UNIVERSITY OF DELAWARE

DOCTORATE PROGRAM IN BIOMEDICAL ENGINEERING

ACADEMIC PROGRAM APPLICATION

November 2011

PROGRAM POLICY STATEMENT CONTENTS

I. Program History
A. Rationale

This is a proposal for a new PhD degree in Biomedical Engineering to be offered in the College of Engineering as part of the Biomedical Engineering Program.

Biomedical Engineering is an emerging and rapidly expanding field where engineering and biological disciplines converge. According to the National Institutes of Health, Biomedical Engineering is defined as follows:
"Biomedical Engineering integrates physical, chemical, mathematical, and computational sciences and engineering principles to study biology, medicine, behavior and health. It advances fundamental concepts, creates knowledge from the molecular to the organ systems levels, and develops innovative biologies, materials, processes, implants, devices, and informatics approaches for the prevention, diagnosis, and treatment of disease, for patient rehabilitation, and for improving health." - From www.nibib.nih.gov

The outlook for biomedical engineers is incredibly promising. In May 2010, the Bureau of Labor Statistics identified Biomedical Engineering as the fastest-growing occupational field, with jobs over the next decade being expected to grow by 72%. Major categories of employment include medical equipment and supplies manufacturing, scientific research and development, and pharmaceutical and drug manufacturing.

We propose to offer a *PhD in Biomedical Engineering* to train the next generation of researchers and professionals who will play a key role in multi- and interdisciplinary teams that bridge the gap between engineering and the biological sciences. This PhD program will build upon the successful foundation of the undergraduate degree program in Biomedical Engineering. It will be built on a first year core curriculum with advanced curricula that are based on the research the student will perform for the thesis.

Due to the interdisciplinary nature of Biomedical Engineering, faculty at the University of Delaware that are affiliated with this field are currently housed in the College of Engineering and the College of Arts and Sciences and may eventually expand to reside in other colleges. The students will identify a Faculty Advisor from among these Biomedical Engineering-affiliated faculty who will be responsible for defining the student's research responsibilities and for evaluating the student's performance. The PhD degree will be administered by the Biomedical Engineering Program and will be awarded by the College of Engineering.

This multi-disciplinary graduate program will build upon the established biomedical research strength at the University of Delaware, largely within the College of Engineering. There are currently 44 affiliated faculty within the Biomedical Engineering Program from multiple departments. Up until now, students interested in biomedical research have had to enroll in various programs and departments not designed for Biomedical Engineering-specific training to pursue their interests. The Biomedical Engineering PhD program will provide a home for these students. This PhD program will enhance graduate student recruitment to UD and will help to attract and retain talented faculty in various areas, including engineering and the biological sciences. It will offer academic rigor, as well as flexibility, to meet the needs and interests of students from different backgrounds and of their faculty advisors from

different research areas. This program will also provide a foundation for educational funding and training grant opportunities.

Since most of the highest-ranked engineering colleges in the U.S. have a Biomedical Engineering graduate program, adding this program to UD is critical to UD's *Path to Prominence*. It will offer graduate education in a discipline essential for UD as a major research university, providing a critical component to the University's strategic priorities in life and health sciences. It will also align with the University's strategic plan to "*engage closely with the critical issues of our day, to increase the global impact of the University, and to raise its prominence in the world*." Its overall measure of success will be the placement of students in the biomedical workforce or in research careers.

B. Date of Permanent Status
This program will begin in fall of 2012, with an intended initial PhD class size of 2-6 students. We expect it to expand as resources become available.

C. Degrees Offered
The Biomedical Engineering program will offer a Doctor of Philosophy Degree (PhD) in the College of Engineering.

II. Admission
A. Admission Requirements
Admission to the graduate program is competitive. Those who meet stated requirements are not guaranteed admission, and those who fail to meet all of those requirements are not necessarily precluded from admission if they offer other appropriate strengths.

Applicants to the PhD program in Biomedical Engineering (BME) should meet the following requirements:

- A bachelor's degree or higher in engineering, physical, or biological sciences from an accredited 4-year college or university with a minimum cumulative GPA of 3.2 on a 4.0 scale.
- Completed coursework that includes 1 year of calculus-based physics, 1 year of biology, 1 semester of physiology, 1 semester of organic chemistry, and calculus through differential equations. Some of these courses may be completed after admittance, but they should be completed by the end of the first year and they will not count toward the graduate degree.
- Competitive GRE scores of 700 for Quantitative and 1200 or higher for Quantitative + Verbal. With the new GRE scoring system, this corresponds to a score of 155 for Quantitative, 153 for Verbal, and 308 or higher for Quantitative + Verbal.
- For international applicants, a TOEFL exam taken within the last 2 years with a minimum score of 240 for CTOEFL and of 100 for the iBT with a 22 for the iBT speaking component.
- Three letters of recommendation from individuals acquainted with the student and his/her academic work or from employers or others who have had a supervisory relationship with the applicant and are able to assess the applicant's potential for success in graduate studies.
- A personal statement (1 page) that indicates:
    - the reason for his/her interest in graduate study
    - a discussion of previous research experience
    - his/her area of interest and a list of faculty whose research area is of interest
    - his/her career objectives
- Official, up-to-date transcripts of all undergraduate and graduate programs.

We encourage candidates with research experience (undergraduate as well as industrial), as well as those with practical industrial experience after the baccalaureate degree to apply.

B. Application Deadlines
Admission decisions are made by the Biomedical Engineering Graduate Committee (BME GC). Initial decisions on applicants will begin on January 15th of the year of desired fall matriculation and will continue on a rolling admissions basis.

To be considered for financial aid, a complete application must be submitted no later than January 9 for matriculation in the fall semester. Decisions on whether to accept offers of admission with financial aid must be made by April 15 for matriculation in the fall semester. Regular applications must be submitted by July 1 for matriculation in the fall semester, by December 1 for the spring semester, and by April 1 for the summer session. Regular applications are generally without financial aid, although aid may be provided at the discretion of the BME GC.

C. Admission Categories
Students may be admitted into the PhD program in BME with regular or provisional status.
Regular. Regular status is offered to students who meet all of the established entrance requirements, who have a record of high scholarship in their fields of specialization, and who have the ability, interest, and maturity necessary for successful study at the graduate level in a degree program.
Provisional. Provisional status is offered to students who are seeking admission to the degree program but lack one or more of the specified prerequisites. All provisional requirements must be met before regular status can be granted and before the Qualifying Exam can be taken. Students admitted with provisional status are generally not eligible for assistantships or fellowships. Students who file an application during the final year of undergraduate or current graduate work and are unable to supply complete official transcripts showing the conferral of the degree will be admitted pending conferral of the degree if their records are otherwise satisfactory and complete.

D. Change of Classification
Students that are currently matriculated in other degree programs within the University of Delaware should complete a "Change of Classification" Form to seek approval to be admitted into the BME Program. The BME GC will evaluate the change in classification requests on a case-by case basis to determine if the applicant will need to complete a full application form to submit to the Office of Graduate and Professional Education.

III. Academic

A. Degree Course Requirements
The proposed graduate program has been carefully tailored by studying the Biomedical Engineering graduate curricula offered at select, prominent research universities. The table below lists the course requirements for a PhD degree in Biomedical Engineering.

PhD requirements in Biomedical Engineering: 39 credits total	
5 Core courses	
Principles of Biomedical Engineering (2 courses)	6 credits
Advanced Math	3 credits
Statistics	3 credits
Communication and Ethics	3 credits
4 Elective courses (minimum)	12 credits

Research	3 credits minimum
Dissertation	9 credits minimum
Seminar series (3 semesters)	0 credits

B. Course Curriculum

Core Courses (15 credits)	
Principles of Biomedical Engineering (6 credits)	BMEG 605 Principles of Biomedical Engineering I: Molecular and cellular systems BMEG 606 Principles of Biomedical Engineering II: Tissue and organ systems (allow BISC 606 Physiology as a substitute)
Advanced Math (3 credits) Choose 1	MATH 607 Survey of Scientific Computing MATH 616 Introductions to Applied Mathematics I
Statistics (3 credits) Choose 1	BISC 643 Biological data analysis STAT 608 Statistical research methods
Communication and Ethics (3 credits)	BMEG 801 Communication and Ethics in Biomedical Engineering

Elective Courses (12 credits minimum, choose 4 minimum)	
BISC 602	Molecular Biology of Animal Cells
BISC 605	Advanced Mammalian Physiology
BISC 612	Advanced Cell Biology
BISC 625	Cancer Biology
BISC 626	Advanced Neuroanatomy
BISC 627	Advanced Neurophysiology
BISC 639	Developmental Neurobiology
BISC 660	Environmental Physiology
BISC 671	Cellular and Molecular Immunology
BISC 675	Cardiovascular Physiology
BISC 806	Advances in Cell and Organ Systems
CHEG 620	Biochemical Engineering
CHEG 621	Metabolic Engineering
CHEG/CHEM 649	Molecular Biophysics
CHEG 650	Biomedical Engineering
CHEG 801	Process Control and Dynamics
CHEG 825	Chemical Engineering Thermodynamics
CHEG 827	Chemical Engineering Problems
CHEG 828	Statistical Thermodynamics
CHEG 842	Selected Topics in Biochemical Engineering
CHEG 845	Advanced Transport Phenomena
CHEM 641	Biochemistry
CHEM 642	Biochemistry

CHEM 643	Intermediary Metabolism
CHEM 645	Protein Structure and Function
CHEM 646	DNA-Protein Interactions
CHEM 647	Biochemical Evolution
CHEM 648	Membrane Biochemistry
CISC 642	Intro to Computer Vision
CISC 681	Artificial Intelligence
CISC/BINF 689	Topics: Artificial Intelligence
CISC/BINF 849	Advanced Topics in Computer Applications
CISC 852	Computer Network Performance
CISC 887	Internet Information Gathering
ELEG 630	Information theory
ELEG 631	Digital signal processing
ELEG 636	Statistical signal processing
ELEG 671	Mathematical Physiology
ELEG 675	Image processing with biomedical applications
ELEG 679	Intro to medical imaging systems
ELEG 680	Immunology for engineers
ELEG 801	Advanced topics in biomedical engineering
MATH 529	Fundamentals of Optimization
MATH 611	Introduction to Numerical Discretization
MATH 617	Introductions to Applied Mathematics II
MATH 630	Probability Theory and Applications
MATH 660	Intro to Systems Biology
MEEG 612	Biomechanics of human movement
MEEG 624	Control of dynamic systems
MEEG 682	Clinical biomechanics
MEEG 683	Orthopedic biomechanics
MEEG 684	Biomaterials and tissue engineering
MEEG 685	Control of human movement
MEEG 686	Cell and tissue transport
MEEG 862	Advanced Engineering Analysis
MSEG/CHEG 601	Structure and Properties of Polymer Materials
MSEG 625	Entrepreneurship and risk: meeting the challenges
MSEG 630/CHEG 600	Introduction to Polymer Science and Engineering
MSEG 633/833	Polymer Synthesis and Characterization Laboratory
MSEG 635/835	Principles of Polymer Physics
MSEG 660	Biomaterials and Tissue engineering
MSEG 803	Equilibria in Materials Systems
MSEG 804	Kinetics in Materials Systems
MSEG 817	Composite Materials
MSEG/CHEG 823	TEM in Materials Science
MSEG 832	Principles of Polymerization
STAT 609	Regression and Experimental Design

Courses not on the above Elective list can be substituted with permission of the Faculty Advisor and the Graduate Director. This list will be updated and provided on the program website annually.

Other Courses (12 credits minimum)	
Research (3 credits minimum)	BMEG 868 Research
Dissertation (9 credits maximum)	BMEG 969 Doctoral Dissertation
Seminar series (0 credits)	BMEG 890 Seminar

Description of new BMEG courses:

BMEG 605: Principles of Biomedical Engineering I: Molecular and cellular systems (3)
The goal of this two-semester sequence is to develop a firm foundation for and fundamental knowledge of Biomedical Engineering with a multi-scale approach. The first course introduces fundamental concepts of molecular and cellular physiology, applies quantitative engineering analysis to physiology at this length scale, and teaches students to think critically about the physiology and cell biology literature. PREREQ: General Physiology (e.g., BISC 306)

BMEG 606: Principles of Biomedical Engineering II: Tissue and organ systems (3)
The goal of this two-semester sequence is to develop a firm foundation for and fundamental knowledge of Biomedical Engineering with a multi-scale approach. The second course introduces fundamental concepts of tissue and organ physiology, applies quantitative engineering analysis to physiology at this length scale, and teaches students to think critically about the organ function literature, such as musculoskeletal, cardiovascular, pulmonary, and nervous systems. PREREQ: General Physiology (e.g., BISC 306)

BMEG 801: Communication and ethics in Biomedical Engineering (3)
This course will cover communication methods for professional development such as written and oral presentations. Emphasis will be placed on topics such as preparing proposals, journal papers, and dissertations. Proposal preparation will include topics such as selecting a research topic, reviewing the literature, generating hypotheses, and writing study designs. Issues of authorship, peer review, plagiarism, recordkeeping, patents, technology transfer, conflicts of interest, and copyright will be addressed.

C. Committees and Director

C.1 BME Graduate Committee (BME GC)

This committee consists of at least 5 BME-affiliated faculty generally representing each department with BME-affiliated faculty. It is responsible for 1) reviewing applications, 2) recommending student visits and admissions, 3) matching students to an advisor, 4) developing and approving the curriculum, 5) reviewing annual Progress Reports, 6) assigning Qualifying Exam committee, 7) reviewing and approving Dissertation Committee members and chair, 8) dealing with petitions for course substitutions, and 9) dealing with petitions for the extension of Candidacy and Dissertation Defenses.

Current BME Graduate Committee:

Member	College	Department
Elliott, Dawn (Interim Graduate Director)	Engineering	Biomedical Engineering
Buchanan, Thomas	Engineering	Mechanical Engineering
Jia, Xinqiao	Engineering	Materials Science Engineering
Kambhamettu, Chandra	Engineering	Computer and Information Systems
Lenhoff, Abraham	Engineering	Chemical Engineering
Mirotznik, Mark	Engineering	Electrical and Computer Engineering
Nohe, Anja	Arts and Sciences	Biological Sciences

C.2 Graduate Director

The BME Associate Director for Graduate Studies chairs the BME GC and is called the Graduate Director. He/she will be responsible for the overall implementation, quality and progress of the degree program, advised by the BME GC. He/she will also act as advisor to the student during the first semester until the student has a Faculty Advisor. At the end of the PhD program, he/she will approve the application for the degree upon verifying that the student has successfully completed the requirements. This position will have a three-year renewable term. The Graduate Director may appoint a coordinator to provide day-to-day program management and to assist with student recruitment, admission, advising, and progress assessment.

D. Satisfactory Progress

D.1 Faculty Advisor

Students will be matched to a Faculty Advisor from a list of Biomedical Engineering-affiliated faculty members participating in the degree program. For the first 2 months following fall matriculation, the student will be advised by the Graduate Director (unless a direct match to an advisor is made during the admission process). The student will be responsible for identifying potential faculty advisors by meeting with faculty in early September, attending faculty presentations in BMEG 801, and attending research group meetings. By Oct 15th students must submit a ranked list that contains at least 3 potential advisors. Advisors also submit a ranked list of students (blind to student ranking). The Graduate Director will match the student to a Faculty Advisor before the end of October.

The Faculty Advisor will be the primary contact of the student for questions and advice on his/her thesis research throughout the remainder of the program. The student will develop a plan of study for the program with the Faculty Advisor by the end of the second semester of their first year. Any changes to a student's program of study must be approved by the Faculty Advisor and the BME Graduate Director.

D.2 Academic Load
Full-time students are expected to complete the PhD program in 4-6 years. The program may be completed over a longer time frame for part-time students. Students must be enrolled in at least 9 credit hours or in sustaining credit to be considered full-time students. Those enrolled for fewer than 9 credit hours are considered part-time students, although students holding assistantships are considered full-time with six credits. Students are expected to take 9 credit hours of course work for the first semester in order to be funded. All graduate students are expected to register for research credits during the summer term but not the winter term. Generally, a maximum load is 12 graduate credit hours in spring and fall; however, additional credit hours may be taken with the approval of the student's adviser and the Office of Graduate and Professional Education.

D.3 Transferability
If the student has a Master's degree, he/she can petition to substitute research credits (BMEG 868) or elective course credits for a maximum of 3 of the 5 required core courses. Both the Faculty Advisor and the BME Graduate Director must approve petitions for course substitution.

D.4 Annual Progress Report
The student's progress toward his/her PhD will be monitored annually by the BME GC. Before July 1st each year, the student must submit a Progress Report Form (see Appendix III) to the Graduate Director that is signed by the Faculty Advisor. This form includes a checklist of course requirements, research accomplishments, self assessment, advisor feedback, and verifications that annual Dissertation Committee meetings are occurring.

D.5 PhD Requirements
PhD students must complete 27 credit hours of course work, plus at least 3 credit hours of research (BMEG 868) and 9 credit hours of dissertation research (BMEG 969). They must also attend 3 semesters of a seminar series (BMEG 890). Specific course requirements are described above in Section III B, Course Curriculum. PhD students must also complete the PhD Candidacy requirements (D.5a-d) and a Dissertation Exam with a written dissertation and an oral defense (D.5e).

To qualify to be a PhD candidate, students must complete the following:
a. Complete a one semester **Teaching Aid Requirement**
b. Pass the **Qualifying Exam**
c. Establish a **Dissertation Committee**
d. Present a **Candidacy Defense**

D.5a Teaching Aid Requirement
The ability to communicate ideas, concepts, and factual information is an essential skill for all PhD graduates, even those who have no interest in an academic position. In recognition of this, all PhD students are required to fulfill a Teaching Aid Requirement for 1 semester that consists of serving as a Teaching Aid. Note that this is different from the Teaching Assistantship described as financial aid in Section IVA. While fulfilling this Teaching Aid Requirement, students are expected to continue being actively involved in their research.

The responsibilities of the Teaching Aid Requirement will be defined by the course instructor and should not exceed approximately 10 hours per week. In general, the PhD student should not merely be assigned grading responsibilities. He/she should have an opportunity to plan and deliver lectures, lead discussion sections and lead laboratory exercises. Direct interaction with course students is highly encouraged.

The University requires that all first time Teaching Aids take a 2-day TA teaching conference offered by the Center for Teaching and Learning. International students must also enroll in the winter session of the ELIITA (English Language Institute International Teaching Assistant) program before performing their teaching requirement.

Although the exact timing of these appointments is flexible, it is highly desirable to complete all teaching responsibilities during the 2nd year, although they can extend to the 3rd year. The BME GC assigns these positions in November (for the upcoming spring semester) and in May (for the following fall). Students are encouraged to submit their preferences for specific positions early to facilitate the process. Although every effort will be made to satisfy these requests, students should recognize that this is not always possible.

D.5b Qualifying Exam

The Qualifying Exam must be taken in the summer after the first year (and after completion of at least 5 approved courses with a cumulative GPA of 3.00 or better). For students with non-fall matriculation or part-time study, the timing of this exam will be set based on course completion and approval by the Graduate Director.

This exam has a written proposal and an oral presentation of the proposal. The student will have 2 weeks to prepare a 6-page maximum research proposal (on a topic suggested by the advisor) that 1) identifies a research question, 2) formulates testable hypotheses and aims, and 3) describes a study design that addresses these aims. **Note: This proposal is NOT their thesis proposal, although the advisor can select an area within the likely general topic of the eventual thesis. The student will give a 15 min oral presentation to and will be questioned by a small committee of 3 BME faculty members chosen by the BME GC. The student will be evaluated on his/her bioscience knowledge, engineering knowledge, written proposal, presentation, and quality of the Q&A. The outcome will be Pass, Conditional Pass, or Fail. With a Conditional Pass, the student must address the specific concerns within a period designated by the committee that cannot be more than 1 year (e.g., take certain courses, revise the proposal in a specific manner). If the conditional pass terms are not met or if the student fails, he/she will be dis-enrolled from the PhD program.

D.5c Dissertation Committee

Within 2 years of the Qualifying Exam, the student must establish a Dissertation Committee. The Dissertation Committee is selected by the Faculty Advisor and the student, and must have a minimum of 4 members that include the advisor and at least 3 additional faculty. Of these 3 additional faculty, 2 must be BME-affiliated faculty and 1 must be from outside the BME-affiliated faculty and may be from outside the University of Delaware. One must also be from outside the primary research area of the thesis topic. The Graduate Director must approve the committee and chair, and any subsequent changes in committee members.

D.5d Candidacy Defense

The Candidacy Defense requires a written proposal outlining the plan of research for the PhD and an oral presentation and defense of this proposal to the Dissertation Committee. The written proposal will follow a NIH R01 format, with a page limit of 15 pages. A curriculum vita, Progress Report Form (see Section III D.4) and a graduate-level transcript should also be included. All materials should be distributed to the Dissertation Committee at least 2 weeks before the oral defense. The defense will include a 30 min presentation by the student, followed by a 60 min Q&A discussion. The student must complete the Candidacy Defense within 2 years of the Qualifying Exam or must petition for an extension.

Once the student has completed D.5a-d, he/she may be certified as a candidate for the PhD by the Office of Graduate Studies.

D.5e Dissertation Exam

The Dissertation Exam involves approval of the written dissertation and an oral defense of the dissertation. The written dissertation must be submitted to his/her Dissertation Committee at least 2 weeks before the defense. The oral presentation will be open to the public and will last about an hour. After questions from the public, a closed Q&A session will follow. The student will be responsible for making corrections to the dissertation document and for meeting all Graduate School deadlines for submission. Student must complete the Dissertation Exam within 5 years of the Qualifying Exam (6 years after matriculation) or must petition for an extension.

D.6 Grade Requirements

Only graduate courses completed with a grade of B- or higher will count towards the requirements of the BME program. Students must maintain at least a 3.0 cumulative grade point average in the courses in the curriculum to receive the degree. If student does not achieve a B- or higher in a core course, he/she must retake the course (or any of the optional core courses in that category), and if the retake is below a B-, the student will be recommended for dismissal. If student achieves lower than a B- on an elective course, he/she can retake the course or replace it with another elective course. University of Delaware has a No Replacement policy so both grades of a repeated course are included in the cumulative GPA and the University requires that this GPA must be over 3.0. However, the cumulative GPA for the courses that lead to the PhD degree only use the higher grade of the repeated course.

D.7 Consequences of Unsatisfactory Progress

The BME GC will meet at least once each year to evaluate each student's progress. To monitor this progress, the student must annually submit a Progress Report Form to the Graduate Director before July 1. If the student does not complete a Progress Report, fall registration is cancelled and funding is stopped until it has been completed. If the student is failing to make satisfactory progress towards a degree, the committee will recommend suitable action to the BME Graduate Director. Possible actions include (but are not limited to): (i) requirement for additional courses, (ii) suspension of financial support, and (iii) recommendation for dismissal.

D.8 Standards of Student Conduct

All graduate students are subject to University of Delaware regulations regarding academic honesty. Violations of the UD regulations regarding academic honesty or other forms of gross misconduct may result in immediate dismissal from the Program.

D.9 Dismissal

The procedures for dismissal as detailed in the University Catalog will be followed. Briefly, the BME GC will report its recommendation and reason for dismissal to the BME Graduate Director. He/she will make a recommendation to the Office of Graduate Studies, who will decide whether to dismiss the student. The student may appeal this decision to the Office of Graduate Studies, following the procedure given in the University Catalog.

D.10 Graduate Student Grievance Procedure

Students who feel that they have been graded inappropriately or have received what they perceive as an unfair evaluation by a faculty member may file grievances in accordance with University of Delaware policies. Students are encouraged to contact the Director of the BME Program and/or the Graduate Director prior to filing a formal grievance in an effort to resolve the situation informally.

D.11 Attendance at Conferences and Professional Meetings

The BME program encourages students to attend conferences and professional meetings. They provide opportunities to meet future employers and colleagues, and can offer specialized training beyond course work.

IV. Financial Aid

A. Financial Awards

Financial assistance is awarded on a competitive basis to the pool of admitted applicants. The University of Delaware's policies apply to all forms of financial aid. Please refer to the University Policies for Graduate Student Assistantships and Fellowships.

The majority of students in the BME program will be supported on research contracts and grants obtained by their Faculty Advisors. Students on projects without external funding will be provided support (assuming that their progress is satisfactory) through the use of either other program funds or by appointment as a teaching assistant. No student will be supported by departmental funds for more than 2 semesters; funds beyond such a commitment must be provided by the Faculty Advisor or by appointment as a teaching assistant. In general, funding is not guaranteed beyond five years.

Students in the Biomedical Engineering program may be provided Graduate Assistantships:

- **Research Assistants (RAs)** are generally funded by research grants and contracts provided by external funding agencies. Students should be supported as an RA through their Faculty Advisor's research funds once they are matched (beginning in November 1 of the student's matriculating year). RAships provide full tuition and a stipend.
- **Teaching Assistants (TAs)** are offered for graduate students to perform teaching and other instructional activities. Note that this is different from the Teaching Aid Requirement described in Section III D.5a. The amount of service may vary from week to week but the average is usually expected to be 20 hours per week. A TAship provides full tuition and a stipend. In accordance with University of Delaware regulations, TAs must fulfill the requirements detailed in Section III D.5a in order to qualify for this type of assistantships.

B. Continuation of Financial Aid

Students who are awarded financial aid must maintain satisfactory academic progress with satisfactory performance of assistantship duties (see below). Satisfactory academic progress includes maintaining full-time status as detailed in Section III D.2 above, and maintaining the grade requirements detailed in Section III D.6.

The Faculty Advisor will establish the Research Assistant (RA) responsibilities and performance standards. In the event of an unsatisfactory performance by an RA, the Faculty Advisor will notify the BME Graduate Director and the student of the problem in writing. The Advisor will give the student a performance appraisal that lists the specific areas that need improvement and a timeline by which to rectify the situation (typically 1 to 3 months) before the assistantship is terminated.

The director of the course in which the student teaches will establish the Teaching Assistant (TA) responsibilities and performance standards. In the event of an unsatisfactory performance by a TA, the course director will notify the student and the BME Graduate Director in writing detailing the specific areas that need improvement. If the student does not rectify the situation (typically within 2-4 weeks), the BME Graduate Director may recommend termination of the assistantship.

During the student's time in the graduate program, the student must fill out a graduate student contractile responsibility form (GSCRF) to show how he/she is being funded. This may be done once

a year (if funding source is constant) or separately for spring, summer, and fall (if funding source varies). Changes in status from TA to RA or from full time to sustaining require updating with a new form. Once the GSCRF has been approved, a Student Funding Accountability Form (SFAF) must be completed in order to put the student into the payroll system.

V. Implementation and Evaluation

A. Implementation Plan

The PhD program in Biomedical Engineering (BME) is planned for an official start in the Fall semester of 2012. The Biomedical Engineering Graduate Committee will establish policies of its operation and for the program, and it will coordinate with participating departments about course offerings.

Simultaneous with this proposal, Faculty Senate approval will be sought for new or revised courses required for the curriculum, as submitted to the Course Challenge list.

B. Assessment Plan

B.1 Program Objective

The graduate program in BME aims to train the next generation of researchers and professionals who will play a key role in multi-disciplinary teams, bridging engineering, life sciences and medicine. The Doctor of Philosophy degree will prepare students for a biomedical engineering professional career in academics, industry, business, government agencies, or non-profit organizations.

B.2 Curricular Map and Learning Outcomes

This PhD program has 6 major curriculum components:
1) Core courses in BME, Math and Statistics.
2) Communication and Ethics core
3) Electives in Engineering and Life Sciences
4) Seminars in BME
5) Teaching Requirement in BME
6) Thesis Research in BME

The curricular map indicates the following learning outcomes addressed in the curriculum:

- Core competency in BME
- Knowledge of scientific/biomedical ethics
- Advanced knowledge of BME and related disciplines
- Competence in scientific communication
- Independent mentored research experience in BME
- Experience working with interdisciplinary teams, bridging engineering, life sciences and medicine.

	Learning Outcomes					
Curriculum	Core competency in BME	Knowledge of ethics	Advanced knowledge of BME & related disciplines	Independent research experience	Competence in scientific communication	Experience working with interdisciplinary teams
1) Science Core	x		x			
2) Communication & Ethics Core		x			x	
3) Engineering & Life Science Electives			x			
4) Seminar			x			
5) Teaching Requirement					x	x
6) Thesis Research				x	x	x

B.3 Assessment Plan

Program improvement will be an ongoing process. The results of the assessment measures described below will be shared with the Biomedical Engineering Executive and Graduate Committees. The curriculum will be modified as necessary to achieve the goal of producing graduates who apply the knowledge, skills and abilities gained from the PhD program in Biomedical Engineering to their careers.

Objectives	Strategic Activities	Measures	Short-term Outcomes	Long-term Impact
Train students in the science disciplines pertinent to BME	Recruit excellent applicants and matriculate students with credentials similar to those in UD engineering graduate programs	Number and demographic data of student applicants and matriculated students	Retention and time to degree statistics	Students gain employment in BME field
	Course work covering the disciplines related to BME (Core and Electives)	Faculty evaluation of student's progress in course work; Survey Faculty Advisors; Survey graduate students in the program and post-graduation	Course work helps students secure initial employment; Graduates report applying knowledge from courses to work settings	Graduates enjoy long term success in academic or professional careers
Provide training in science/biomedical related ethics and communication	Course work addressing these issues	Survey students on their experiences in these classes; Survey graduates to determine the utility of these classes to their career; Faculty evaluation of student's progress in course work	Graduates report applying knowledge from course to work settings	Graduates enjoy long term success in academic or professional careers
Provide experiential training to prepare students for the expectations of the workplace	Thesis research; Seminars on specialized topics and cutting edge developments; Teaching requirement provides training for giving lectures and presentations	Survey students on their research experiences in their theses; Survey graduates to determine the use of their experiential training in their careers; Faculty Advisor evaluation of dissertation and teaching	Experiential training prepares students for their workplace and helps them secure their first post-graduation position	Graduates enjoy long term success in academic or professional careers