

**CLEMSON UNIVERSITY**

**College Of Engineering and Science  
Department of Bioengineering**

**TO THE SOUTH CAROLINA COMMISSION ON HIGHER EDUCATION**

**PROGRAM MODIFICATION PROPOSAL**

**REQUEST APPROVAL TO EXPAND PROGRAMS TO AN  
OFF-CAMPUS TEACHING SITE**

Master of Science Degree in Bioengineering  
Doctor of Philosophy in Bioengineering

Date of Submission: January 15, 2014

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## **Classification**

- a) Program title:
  - Master of Science Degree in Bioengineering
  - Doctor of Philosophy Degree in Bioengineering
- 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):  
M.S. (thesis), M.S. (non-thesis), Ph.D. (all graduate level degrees)
- e) Proposed date of implementation: August 15, 2014
- f) Current CIP code of the program to be modified: 140501
- g) Site: Expand our delivery of courses in the MS/PhD in Bioengineering to CUBEInC – Clemson University Biomedical Engineering Innovation Campus, 200 Patewood Rd, Suite 400C, Greenville, SC. [We will continue to offer the degree program on our main campus and in Charleston in collaboration with MUSC as previously approved.]
- 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– May 2010
- b) Clemson University Board of Trustees – January 31, 2013

## **Purpose**

- a) Detailed description of the proposed modification:  
We are requesting permission to expand our existing MS/PhD in Bioengineering to the Patewood campus in Greenville, SC. The Clemson University Biomedical Engineering Innovation Center (CUBEInC) is located on the GHS Patewood campus and Clemson faculty and graduate students have been conducting their research on site for a number of years. We would like to expand the number of graduate level courses offered so that a student might obtain 100% of their degree program on site.
- b) Statement of the purpose of the modified program:  
The bioengineering profession works in close partnership with clinical practice. Delivering certain courses in our curriculum in close proximity with clinical

collaborators and facilities can add significant value to the students' educational experience and increase their competitiveness upon graduation.

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 (Figure 1). It consists of 29,615 sq. ft. (4<sup>th</sup> floor of Patewood Building C) (Figure) of newly built state-of-the-art research and laboratory facilities for translational biomedical engineering located above orthopaedic and vascular surgery clinics. The purpose of this proposal is to request permission to offer coursework at the CUBEInC off-campus site to provide students with unique opportunities for a superior education in bioengineering.



Figure 1. Location of CUBEInC in Greenville SC.

- c) Discussion of the objectives of the modified program:  
Clemson University is one of the nation's leading research institutions in medical device technology. It is distinguished by its groundbreaking research and discoveries that have significantly and positively impacted health care delivery and outcomes for the past 50 years. Clemson's bioengineering program began in 1963 with the creation of a Ph.D. program in bioengineering. A master's degree program was added in 1966. The Department has achieved national recognition for the strength of its graduate and research programs, whose primary emphasis is on the study of biomaterials, particularly for cardiovascular and orthopaedic applications and related areas. Clemson University is known as the international birthplace of the field of "biomaterials", building blocks of medical devices. The Society for Biomaterials, the premier professional society in the field of bioengineering began at Clemson in 1974. In 2013, Clemson University ranked 35 in the top private and public biomedical/bioengineering graduate programs in the United States (US News and World Report, 2013). During the past year, research laboratories have been equipped and research programs that focus on clinical translational research have been developed at CUBEInC. With utilization of the research space, it was rapidly recognized that its location and access to clinicians and medical device industry also present important opportunities for enriching the educational experience of bioengineering graduate students such as facilitating guest lectures from local clinicians and entrepreneurs, as well as site visits to clinical facilities. The delivery

of several available bioengineering courses will be enhanced by the proximity to research facilities existing at CUBEInC.

## Justification

- a) Need and rationale for the proposed modification:  
This location provides access to clinicians and healthcare practitioners at the Greenville Health System for collaboration and mentoring of graduate students. The bioengineering profession works in close partnership with clinical practice. Delivering certain courses in our curriculum in close proximity with clinical collaborators and facilities can add significant value to the students' educational experience and increase their competitiveness upon graduation.
- b) Centrality of the modified 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. CUBEInC is a new state-of-the-art facility primarily dedicated to biomedical technology research and economic development and emphasizes the mission of the institution.

## Enrollment

- a) *Impact of the proposed modification on student enrollment;*  
Offering courses within this program at CUBEInC will provide increased accessibility to non-traditional students working full time in the medical device industry. As new faculty members have been hired with laboratories located at CUBEInC, the number of graduate students working full-time at CUBEInC has been rapidly expanding.
- b) *Estimated New Enrollment table showing the estimated **new** student enrollment by headcount and credit hours generated (Table H). The table must represent **only new enrollments** at the institution resulting from the proposed modification (i.e., students already enrolled at the institution who transfer to the program must be excluded).*

<b>Table H: ESTIMATED NEW ENROLLMENT</b>						
<b>YEAR</b>	<b>FALL</b>		<b>SPRING</b>		<b>SUMMER</b>	
	Headcount	Credit Hours	Headcount	Credit Hours	Headcount	Credit Hours
2014 – 15	10	120	10	120	10	120
2015 – 16	15	180	15	180	15	180
2016 – 17	18	216	18	216	18	216
2017 – 18	22	264	22	264	22	264
2018 – 19	25	300	25	300	25	300

**Curriculum**

*a) a discussion of curricular changes required for the proposed modification; and*

No curricular changes are required for the proposed modification. The admission standards remain the same, and there are no changes in the core requirements for graduation.

**Degree Program for Master of Science**

The curriculum for the M.S. degree in bioengineering is designed around two basic options: a thesis option requiring formal research, and a non-thesis option that concentrates on course work but requires a report. The final defense for the non-thesis option will cover the student's entire course work reflecting this emphasis on courses. The report will usually take the form of an in-depth literature survey or a detailed analysis of a sub-topic within the field of bioengineering.

General requirements for both options are:

1. The student must spend at least one academic semester in residence.
2. The usual minimum time period necessary to complete all requirements is 18 months.
3. The student must successfully present and defend a thesis or report in an oral comprehensive examination, which will be open to the public.

Requirements specific to the thesis option are:

1. The student must successfully complete a minimum of 30 semester hours, which include six semester hours of research, which will provide the basis for a thesis.
2. The student must submit an approved thesis to the Graduate Dean at least one week before the end of the semester in which the degree is expected.

Requirements specific to the non-thesis option are:

1. The student must successfully complete a minimum of 33 semester hours which include six semester hours of non-thesis research, special topics, or internship at an approved external institution.
2. The student is required to prepare a report whose subject will be chosen by the advisor, in cooperation with the student. The report must be comparable in form and quality with technical review articles appearing in peer reviewed journals and with approval by the advisory committee.

#### Degree Program for the Doctor of Philosophy

Direct PhD students: Total of 60 credit hours composed of 36 course credit hours; up to 6 credit hours of graduate BioE Seminar (BioE 8000) and 18 credit hours of doctoral research (BioE 9910). This includes 10-12 credits hours of required and core courses and 26-31 credit hours of elective courses as selected in consultation with research advisor or as per suggestion of PhD dissertation committee members.

PhD students with MS degrees: Total of 60 credit hours composed of 36 course credit hours; up to 6 credit hours of graduate BioE Seminar (BioE 8000) and 18 credit hours of doctoral research (BioE 9910). Students may transfer up to 24 graduate level course credit hours to replace either core or elective bioengineering courses. The student's research advisor and/or the Chair will approve transfer of credits based on demonstrated equivalent course content and bioengineering context, and satisfactory student performance in the transferred course (minimum of 'B' grade or higher required). All transfer courses must also be approved by Graduate School and the faculty.

The core consists of the following required courses:

BIOE 6150 - Research Principles

BIOE 8000 – Seminar in Bioengineering

BIOE 8010 - Biomaterials

BIOE 8460 – Biomedical Basis for Engineering Replacements

One of the following Three Courses

BIOE 8200 – Structural Biomechanics

BIOE 8470 - Transport Processes in Bioengineering

BIOE 8700 - Bioinstrumentation

- b) *a list of **all new courses** with catalog type descriptions that are to be added to the institution's course catalog as a result of the modification within three years for associate degree programs or five years for all other degree programs. New courses must be clearly identified as such.*

No new courses are planned to be added to the catalog as a result.

#### 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).

## Physical Plant

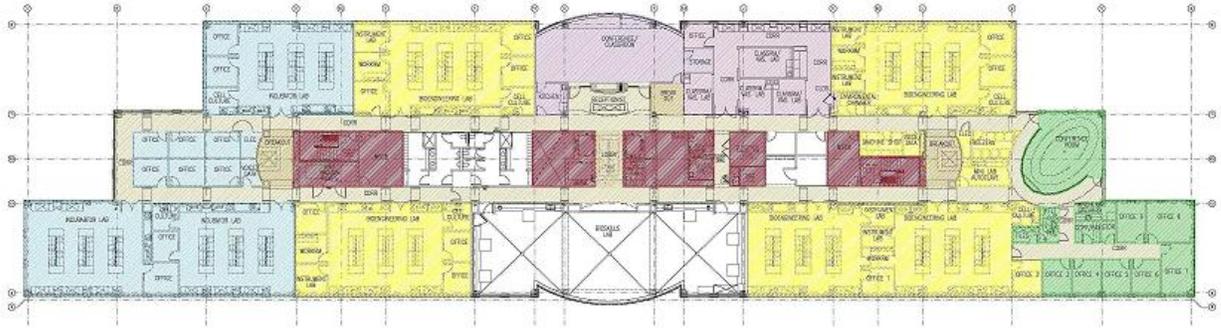
a) *Explanation of the proposed modification's effect on the physical plant's ability to support the program:*

Strategically located above three floors occupied by clinical vascular/cardiovascular surgery and orthopaedic surgery, 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. This program is aimed at providing 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. This strategic expansion that will clearly position Clemson University and the State of South Carolina as national leaders in translational medical research includes multi-investigator research laboratories supplemented by clinical and industrial participation. Research conducted through this initiative results in a large number of innovations in the practice of medicine and enhances patient-oriented outcomes while stimulating economic growth in the State through entrepreneurship. Targeted research areas include cardiovascular science and engineering, orthopaedic performance and biomechanics, regenerative medicine, tissue engineering, advanced surgical technologies, and drug development among others. CUBEInC integrates education, research and economic development in medical technology. Overall, it is aimed at providing the essential environment to faculty and students at Clemson University to further the development of clinically relevant technology to improve patient care delivery and disease diagnosis in collaboration with health care practitioners.

The 29,615 sq. ft. research and education CUBEInC facilities (figure 2) consist of:

- research laboratories (wet labs) of approximately 1200 square feet each (figure 3)
- support labs adjacent to each research lab (approximately 400 square feet)
- office space for researchers, students and post-docs adjacent to labs
- shared facilities for freezers, machine shop, microscopy, histology, and material processing
- surgical skills facilities and conference center (~5,000 sq. ft.) (figure 4)
- conference and teaching rooms (1500 sq. ft.)

Figure 2. Floor plan of the 29,615 sq. ft. research and education CUBEInC facility.



The maintenance and upgrade of CUBEInC facilities including service contracts for equipment, equipment certification and validation, and computer and software upgrade used by the bioengineering program are the responsibility of the department of bioengineering. A budget line item is dedicated annually for maintenance and upgrade. TAs, technical staff, and instructors conduct routine checks and report issues to an assigned administrative assistant who takes immediate actions. Substantial teaching-laboratory-equipment check and space remodeling if needed are conducted in the summer between academic semesters.



Figure 3. Research and teaching laboratory at CUBEInC



Figure 4. Bioskills and surgery training laboratory.

## **Equipment**

Specialized equipment has been acquired for the laboratories to be established for the program. Cell culture facility for tissue engineering and cell-material interactions (\$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. Laboratories were developed and equipped when the facilities were up-fitted and completed in December 2011. Full operation of the site with equipment purchase (including service maintenance contract) occurred in June 2012.

## **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 at CUBEInC. 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. CUBEInC is linked through Clemson University through broadband internet access.

## **Accreditation, Approval, Licensure, or Certification**

There is no impact on the current graduate programs.

## **Estimated Costs and Sources of Financing**

Recurring funding for each program in the College of Engineering and Science is allocated in broad categories using a –block funding model. Salary for regular faculty and staff are 100% funded in the salary funding block. Funds for teaching assistants and graders are allocated in a graduate block. Additional recurring funds are allocated in travel, a miscellaneous category, laboratory fees, and research infrastructure support (RIS) funds (returned from the Vice-President for Research). Laboratory fees and RIS funds are recurring, but the allocated amounts vary over time. Once these funds are transferred to the program, the budget is managed by the Department Chair. One-time funds may be derived from Instructional infrastructure improvement/renovation funded from the Provost's office. Requests from the programs are prioritized at the College level, and these requests managed by the Director of Instructional and Research Support. Activities conducted at CUBEInC are supported by the department of bioengineering and the Vice-President for Research office. The latter supports the maintenance and utilities of CUBEInC physical space through a memorandum of understanding with the Greenville Health System. Lab fees paid for class instruction by the students who will be enrolled in courses taught at CUBEInC will be used to provide the necessary supplies for those courses. The university provides a commuter service operated by Greenlink through an agreement with the City of Greenville Transportation System between main campus (Clemson SC) and CU-ICAR campus in Greenville and a connector service to CUBEInC.

An amount of \$75,000 has been estimated for supplies, equipment licenses, and transportation with a 5% yearly increase. No new equipment will be needed. However, service contract for the existing equipment to be used for teaching purposes is accounted as new cost under equipment. The total budget of the department of bioengineering including E&G funds, self-generated revenues, endowments, lab fee, etc., exceeds \$5M. Pending on site approval for teaching, an administrative assistant (band 5) will be located at CUBEInC to ensure that course and student needs are met. There is no anticipated new cost (Table I) in delivering these courses at CUBEInC rather than at the Clemson University main campus as the site is already functional and used for academic activities and existing bioengineering faculty members will deliver the courses at CUBEInC. Maintaining the videoconferencing capabilities for course purposes will require additional cost for service maintenance on a regular basis.

a) Table I - New Costs to the Institution and Sources of Financing

<b>Table I: ESTIMATED COSTS BY YEAR</b>						
<b>CATEGORY</b>	<b>1<sup>st</sup></b>	<b>2<sup>nd</sup></b>	<b>3<sup>rd</sup></b>	<b>4<sup>th</sup></b>	<b>5<sup>th</sup></b>	<b>TOTAL</b>
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	58,000	58,000	58,000	58,000	58,000	290,000
Supplies and Materials	75,000	78,750	82,687	86,822	91,163	414,422
Library Resources	0	0	0	0	0	0
Equipment	23,000	23,000	23,000	23,000	23,000	115,000
Facilities	10,000	10,000	10,000	10,000	10,000	50,000
Other (Identify)*	0	0	0	0	0	0
<b>TOTALS</b>	166,000	169,750	173,687	177,822	182,163	869,422
<b>SOURCES OF FINANCING BY YEAR</b>						
<b>CATEGORY</b>	<b>1<sup>st</sup></b>	<b>2<sup>nd</sup></b>	<b>3<sup>rd</sup></b>	<b>4<sup>th</sup></b>	<b>5<sup>th</sup></b>	<b>TOTAL</b>
Tuition Funding	119,430	179,145	214,974	262,746	298,575	1,074,870
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
<b>TOTALS</b>	119,430	184,545	223,374	273,946	313,375	1,119,470

\*Special legislative appropriations to support the program.

\*\*Specify significant internal sources of reallocated funds. Add additional rows as necessary.

All assumptions for tuition revenue are based on the estimated enrollment in Table H (Section 6) using a resident full-time tuition cost of \$3,981/student/academic semester. No unique cost

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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.