering* [6]**

Institution	State
Tufts University	Massachusetts
Montana State University	Montana
University of California, San Diego	California
The Catholic University of America	Virginia
Stevens Institute of Technology	New Jersey
Tennessee State University	Tennessee
University of Virginia	Virginia
Worcester Polytechnic Institute	Massachusetts
Boston University	Massachusetts
Widener University	Pennsylvania
Cornell University	New York
University of Florida	Florida
Southern Illinois University Carbondale	Illinois
Texas A&M University	Texas
Vanderbilt University	Kentucky
Rice University	Texas
Duke University	North Carolina

ASEE Statistics 2013 - http://www.asee.org/papers-and-publications/publications/468-521.pdf

Additionally, such a program is not offered to South Carolina residents through the Southern Regional Education Board's Academic Common Market or as an online degree. Compared to both Vanderbilt and Duke's M.E. in BME programs, Clemson University and the University of South Carolina offer unique curricula focused on specific strengths and expertise that have evolved since the conception of either program. Additionally, the proposed M.E. in BME program was developed following observations and critical analysis from the Biomedical Engineering Society (BMES) membership committee, the Council of Chairs of Bioengineering/Biomedical Engineering Departments in the United States, and SCBIO Workforce Committee; emphasizing the critical need to integrate leadership, entrepreneurship

and commercialization of medical device skills for biomedical engineering graduates to better address industrial expectations.

Despite the apparent need, there are currently no other M.E. in BME programs in the state, which has propelled The University of South Carolina to fill this educational void. Careful planning has ensured that the proposed program at The University of South Carolina is well-aligned with the existing B.S., M.S., and Ph.D. degrees in the areas of chemical engineering and mechanical engineering. The program to be implemented at Clemson University is significantly different and targets existing education and training strengths in the Department of Bioengineering: biomaterials engineering and Bioelectrical engineering. Both programs will offer different fundamental training that will jointly address the needs of biomedical engineering economic development in the state. Overall, by offering M.E. in BME degrees, Clemson University and the University of South Carolina will be central and pivotal in developing the workforce to secure a market advantage in this economic sector for South Carolina.

6. ADMISSION CRITERIA

The same admission criteria as those currently required by the University of South Carolina for graduate engineering students will be followed for the proposed program. Applications will be reviewed bi-annually by the graduate committee, and acceptance to the program will be granted for program initiation in both the Fall and Spring semester of a given academic year. In addition, individuals with the following qualifications will be admitted into the M.E. in BME program:

- Must hold a B.S. degree from an ABET-accredited program (or equivalent if from an international university) in bioengineering, biomedical engineering or other related engineering and technology disciplines and must provide transcripts from the institution where the degree was obtained.
- A minimum undergraduate grade point average (GPA) of 3.0 is required for admission.
- International students are required to submit TOEFL scores.
- Individuals may request a waiver of some of the above requirements (e.g., undergraduate GPA less than 3.0, or undergraduate degree not in engineering) and admission to the program if they provide sufficient evidence to the graduate program director that they have had compensatory industrial experience to warrant a waiver. It will be up to the program to accept or decline this request.

7. ENROLLMENT

We anticipate sustained growth in the M.E. degree in BME over the first five years it is offered. We anticipate that few to none of these students will enroll via transfer from another program at USC, but a large fraction will be drawn from recent SC graduates who have earned a B.S. in BME or a related discipline. Based on surveys with the current undergraduate population in BME at USC, we anticipate at least 10 students will enroll for the Fall semester immediately upon offering of this degree and another 3 will enroll in the Spring semester of that academic year. We expect a 30% annual increase in new student enrollment and will enforce a cap of 30 new students enrolled annually to ensure the highest quality students. We anticipate an annual graduation rate of 25%, and an attrition rate of 20%. The Biomedical Engineering Program is working closely with the South Carolina's Life Sciences Industry Organization (SCBIO) and its members to assure that the curriculum that will be delivered through this professional degree will meet the needs of the biomedical manufacturing community. The tabulated numbers below are based on the estimated rates of enrollment, attrition and graduation

Table A – Projected Total Enrollment

YEAR	FALL		SPRING	
	Head count	**Credit Hours**	**Head count**	**Credit Hours**
2014 –	10	150	13	195
2015 –	20	300	24	360
2016 –	30	450	35	525
2017 –	38	570	44	660
2018 –	52	780	57	855

8. CURRICULUM

The proposed curriculum is detailed below. Please note that no new courses will be added to the current institution's course catalog, but rather the program curriculum will be constructed from currently available courses.

The proposed curriculum consists of 30 total credit hours including:
Mandatory Courses (12 Credit Hours – all courses):

BMEN 710	Modeling and Simulation of Biomedical Systems.	(3)
BMEN 713	Human Cell and Molecular Biology for Biomedical Engineers.	(3)
BMEN 720	Transport Phenomena in Biomedical Systems.	(3)
BMEN 723	Anatomy and Physiology for Biomedical Engineers	(3)

Recommended Core Courses (6 Credit Hours – two courses):

BMEN 546	Delivery of Bioactive Agents	(3)
ECHE 572	Tissue Engineering	(3)
BMEN 589W (3)	BioMEMS (Bio-Micro-Electro-Mechanical Systems)	
BMEN 589W (3)	Micro/Nanofluidics and Lab-on-a-Chip	

Choice of BMEN Electives (12 Credit Hours – three to four courses):

College of Engineering and Computing:

BMEN 795 Biomedical Engineering Literature (1 credit)
BMEN 797 Biomedical Engineering Development (1 credit)
BMEN 798 Graduate Seminar in Biomedical Engineering (1 credit)
ECHE 710 Advanced Chemical Engineering Thermodynamics
ECHE 720 Advanced Fluid Flow Analysis

ECHE 721 Advanced Heat Flow Analysis
ECHE 722 Advanced Mass Transfer
ECHE 725 Rheology
ECHE 730 Chemical Reactor Design
ECHE 750 Process Dynamics and Control
ECHE 770 Electrochemical Engineering
ECHE 772 Principles of Polymer Systems
EMCH 717 Advanced Finite Element Methods
EMCH 722 Plasticity
EMCH 741 Viscous and Turbulent Flow
EMCH 751 Advanced Heat Transfer
EMCH 771 Design Properties of Plastics
EMCH 794 Thermodynamics
CSCE 555 Algorithms in Bioinformatics.
CSCE 561 Numerical Analysis.
CSCE 563 Systems Simulation.
CSCE 564 Computational Science.
CSCE 580 Artificial Intelligence.
CSCE 758 Probabilistic System Analysis
CSCE 763 Digital Image Processing.
CSCE 768 Pattern Recogn.and Classification.
CSCE 769 Computational Structural Biology
CSCE 784 Neural Information Processing
CSCE 822 Data Mining and Warehousing

College of Arts and Sciences:
CHEM 751 Biosynthesis of Macromolecules
CHEM 752 Regulation and Integration of Metabolism
CHEM 753 Enzymology and Protein Chemistry
CHEM 754 Biomedical Biochemistry I
CHEM 755 Biomedical Biochemistry II
BIOL 714 Advanced Cell Biology
BIOL 736 Advanced Developmental Biology

School of Medicine:
ANAT 700 Principles of Electron Microscopy
ANAT 701 Human Embryology and Gross Anatomy
ANAT 720 Special Topics in Microscopic Anatomy
BMSC 700 Biomedical Science Interdisciplinary Laboratory I
BMSC 701 Biomedical Science Interdisciplinary Laboratory II
BMSC 720 Signal Transduction
BMSC 730 Cardiovascular Science
CBNS 702 Human Microscopic Anatomy
MBIM 710 Advanced Immunobiology
MBIM 720 Comprehensive Microbiology
MBIM 739 Medical Bacteriology
MBIM 740 Virology
MCBA740 Biological Microscopic Imaging
MCBA741 Molecular Imag/Biomed Res
PATH 710 Neoplasia
PATH 741 Pathology I
PATH 742 Pathology II
PATH 760 Topics in Pathobiology
PHPH 705 Biomedical Pharmacology
PHPH 735 Cardiovascular Pharmacology
PHPH 740 Neuroscience
PHPH 745 Neurophysiology
PHPH 750 Fundamental Neuroscience I
PHPH 751 Fundamental Neuroscience II

9. Assessment

a. Assessment Process

Assessment is a faculty-driven process involving all biomedical engineering program faculty members. The Biomedical Engineering Program will assess the M.E. program at multiple levels, using both direct and indirect measures for the Student Outcomes as currently conducted for its B.S., M.S., and Ph.D. degrees in Biomedical Engineering. The Biomedical Engineering Program has a standing Assessment Committee that evaluates its degree programs. This committee is composed of at least four assigned members with a designated committee chair. The committee organizes assessment for the entire Biomedical Engineering Program including assessment for both undergraduate and graduate degree programs. A sub-committee for M.E. in BME Assessment will be formed with responsibility to oversee the academic curriculum and coordinate the presentation of all curriculum changes to the faculty at-large for approval. The chair of the M.E. in BME Assessment Sub-Committee will sit on the Program Curriculum Committee and Graduate Committees. This structure allows for fluid communication between the Committees such that the formal assessment milestones are obtained. The assessment process assigns responsibility for all assessment activities, ties the assessment instruments (measures) to the Program Education Objectives and Student Outcomes, and determines an assessment cycle for each instrument.

b. Student Learning Outcomes

Assessment of this new degree program will include a program assessment plan and reporting using WEAVE online, which is an assessment plan composer software. As mentioned in Section 4B, all M.E. in BME graduates will demonstrate the following student learning outcomes (SLO):

- An ability to apply Mathematics, Life Sciences, Physical Sciences, and Engineering to advanced biomedical engineering problems. (SLO1)
- An ability to proficiently design and evaluate experiments, systems, components, or processes to meet desired needs. (SLO2)
- An ability to proficiently identify, formulate, and solve advanced biomedical engineering problems. (SLO3)
- An ability for proficient contemporary technical and scientific comprehension and lifelong learning. (SLO4)
- An ability for proficient technical and scientific communication. (SLO5)
- An ability to use advanced techniques, skills, and modern engineering tools necessary for biomedical engineering practice. (SLO6)

c. Assessment Instruments

There are seven identified assessment tools/instruments to be used to evaluate the Student Outcomes:

1. Digital records of student work (M1)
2. Course Notebooks (M2)
3. Employer Survey (M3)
4. Student evaluation for BMEN 723 – Anatomy and Physiology for Biomedical Engineers (M4)
5. Internship preceptor evaluation (M5)
6. Exit survey (M6)
7. Program safety compliance program (M7)

These measurement instruments encompass both direct and indirect measures, but with at least one direct measure per Student Outcome. Not all assessment tools will apply to all students. For example, because internships are not are required program component, acquisition of M5 data will only be possible for the subset of students who chose to pursue internships. Table 4 lists descriptions of the assessment instruments with the responsible party and schedule, as well as evaluation criteria. Table 5 maps these assessment instruments to particular Student Outcomes and program objectives.

Table 4: Description of Assessment Instruments

Assessment Instrument	Description of Assessment Instrument	Responsibility	Schedule	Evaluation Criteria
M1- Digital records of student work	Digital collection of representative student work with artifacts demonstrating competency in biomedical engineering design, oral/written communication, industrial practices, and mentoring/ leadership addressing the program learning objectives. Will be generated by the instructors of all required courses.	Assessment Sub-Committee and departmental industrial advisory board (consisting of practicing bioengineers in the biomedical device and technology industry).	Every year	Assessment sub-Committee and advisory board sub-committee will conclude that the records are complete and outcomes have been met.
M2 - Course Notebooks	A course notebook contains examples of all graded work collected from students (e.g., exams, homework, lab reports, etc), course syllabus, and textbook(s). Made for each course.	Course Instructors and Assessment Committee	Every third year in December and May	Assessment Committee will conclude that the Student Outcomes examined during a particular review have been achieved.
M3 - Employer Survey	Employers are queried for assessment of Student Outcomes of graduates employed at their institutions. Additionally, BIOE Advisory Board members meet with students during their campus visits.	Program Director and Assessment Committee	Every other year in March	BIOE Advisory Board member surveys will indicate that graduating seniors have achieved the Student Outcomes
M4 –BMEN 723 student evaluation	Mentoring undergraduate students is a core course where M.Eng. candidates will practice management and mentoring skills through supervision. Mentor will be evaluated by mentees.	Course Instructor and Assessment Committee	Every year	At least 80% of the mentees will concur that their mentors are effective and have met outcomes SLO4 and SLO5.
M5 - Internship preceptor evaluation	A performance report following the completion of the internship by the assigned preceptor reviews technical, professional, leadership, and communication skills of the intern.	Program Director and Assessment Committee	Every year	At least 80% of preceptors will concur that students have met outcomes.
M6- Exit Survey	Department Chair surveys graduating students using Exit Survey Form	Program Director	Before GS7 submitted to GS and every three year thereafter	At least 80% of students will agree that the Student Outcomes are achieved.
M7- Safety compliance program	CITI training and institution courses for Student education, responsible conduct in research, and conflicts of interest.	Program Director	Every year	At least 90% of students will achieve compliance and meet outcome.

Table 5 – Summary of the ME in BME Program Assessment Plan

Program Objectives	Student Learning Outcomes	Measures
Advanced Knowledge and Life-long Learning	SLO1 SLO2 SLO3 SLO4 SLO6	M1,M2, M7 M1, M2, M7 M1, M2, M7 M4, M5, M8 M1, M2, M5
Career Opportunities	SLO3 SLO5 SLO6	M1, M2, M7 M1, M3, M6 M1, M3, M6
Awareness and Responsibility	SLO4	M4, M5, M8

At an annual Spring Faculty meeting, all results from assessment instruments are collated and presented to the faculty by the M.E. in BME Assessment sub-committee. Faculty are encouraged to voice any concerns regarding the execution and outcomes of the M.E. degree program. These discussions will result in three possible actions: 1) Continue to monitor student learning as described, 2) change a particular aspect of the curriculum, 3) change a pre-requisite course or course content. The goal of any change is to strengthen the program and improve the education provided to our students.

Employment of students following attainment of the M.E. degree will be monitored through the CEC Career Office staffed with a student services coordinator. This office provides guidance on biomedical engineering career fair held annually (Southeast and Mid-Atlantic Biomedical Engineering Regional Career Conference (SEMABECC), as well as maintaining an electronic network where students can search for job postings. The network consists of biomedical device industry in South Carolina (SCBIO) and biomedical engineering alumni.

10. FACULTY

(a) Faculty List

Table B details the rank (not name) and academic qualifications of each faculty member who will be directly involved in the core courses which comprise the proposed program. In addition to the listed faculty, a number of other faculty will contribute to the success of the program by virtue of offering courses that will serve as electives in the proposed curriculum.

Table B– Faculty List

List Staff by Rank (e.g. Professor #1, Professor #2, Associate Professor #1, etc.)	Highest Degree Earned	Field of Study	Teaching in Field (Yes/No)
Program Director (#1)	Ph.D.	Mechanical Engineering	Yes
Professor (#1)	Ph.D.	Mechanical Engineering	Yes
Associate Professor (#1)	Ph.D.	Chemical Engineering	Yes
Associate Professor (#2)	Ph.D.	Cell Biology & Anatomy	Yes
Associate Professor (#3)	Ph.D.	Chemical Engineering	Yes
Associate Professor (#4)	Ph.D.	Computer Science & Engineering	Yes
Associate Professor (#5)	Ph.D.	Computer Science & Engineering	Yes
Associate Professor (#5)	Ph.D.	Computer Science & Engineering	Yes
Associate Professor (#6)	Ph.D.	Mechanical Engineering	Yes
Assistant Professor (#1)	Ph.D.	Chemical Engineering	Yes
Assistant Professor (#2)	Ph.D.	Chemical Engineering	Yes
Assistant Professor (#3)	Ph.D.	Mechanical Engineering	Yes

(b) Enumeration and Necessary Qualifications of New Faculty

Although no new faculty hires are anticipated in the realization of this program, the following qualifications would be sought for new hires at various stages in their academic careers:

- The new faculty member at the Professor level will have significant experience in both research and teaching in the biomedical engineering field and will be expected to lead the program.

- The new Associate Professors will have significant experience in both research and teaching in the biomedical engineering field.

- The new Assistant Professors will have the potential for development of research areas as well as the ability to teach in the biomedical engineering field.

(c) Proposed Changes in Assignment for Current Faculty

Current faculty members in the Departments of Mechanical and Chemical Engineering, and Cell and Developmental Biology and Anatomy will teach courses in this curriculum. All courses are currently taught by faculty in the M.S. and Ph. D. programs. This M.E. program will simply put more students in classes, improving educational efficiency.

(d) Institutional Plan for Faculty Development

The faculty already receive release time for research, consulting, and curriculum development. In addition to fulfilling the teaching requirements of the proposed program, the faculty devote a significant part of their time to research in biomedical engineering related activities. There will be a concerted effort to incorporate research activity into course curriculum, such that students will be exposed to current concepts and issues in the field.

The biomedical engineering field is rapidly evolving. To stay current, faculty members in the BME program attend conferences and symposia where the latest research and teaching trends are presented and discussed. In addition, several faculty members each year attend summer biomedical engineering workshops such as those sponsored by the United States National Institutes of Health and other health organizations.

(e) Institutional Definition of the Full-Time Equivalents (FTE)

One FTE is equivalent to a teaching load of 100 undergraduates, 48 masters-level, or 18 PhD-level graduate students in a 3-hour class.

(f) Unit Administration, Faculty, and Staff Support

Table C lists new and currently employed faculty, administrators, and staff for the proposed program. It should be noted that one FTE is equivalent to a teaching load of 100 undergraduate, 48 masters-level, or 18 PhD-level graduate students in a 3-hour class.

Table C – Unit Administration, Faculty & Staff Support

UNIT ADMINISTRATION, FACULTY, AND STAFF SUPPORT						
YEAR	**NEW**		**EXISTING**		**TOTAL**	
	Headcount	**FTE**	**Headcount**	**FTE**	**Headcount**	**FTE**
Administration						
2014 – 15			**1**	**0.25**	**1**	**0.25**
2015 – 16			**1**	**0.25**	**1**	**0.25**
2016 – 17			**1**	**0.25**	**1**	**0.25**
2017 – 18			**1**	**0.25**	**1**	**0.25**
2018 – 19			**1**	**0.25**	**1**	**0.25**
Faculty						
2014 – 15			**12**	**5**	**12**	**5**
2015 – 16			**12**	**5**	**12**	**5**
2016 – 17			**12**	**5**	**12**	**5**
2017 – 18			**12**	**5**	**12**	**5**
2018 – 19			**12**	**5**	**12**	**5**
Staff						
2014 – 15			**2**	**1**	**2**	**1**
2015 – 16			**2**	**1**	**2**	**1**
2016 – 17			**2**	**1**	**2**	**1**
2017 – 18			**2**	**1**	**2**	**1**
2018 – 19			**2**	**1**	**2**	**1**

Administration of the program will be overseen in tandem by the current Director of Biomedical Engineering and the Graduate Director in Biomedical Engineering at USC. The core faculty who will deliver the proposed curriculum will consist of 12 members with affiliation to the Biomedical Engineering Program. A USC staff member will coordinate all administrative issues associated with the proposed program. All administrators, faculty, and staff referenced above are currently employed by USC. Introducing this new degree program will not increase the faculty teaching load. Additionally will be no increase in the administration work load of the BME Director or the BME graduate director. Only ½ time of an administrative assistant will be added for this new degree program.

11. PHYSICAL PLANT

All resources required to deliver the proposed curriculum are already present at USC, and are available for the realization of this program. No additional physical plant requirements are foreseen specifically for the proposed program. However, some reallocation of existing space may be performed to allow for the development and operation of the class-associated laboratories as needed.

12. EQUIPMENT

No new equipment or resources are needed to support the proposed program.

13. LIBRARY RESOURCES

(a) Assessment of current holdings

University Libraries currently has 522 books and subscribes to 31 periodicals in biomedical engineering and the related fields. As a government Depository Library, University Libraries also has full access to NIH and other government publications. Holdings include the principal professional publications from the American Society of Mechanical Engineers (ASME), American Society of Chemical Engineers (ASCE), and Society of Manufacturing Engineers (SME), including publications relevant to biomedical engineering. Additionally, University Libraries currently subscribes to the principal publication of the Biomedical Engineering Society (BMES) and numerous, more specialized, basic science and clinical journals of relevance to aspects of biomedical engineers. These holdings are adequate for the proposed biomedical engineering degree program.

(b) Estimate of Acquisitions Needed Annually

The current BS, MS, and PhD degree programs in Mechanical Engineering and Chemical Engineering are supported by an allocation of about $8,000 from the current library budget. An additional $2,500, annually, will be requested to add books and periodicals explicitly devoted to biomedical engineering.

14. ACCREDITATION, APPROVAL, LICENSURE, OR CERTIFICATION

Not applicable

15. ARTICULATION

There are no formal articulation agreements associated with the proposed program. However, as mentioned above, the University of South Carolina and Clemson University have discussed the courses and curricula of both M.E. degrees. While we have not examined other possibilities of course sharing or other collaboration, we would certainly welcome collaboration with other schools.

16. ESTIMATE OF COSTS

The cost of implementation of the ME in BME is $42,500 per semester. This includes $15,000 for administrative oversight and advising students, and $25,000 for supplies, consumables, marketing, publications, printing and other commercialization costs each semester. Student tuition will cover these implementation costs. The formula used to calculate the tuition in Table D is the number of credit hours listed in Table A multiplied by the in-state tuition per graduate credit hour. No new faculty, staff, or administrative costs are anticipated. All courses for the degree are already taught and managed as part of the Master of Science in Biomedical Engineering program.

Table D – Estimated Costs and Sources of Financing by Year

ESTIMATED COSTS BY YEAR						
CATEGORY	**1st year**	**2nd year**	**3rd year**	**4th year**	**5th year**	**TOTALS**
Program Administration	$30,000	$30,000	$30,000	$30,000	$30,000	$150,000
Faculty Salaries	$400,000	$400,000	$400,000	$400,000	$400,000	$2,000,000
Graduate Assistants						
Clerical/Support Personnel	$69,000	$69,000	$69,000	$69,000	$69,000	$345,000
Supplies and Materials	$50,000	$50,000	$50,000	$50,000	$50,000	$250,000
Library Resources	$5,000	$5,000	$5,000	$5,000	$5,000	$25,000
Equipment						
Facilities						
Other (Identify)						
TOTALS	$554,000	$554,000	$554,000	$554,000	$554,000	$2,770,000
SOURCES OF FINANCING BY YEAR						
Tuition Funding*	$107,325	$142,100	$194,875	$259,550	$352,975	$1,056,825
Program-Specific Fees						
State Funding						
Reallocation of Existing Funds**	$446,675	$422,900	$359,125	$294,450	$201,025	$1,724175
Federal Funding						
Other Funding (Specify)						
TOTALS	$554,000	$554,000	$554,000	$554,000	$554,000	$2,770,000

*All assumptions for tuition revenue are based on the estimated enrollment in Table 3 (Section 7) using a resident full-time tuition cost of $2,910/student/academic semester and $485/credit for summer. No unique cost or other special state appropriations will be or have been required or requested. Cost for materials and supplies needed for the laboratories will be secured through lab fees.
** As mentioned earlier, the Biomedical Engineering Program is an existing interdisciplinary program with several approved degrees. All faculty members and staff are currently on payroll in permanent positions within the College of Engineering and Computing.

17. REFERENCES

1. Forbes Magazine. 2012. (http://www.forbes.com/sites/jennagoudreau/2012/05/15/best-top-most-valuable-college-majors-degrees/).
2. CNN Money – October 2013. http://money.cnn.com/pf/best-jobs/2013/snapshots/1.html.
3. US Bureau of Labor Statistics. 2012. http://www.bls.gov/ooh/architecture-and-engineering/biomedical-engineers.htm.
4. Batelle/BIO Bioscience State Industry Development 2012. http://www.bio.org/sites/default/files/v3battelle-bio_2012_industry_development.pdf.
5. SCBIO 2013. www.SCBIO.org.
6. American Society for Engineering Education (ASEE) – 2012. *www.asee.org/papers-and-publications/publications/468-521.pdf*