ACAP
2/20/2014
Agenda Item 3b

CLEMSON UNIVERSITY

College Of Engineering and Science
Department of Bioengineering

TO THE SOUTH CAROLINA COMMISSION ON HIGHER EDUCATION

NEW PROGRAM PROPOSAL

REQUEST TO OFFER A NEW DEGREE

Master of Engineering Degree in Biomedical Engineering

Date of Submission: January 15, 2014

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James Clements, President

Program Contact:
Dr. Martine LaBerge
Chair, Bioengineering
301B Rhodes Hall
Clemson, SC 29634
864/656-5557
Laberge@clemson.edu

University Contact:
Dr. Debra Jackson
Vice-Provost for Academic Affairs and Asst. to the President
302 Sikes Hall
Clemson, SC 29634-5155
P 864/656-4592
F 864/656-0163
DBJ@clemson.edu

Classification

a) Program title:
   - Master of Engineering in Biomedical Engineering

b) Concentrations, options, and tracks: Not applicable

c) Academic unit in which the program resides: Department of Bioengineering

d) Designation, type, and level of degree (if baccalaureate, specify four- or five-year): Master of Engineering Degree (M.Eng.)

e) Proposed date of implementation: August 15, 2014

f) CIP code: 140501

g) Site: 1) Clemson University, Main Campus
   2) CUBEInC (Clemson University Biomedical Engineering Innovation Campus) at Patewood, Greenville, SC

h) Whether the program qualifies for supplemental Palmetto Fellows Scholarship and LIFE Scholarship awards: Not applicable

i) Delivery mode: Traditional in-class lectures and laboratory sessions in which significant site attendance is required

j) Area of certification (only for programs that prepare teachers and other school professionals): Not applicable

Institutional Approval

a) Curriculum Committee – Department of Bioengineering – October 12, 2012
b) Clemson University Academic Council – December 10, 2012
c) Clemson University Board of Trustees – January 31, 2013
d) Curriculum Committee – College of Engineering and Science – February 14, 2013
e) Curriculum Committee – Clemson University – April 12, 2013

Purpose

a) Statement of the purpose of the program:
In today's competitive technology environment, industries need to have highly skilled practicing engineers who are flexible in their professional capabilities. The M.Eng. in Biomedical Engineering (BME) program is a practice oriented, focused degree and caters to the needs of the biomedical device and technology industry where graduates will contribute significantly to the technical competitiveness of business and industry. It provides a graduate degree that focuses on the practice of engineering in order to better serve industrial needs. Rather than culminate in a research experience and a thesis as for the Master of Science degree, the Master of Engineering curriculum provides skills and expertise that enhance the individual's ability to contribute to the technical workforce. The program provides advanced training to students interested in expanding their

knowledge and expertise. The degree adds significant depth to an individual's understanding of the practice of engineering to fill technology gaps to assure the State's and Nation's global competitiveness of its constantly evolving biomedical and biotechnology industry.

b) Program objectives:
The major objective of the M.Eng. in Biomedical Engineering (BME) degree program is to provide an in-depth advanced engineering education to students who have completed a bachelor of science degree in engineering and desire to embrace an industrial career in the field of medical technology. It will provide an intellectually rigorous professional graduate education that emphasizes clinical applications and biomedical engineering design, in order to better train a workforce to sustain a growing biomedical industry in South Carolina and in the United States. This program is based on core biomedical engineering, plus relevant clinical applications, providing the basis for strong technical contributions in industry. This program will prepare engineering graduates for professional practice in BME and leadership roles in the biomedical science and technology private sector to help develop and sustain economic growth.

More specifically, students in the program will acquire a broad perspective of the biomedical engineering discipline that complements their undergraduate training in engineering or science, and an in-depth knowledge of an essential area in biomedical engineering. Graduates will be equipped to design biomedical devices and develop therapeutic strategies within the bounds of health care economics, the needs of patients and physicians, the regulatory environment for medical devices and pharmaceuticals, and stringent ethical standards of biomedical engineering practice. Overall, the program will graduate students who:

- Demonstrate advanced level academic expertise and practical engineering experience necessary to function as biomedical engineering professionals in a modern, ever-changing world. (Advanced Knowledge and Life-long Learning)
- Display competence by being selected for employment by industrial, academic or government entities or further professional/graduate studies. (Career Opportunities)
- Understand the broad, social, ethical and professional issues of contemporary engineering practice. (Awareness and Responsibility).

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

1. Apply Mathematics, Life Sciences, Physical Sciences, and Engineering to advanced biomedical engineering problems. (SLO1)
2. Designing and validate experiments, systems, components, or processes to meet desired needs. (SLO2)
3. Identify, formulate, and solve advanced biomedical engineering problems. (SLO3)
4. Demonstrate contemporary technical and scientific comprehension and lifelong learning. (SLO4)
5. Demonstrate technical and scientific communication. (SLO5)
6. Demonstrate advanced techniques, skills, and modern engineering tools necessary for biomedical engineering practice. (SLO6)

Justification

a) Need for the program in the state and impact on South Carolina's economic development:
The aging baby-boom generation is expected to increase demand for biomedical devices and procedures, such as hip and knee replacements, because this generation seeks to maintain its healthy and active lifestyle. In recent years, South Carolina has become an attractive retirement destination for this population demographic. Additionally, as the public has become aware of medical advances, increasing numbers of people are seeking biomedical devices for themselves from their physicians. Professional biomedical engineers will likely experience more demand for their services because of the breadth of activities they engage in, made possible by the diverse nature of their training.

In 2012, *Forbes* magazine ranked biomedical engineering as the #1 major in the United States [1]. A 2010 CNN Money Report ranked Biomedical Engineering among the 10 best jobs for the future, and noted that "as more schools award biomedical engineering degrees … that credentials will become a must. In this perspective, credentials are associated with advanced degrees such as the M.Eng. degree" [2].

A recent release from the Bureau of Labor Statistics indicated prediction of a 62% job growth rate in the biomedical engineering profession from 2012 – 2020 [3]. Therefore nationally, there is a demand for engineers to serve an industrial need. A 2012 Battelle Institute study reports that bioscience employment in South Carolina grew by more than 45% during the last decade [4]. Bioscience represents the fast-growing sector of the innovation economy in which state inventors earned 357 life science patents over the last six years. The report indicates that South Carolina is developing a diverse biomedical industry sector where its largest subsector, medical devices, has steadily grown, even since 2007. According to SCBIO, more than 572 biomedical and biotechnology companies and institutions employ 13,520 people with an average annual wage of $53,275 in South Carolina [6]. In the past 10 years, initiatives by the South Carolina Legislature, such as the SmartState Centers, have provided tremendous incentives for economic development in the biomedical technology sector. Accordingly, these businesses need employees with knowledge and leadership skills to ensure their competitiveness. Therefore, there is a critical need to establish a formal professional degree program in biomedical engineering to provide professionals who will work in this new knowledge-based economy. Not only is this new program aimed at developing a workforce needed to address the specialized skills needed by South Carolina bioscience based companies, it will provide leverage for recruiting medical device companies to South Carolina where advanced engineering and leadership skills are sought in employees. In this regard, the proposed M.Eng. in BME program curriculum has been developed with the input of the Industrial Advisory Board of the Bioengineering Department at Clemson University representing the international biomedical industry and with the SCBIO Workforce Committee to address current and future state needs.

b) Centrality of the program to the Commission-approved mission of the institution:
The mission of Clemson University is to fulfill the covenant between its founder and the people of South Carolina to establish a "high seminary of learning" through its historical land-grant responsibilities of teaching, research and extended public service. Clemson University is committed to foster the economic development of South Carolina through

education and research that will provide leadership to the state. Clearly, the Bioengineering department has endorsed the mission of the university and served as a substantial tool to better serve the state of South Carolina. The M. Eng. in BME program supports workforce and economic development and emphasizes the mission of the institution.

c) Relationship of the proposed program to other related programs within the institution:
Clemson University currently offers Bachelor of Science (B.S.), Masters of Science (M.S.), and Doctor of Philosophy (Ph. D.) degrees in Bioengineering. The B.S. degree program includes two concentration areas (Biomaterials and Bioelectrical) and is designed to provide technical training appropriate for entry-level industrial positions and preparation for further professional training either through graduate school or medical/dental school. The M.S. and Ph. D. degrees are research-focused programs of study designed to prepare graduates to join (M.S.) and/or lead (Ph. D.) industrial and/or academic research efforts to develop new biomedical technologies. As noted above, industry is increasingly demanding post-baccalaureate training. The proposed M.Eng. program will provide a defined curriculum with an emphasis on practical training that will provide graduates with access to higher-level entry positions in product and technology development or other related focus areas.

d) Comprehensive list of similar programs in the state:
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.Eng. program will provide an integrated education and internship experience preparing students for product and technology development. It is considered a professional terminal degree.

e) Similarities and differences between the proposed program and those with similar objectives offered at other institutions in the state, the region, and the nation:
Other M.Eng. in Biomedical Engineering programs are offered at other universities in the United States (Table 1). The closest universities to South Carolina are Vanderbilt University (Tennessee) and Duke University (North Carolina) and are both private institutions.

Table 1: Master of Engineering Programs in Biomedical Engineering/Bioengineering [7]

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	Tennessee
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.Eng. in Biomedical Engineering programs, Clemson's curriculum is unique and focuses on the unique strengths and expertise in biomaterials and medical devices of Clemson University for the past 50 years. Both above programs address mainly bioinstrumentation and bioimaging. Additionally, the proposed M.Eng. 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.

Even though there is currently no other M. Eng. programs in the state in Biomedical Engineering, The University of South Carolina is in the process of establishing a M.Eng. degree program in Biomedical Engineering. However, the program at The University of South Carolina is aligned with their existing BS, MS, and PhD degrees with foundations in 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 trainings that will jointly address the needs of biomedical engineering economic development in the state. Overall, by offering M.Eng. in Biomedical Engineering degrees, Clemson University and the University of South Carolina will be central and pivotal in developing the workforce to secure market advantage in this economic sector for South Carolina.

Admission Criteria

Admission to a graduate level program is controlled by the Graduate School at Clemson University. M.Eng. in BME applicants must meet the minimum requirements established by the University for admission to a graduate program. In addition, individuals with the following qualifications will be admitted into the M.Eng. program:

- Must hold a BS degree from an ABET-accredited program (or equivalent if from an international university) in Bioengineering, biomedical engineering or other related engineering and technology discipline 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) for admission to the program if they provide sufficient evidence to the graduate program director that they

have had sufficient industrial experience to warrant a waiver. It will be up to the program to accept or decline this request.

Enrollment

a) Table 2 – Projected Total Enrollment

PROJECTED TOTAL ENROLLMENT						
YEAR	**FALL**		**SPRING**		**SUMMER**	
	Headcount	Credit Hours	Headcount	Credit Hours	Headcount	Credit Hours
2014 – 15	12	144	12	144	12	72
2015 – 16	16	192	16	192	16	96
2016 – 17	21	252	21	252	21	126
2017 – 18	28	336	28	336	28	168
2018 – 19	37	444	37	444	37	222

b & c) Process by which these estimates were made, including the academic origin of students to be served and enrollment:

A poll of the Clemson Bioengineering graduating seniors (BS) in the past three years indicated that at least 12 students would have enrolled annually in the M.Eng. degree in biomedical engineering, if offered. Based on enrollment data available through ASEE for M.Eng. in Bioengineering / biomedical engineering programs in Georgia, Virginia and North Carolina since their implementation (average 6 years), it is conservatively estimated that the program could enroll at least 15 new students in August 2014, and thereafter. Additionally, we expect that this new professional program coupled with the stellar reputation of Clemson University as the leader in biomedical devices and biomaterials development will create a substantial interest from international applicants. Not to be neglected is the steady growth of the medical and pharmaceutical industry in South Carolina requiring a workforce to sustain their needs. The Department of Bioengineering will work closely with SCBIO and its members to assure that the curriculum that will be delivered through this professional degree will meet their needs. Therefore, we anticipate that in year one, 12 students will enroll, followed by a 30% increase annually for a cap of 45 students enrolled annually and a graduation rate of 39-42 annually.

Curriculum

The M.Eng. curriculum provides skills and expertise that enhance the individual's ability to contribute to the technical workforce. The degree will provide professionals in the technical

workforce an opportunity to continue their education and development in the context of an advanced degree. The M.Eng. also serves the practicing engineer to further his/her career in the context of an application of engineering knowledge, as opposed to a master's of science in a research context, which is focused on discovering new knowledge.

The minimum requirement for this degree is one year of full-time graduate study, or its equivalent. Eligibility for graduation requires a minimum of thirty (30) graduate credits consisting of 15-17 credits from a recommended core and 13-15 credits of technical elective courses. An internship of 1-2 credits is expected for graduation. No thesis is required for this degree. A student who has previous graduate work at another institution that has not been used towards a degree may petition the Graduate Committee to transfer up to nine (9) semester credit hours of relevant course work with grades of 'B' or better. No curricular changes are required for the proposed modification. New technical elective courses have been added to the graduate curriculum as listed below:

Recommended Core:
BIOE 8000-Seminar (1 credit) (1,0)
BIOE 8130-Industrial Bioengineering (3 credits) (3,0)
BIOE 8140-Medical Device Commercialization (3 credits) (3,0)
BIOE 8500-Mentoring Undergraduates (1 credit) (1,0)
BIOE 8010-Biomaterials (3 credits) (3,0)
BIOE 8200-Biomechanics (3 credits) (3,0)
BIOE 6350-Computer Modeling of Multiphysics Problems (3 credits) (2,0)
BIOE 6351-Computer Modeling of Multiphysics Problems Laboratory (0 credits) (0,3)

Internship:
BIOE 8900-Internship 1-2 credits (45-90 contact hours)

Choice of technical electives:
BIOE 6120-Orthopaedic Engineering (3 credits) (3,0)
BIOE 6230-Cardiovascular Engineering (3 credits) (3,0)
BIOE 6310-Medical Imaging (3 credits) (2,0)
BIOE 6311-Medical Imaging Laboratory (0 credits) (0,3)
BIOE 6400-Biotechnology for Bioengineers (3 credits) (3,0)
BIOE 6710-Biophotonics (3 credits) (3,0)
BIOE 8020-Compatibility of Materials (3 credits) (2,0)
BIOE 3021 Compatibility of Materials Laboratory (0 credits) (0,3)
BIOE 8110-Sterilization and Cleaning Engineering for Medical Devices (3 credits) (2,0)
BIOE 8111-Sterilization and Cleaning Engineering for Medical Devices Laboratory (0 credits) (0,3)
BIOE 8150-Design, Manufacturing, and Validation Methods for Reusable Medical Devices (3 credits) (3,0)
BIOE 8240 Cellular and Molecular Analysis in Tissue Engineering 4 (3)
BIOE 8241 Cellular and Molecular Analysis in Tissue Engineering Laboratory 0 (3)
BIOE 8250 Cardiac Pathophysiology and Pharmacology 3 (3)
BIOE 8270 Cardiac Electrophysiology and Arrhythmias 3 (3)
BIOE 8280 Implantable Cardiac Devices 3 (1)
BIOE 8281 Implantable Cardiac Devices Laboratory 0 (6)
BIOE 8300 Interventional Electrophysiology Imaging 2 (6)
BIOE 8310 Advanced Electrophysiology Procedures 2 (6)
BIOE 8320 Advanced Electrophysiology Problem Solving 2 (6)

BIOE 8460-Biomedical Basis for Engineered Replacement (3 credits) (3,0)
BIOE 8470-Transport Processes in Bioengineering (4 credits) (4,0)
BIOE 8480 Cellular Interactions with Biomaterials 4 (2)
BIOE 8481 Cellular Interactions with Biomaterials Laboratory 0 (2)
BIOE 8700-Bioinstrumentation (3 credits) (2,0)
BIOE 8701-Bioinstrumentation Laboratory (0 credits) (0,3)

Assessment

Assessment of this new degree program will include a program assessment plan and reporting using WEAVE online. All students will also be required to submit an ePortfolio containing artifacts demonstrating competency in biomedical engineering design, oral/written communication, industrial practices, and mentoring/leadership addressing the student learning objectives of the program. This e-portfolio will be evaluated by the assessment committee following a review by a sub-committee of the departmental industrial advisory board who are practicing bioengineers in the biomedical device and technology industry. Measures to be used for assessment include: student ePortfolio (M1), course notebooks (M2), departmental industrial advisory board (M3), mentored student evaluation for BIOE 8500 (M4), internship preceptor evaluation (M5), BIOE 8000 presentation (M6), and graduate exit survey (M7) and departmental safety training (M8). The assessment plan is described in Table 3.

Table 3 – Summary of the M.Eng. 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
Awareness and Responsibility	SLO4	M4, M5, M8

Faculty

As of fall 2013 semester, the Department of Bioengineering comprised 23 full-time T/TT faculty members who participate in the delivery of graduate curriculum and research advising. The faculty members have on average delivered Bioengineering instruction and advising for more than 10 years. They are collectively experienced teachers and advisors. Clemson University tenured and tenure-track faculty members are expected to dedicate their time to teaching, research and scholarly activities, and service to the university, profession, and community. The academic year (fall and spring semesters) workload of a faculty member is based on an eight-block load where each block is equivalent to a 3-credit course. Research active faculty members are assigned one block each semester for scholarly research activities including publications, grant management, and grant development. Committee work, graduate and undergraduate research supervision, graduate and undergraduate coordinator, student organization advisory, administrative responsibilities, professional society activities, etc. are credited on the basis of

one block for a minimum of 150 clock hours of assigned activity each semester (where 1 credit hour is equivalent to a minimum of 50 clock hours).

a) Table 4– 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)
Professor #1	PhD	Biomedical engineering	Yes
Professor #2	PhD	Bioengineering	Yes
Professor #3	PhD	Bioengineering	Yes
Professor #4	PhD	Bioengineering	Yes
Professor #5	PhD	Medical Physics	Yes
Professor #6	PhD	Chemistry	Yes
Associate Professor #1	PhD	Bioengineering	Yes
Associate Professor #2	PhD	Biomedical engineering	Yes
Associate Professor #3	PhD	Chemical Engineering	Yes
Associate Professor #4	PhD	Biomedical engineering	Yes
Associate Professor #5	PhD	Biomedical engineering	Yes
Associate Professor #6	PhD	Molecular Biology	Yes
Associate Professor #7	PhD	Inorganic chemistry	Yes
Associate Professor #8	PhD	Electrical Engineering	Yes
Assistant Professor #1	PhD	Bioengineering	Yes
Assistant Professor #2	PhD	Bioengineering	Yes
Assistant Professor #3	PhD	Biomedical engineering	Yes
Assistant Professor #4	PhD	Materials Science and Eng	Yes

Assistant Professor #5	PhD	Pharmaceutics	Yes
Assistant Professor #6	PhD	Biochemistry	Yes
Assistant Professor #7	PhD	Biological Sciences	Yes
Assistant Professor #8	PhD	Bioengineering	Yes
Assistant Professor #9	PhD	Physics	Yes
New Technical Specialist #1	BS-MS	Electronics	No

b) Proposed changes in assignment and of the extent to which each new assignment may require the addition of new positions to fulfill the former assignment:
No changes in faculty members' academic duties are expected. New faculty positions may be filled in the next years to provide expertise to complement the current expertise and skills in the department and provide support for teaching and research, if necessary. Each new hire will conduct undergraduate and graduate teaching, research, service activities. All new faculty hires will be enrolled in the mentoring program of the College of Engineering and Science. Departmental allocation of funds will be provided for attendance at scientific conferences, professional society meetings, grant writing workshops, and academic leadership workshops, during the first two years of employment. Technical support is crucial for teaching and training for highly specialized courses in Bioengineering. One technical classified position will be filled to support courses focused on bioistrumentation, Bioelectronics, and bioimaging. Technical supervision is also needed for equipment maintenance, safety and compliance regulation.

c) Institutional plan for faculty development as it relates specifically to the proposed program, including but not limited to, release time for research, consulting, conferences, and curriculum development:
The university, college, and department host various professional development activities related to teaching effectiveness, research proposal development and compliance, and personal development. A list of teaching effectiveness workshops regularly offered by the Office of Teaching Effectiveness and Innovation is available on request and online at http://www.clemson.edu/OTEI/. Further, the university supports faculty development in the form of sabbatical leave. The department has organized academic leadership workshops. The purpose of these workshops is to provide necessary skills needed for the faculty to address conflict, build teams, time management, and become more assertive in their day-to-day activities. This particular workshop also provided the faculty members tools to be more confident about advising and mentoring. Faculty members are encouraged to participate in professional development activities sponsored by professional societies including American Society for Engineering Education (ASEE), Society for Biomaterials (SFB), and Biomedical Engineering Society (BMES). The department provides funds for participation in these workshops as needed and requested. Faculty members in the tenure-track process are provided with individual mentoring.

d) Institutional definition of full-time equivalent (FTE):
Clemson University defines one Full-Time Equivalent (FTE) as 12 credit hours. Faculty workload is equal to four three-credit hour courses. Faculty workload is divided among responsibilities on teaching, research, and service.

e) Table 5. Head Count – Department of Bioengineering

UNIT ADMINISTRATION/FACULTY/STAFF SUPPORT						
YEAR	**NEW**		**EXISTING**		**TOTAL**	
	Headcount	FTE	Headcount	FTE	Headcount	FTE
Administration						
2014 –15	0	0	2	0.50	2	0.50
2015 – 16	0	0	2	0.50	2	0.50
2016 – 17	0	0	2	0.50	2	0.50
2017– 18	0	0	2	0.50	2	0.50
2018 – 19	0	0	2	0.50	2	0.50
Faculty						
2014 –15	0	0	23	5.75	23	5.75
2015 – 16	0	0	23	5.75	23	5.75
2016 – 17	0	0	23	5.75	23	5.75
2017– 18	0	0	23	5.75	23	5.75
2018 – 19	0	0	23	5.75	23	5.75
Staff						
2014 –15	1	1	3	3	4	4
2015 – 16	0	0	0	0	0	0
2016 – 17	0	0	0	0	0	0
2017– 18	0	0	0	0	0	0
2018 – 19	0	0	0	0	0	0

Physical Plant

The Department offers ample instructional and laboratory facilities which are all functional and well equipped to meet the needs appropriate to our educational goals. The original classroom and laboratory teaching space occupies the majority of Rhodes Engineering Research Center; in 2009 the Department has expanded its instructional capacity by building Rhodes Annex. The Department now has dedicated over 17500 sq. ft. for teaching laboratories in the Rhodes Building and Rhodes Annex with equipment and computers needed to support the program, in addition to facilities at the Clemson University Biomedical Engineering Innovation Campus (CUBEInC) in Greenville. Overall, research and teaching space in Rhodes, Rhodes Annex and CUBEInC is approximately totaling 110,000 square feet.

Inaugurated in December 2011, CUBEInC is located 35 miles from Clemson University main campus in Greenville SC on the Patewood Campus of the Greenville Health System (GHS) off highway 385. CUBEInC is linked to Clemson Unviersity main campus through a bus commuter system (Greenlink). It consists of newly built state-of-the-art research and laboratory facilities for translational biomedical engineering located above orthopaedic and vascular surgery clinics. CUBEInC houses research and education facilities, translational/incubator space, meeting and networking accommodations for scientists and clinicians, and state-of-the-art surgical-skills facilities. It provides the essential environment to further the development of clinically relevant technology aimed at improving patient care and disease diagnosis conducted by faculty and students at Clemson University.

The general condition of all laboratories is very good. The laboratories are a combination of very specialized areas of equipment and expertise (for example, mechanical testing, or molecular biology) and general laboratories such as cell culture laboratory, design laboratory and histology laboratory. Most laboratories are operated, and maintained by faculty in the Department, while some laboratories serve as shared facilities, maintained by specialized support personnel. Program classrooms will be established through the existing smart classrooms at Clemson University and at the Clemson University Biomedical Engineering Innovation Campus (CUBEInC) in Greenville SC. In order to provide access to CUBEInC, a classroom with videoconferencing capability in Rhodes will be dedicated to the program. Teaching laboratories and new faculty hires' research laboratories will be housed in Rhodes Engineering Research Center, the current home of the Department of Bioengineering. No additional space will be needed for the program.

Equipment

Specialized equipment has been acquired for new laboratories that will be used for the program courses. Cell culture facility for tissue engineering and cell-material interaction ($100,500); surface engineering laboratory for the characterization of biosurfaces including tissue processing, microscopy, and imaging ($90,000); and biomechanics and biomedical design laboratory including biomedical instrumentation ($240,000) were established for the program to provide the needed environment for students to acquire technical skills.

Library Resources

The university libraries are fully staffed and provide up-to-date reference support for teaching and research programs including free online electronic journals and literature search support for the courses to be delivered. Because the Bioengineering graduate programs (MS and PhD) have been in existence for the past 50 years, the Cooper library subscribes to all pertinent scientific journals, in both hard copy and electronic format for on-campus and off-campus access, as well as new book release pertinent to the field of Bioengineering. The library acquires new titles as requested by the faculty representative of the Department of Bioengineering to the Libraries.

Accreditation, Approval, Licensure, or Certification

A master of engineering program can also be accredited by ABET Inc. Accreditation provides institutions with a structured mechanism to assess, evaluate, and improve the quality of their program. It helps students and their parents choose quality college programs. Accreditation enables employers to recruit graduates they know are well-prepared. It is also used by

registration, licensure, and certification boards to screen applicants. The proposed graduate program in biomedical engineering has been developed targeting future professional accreditation by ABET. The Bachelor of Science Degree in Bioengineering in the Department of Bioengineering is ABET accredited and faculty members are knowledgeable about requirements needed to secure ABET for a M.Eng. degree. The department will conduct self-study annually as a means of internal assessment in order to plan for accreditation of the M.Eng. in Biomedical Engineering program. The members of the Bioengineering External ABET Advisor Board will meet regularly along with an External Constituency Committee to plan for accreditation.

Articulation

This program will be exclusively taught at Clemson University and its facilities including Clemson University Biomedical Engineering Innovation Campus.

Estimated Costs and Sources of Financing

a) New Costs to the Institution and Sources of Financing

ESTIMATED COSTS BY YEAR						
CATEGORY	**1st**	**2nd**	**3rd**	**4th**	**5th**	**TOTAL**
Program Administration	0	0	0	0	0	0
Faculty Salaries	0	0	0	0	0	0
Graduate Assistants	0	0	0	0	0	0
Clerical/Support Personnel	32,750	32,750	32,750	32,750	32,750	163,750
Supplies and Materials	4,000	4,000	4,000	4,000	4,000	20,000
Library Resources	0	0	0	0	0	0
Equipment	0		0	0	0	0
Facilities	0	0	0	0	0	0
Other (Identify)*	0	0	0	0	0	0
TOTALS	122,750	122,750	122,750	122,750	122,750	613,750
SOURCES OF FINANCING BY YEAR						
CATEGORY	**1st**	**2nd**	**3rd**	**4th**	**5th**	**TOTAL**
Tuition Funding	101,892	135,856	178,311	237,748	314,167	967,974
State Funding*	0	0	0	0	0	0
Reallocation of Existing Funds**	0	0	0	0	0	0
Federal Funding	0	0	0	0	0	0
Other Funding (lab fees)	4,800	5,400	8,400	11,200	14,800	44,600
TOTALS	106,692	141,256	186,711	248,948	328,967	1,012,574

All assumptions for tuition revenue are based on the estimated enrollment in Table 2 (Section 7) using a resident full-time tuition cost of $3,981/student/academic semester and $529/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.

REFERENCES

1. Forbes Magazine. 2012. (http://www.forbes.com/sites/jennagoudreau/2012/05/15/best-top-most-valuable-college-majors-degrees/).
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