Bioengineering, M.S.Bioe.

COLLEGE OF ENGINEERING (http://engineering.temple.edu)

About the Program

The M.S.Bioe. program offers students graduate-level interdisciplinary education and research opportunities in bioengineering and engineering applications in related healthcare fields. The program offers concentrations in Bioelectronics, Biomaterials, and Biomechanics. Graduates of the program are prepared for careers in industry or may choose to pursue a program of study leading to the Ph.D. degree. The program offers research opportunities in collaboration with faculty in the College of Science and Technology and the School of Medicine.

Time Limit for Degree Completion: 5 years

Campus Location: Main. Students may also take a significant number of required and elective courses at the Health Sciences Center campus.

Full-Time/Part-Time Status: The degree program can be completed on a full- or part-time basis.

Interdisciplinary Study: The program encourages interdisciplinary research with other branches of engineering as well as with various departments of the College of Science and Technology and the School of Medicine.

Areas of Specialization: For each of the three areas of specialization, research includes:

- Bioelectronics — sensor development and image analysis.
- Biomaterials — wear of ultra-high molecular weight polyethylene, polymer chemistry, and interfacial chemistry.
- Biomechanics — computer-aided design of composite biomaterials, mechanical properties of orthopedic implant materials, design of orthopedic implants, and modeling of biomaterial behavior.

Job Prospects: Graduates with the M.S.Bioe. degree are employed in a variety of biomedical industries ranging from device manufacturers to design engineering. Other possibilities include careers in government, either in regulatory agencies or with the U.S. Patent and Trademark Office. Students who complete the M.S.Bioe. degree with a thesis are prepared to enter a doctoral program.

Non-Matriculated Student Policy: Up to 9 credits of graduate Engineering coursework may be taken at Temple University on a non-matriculated basis and subsequently applied to the M.S.Bioe. degree upon admission. If the applicant's undergraduate GPA was less than 3.0, a GPA of 3.25 or better is required on this non-matriculated graduate coursework to receive an admissions exception. Consequently, the Bioengineering Graduate Program Director may encourage those with an undergraduate GPA less than 3.0 to take their first three graduate courses prior to making formal application to the M.S.Bioe. program. (See the relevant Graduate School policies on special admission procedures for non-matriculated students: 02.23.11.03 (http://www.temple.edu/grad/policies/gradpolicies.htm) and 02.24.19 (http://www.temple.edu/grad/policies/gradpolicies.htm).)

Financing Opportunities: Three forms of financial aid are offered to graduate students:

1. Teaching Assistantship (TA): TA awards are made solely by the Department and require the awardee to work 20 hours per week in support of the Department's undergraduate programs. The TA is compensated with a 9-month stipend, a basic health-insurance plan, and 9 credits per term of tuition remission.
2. Research Assistantship (RA): Individual Bioengineering faculty confer RA awards, using their research funds, upon students who appear well-qualified to carry out the research. Typically, this faculty member becomes the RA's Thesis advisor. The RA normally works up to 20 hours per week and is compensated with a stipend, basic health insurance, and tuition remission.
3. Fellowships: These highly competitive University-wide grants are typically awarded only to Ph.D.-program applicants. See the Engineering, Ph.D. program description for details.

Admission Requirements and Deadlines

Application Deadline:

Fall: March 1
Spring: November 1; August 1 international

Applications are processed on a continual basis. Late applications may be considered for admission. Ordinarily, the applicant is informed of an admissions decision within 4 to 6 weeks of receipt of all supporting application documents.

Applicants who plan to matriculate full-time are automatically considered for financial aid awards so no separate application for financial aid is required. To ensure financial aid consideration for the intended term of study, however, applicants should submit a complete application by January 15 (Fall) and August 1 (Spring).
Both admissions and financial aid award decisions originate in the Bioengineering Department. Applicants are encouraged to contact the Bioengineering Graduate Program Director for advice and consultation in the application process.

**APPLY ONLINE to this graduate program.**

**Letters of Reference:**

*Number Required: 3*

*From Whom:* Letters of recommendation should be obtained from college or research faculty who are familiar with the applicant's competency. If the applicant has an established career in engineering, one of the letters should be provided by the applicant's immediate supervisor. If the applicant has been out of school long enough that relevant academic reference letters appear impractical, s/he should contact the Bioengineering Graduate Program Director to obtain a waiver of this admission requirement.

**Coursework Required for Admission Consideration:** Students not adequately prepared for advanced courses may be required to take a number of prerequisites. The Bioengineering Department identifies the needed coursework on a case-by-case basis.

**Bachelor's Degree in Discipline/Related Discipline:** A bachelor's degree in Bioengineering or a related discipline is the preferred prerequisite degree. However, students who have earned a bachelor's degree in a related field are encouraged to apply, with the understanding that remedial preparatory courses may be a pre-condition of admission to the M.S.Bioe. program.

University regulations stipulate that the applicant must have earned a 3.0 grade-point average on a 4.0 scale in her/his undergraduate studies, but admission exceptions are made for a variety of circumstances. (See Graduate School Policy 02.23.11.03 [http://www.temple.edu/grad/policies/gradpolicies.htm].) The Bioengineering Graduate Program Director helps the applicant navigate the admission possibilities, including the "Non-Matriculated Student Policy" option.

**Statement of Goals:** Describe your relevant technical experiences and career goals in one to two pages.

**Standardized Test Scores:**

GRE scores must be no more than 5 years in advance of the application date. (See Graduate School Policy 02.23.12. [http://www.temple.edu/grad/policies/gradpolicies.htm]) Applicants who require a waiver of the GRE should consult the Bioengineering Graduate Program Director concerning the mechanics and consequences of obtaining an exception.

TOEFL score: 79 iBT or 550 PBT minimum. (See Graduate School Policy 02.23.13.01 [http://www.temple.edu/grad/policies/gradpolicies.htm].)

**Resume:** Current resume required.

**Transfer Credit:** Graduate credits taken at an accredited institution prior to matriculation may be transferred into the M.S.Bioe. program. In order to transfer, the courses must be equivalent to courses offered at Temple in the student's area of study and research, and the grades must be "B" or better. The maximum number of credits a student may transfer is 6. (See Graduate School Policy 02.24.21 [http://www.temple.edu/grad/policies/gradpolicies.htm].)

**Test Waivers:** Applicants with two or more years of employment in an engineering profession performing engineering design and analysis may request a waiver of the GRE. Consult with the Bioengineering Graduate Program Director concerning the mechanics and consequences of obtaining an exception.

**Program Requirements**

**General Program Requirements:**

*Number of Credits Required Beyond the Baccalaureate: 30*

Students choose between three tracks:

1. **Thesis Track**, which is intended for full-time students who have a financial aid award and includes 24 s.h. of didactic coursework and 6 s.h. of thesis (ENGR 9996).
2. **Project Track**, which is intended for full-time students who are self-supporting and includes 27 s.h. of didactic coursework and 3 s.h. of project (ENGR 9995).
3. **Coursework Track**, which is intended for self-supporting part-time students and entails 30 s.h. of didactic coursework.

In the first term, the student and Bioengineering Graduate Program Director jointly establish which track the student will follow; in doing this, they initiate the "M.S.Bioe. Plan of Study." The Plan of Study form lists all required courses and suggests an M.S.Bioe. program-requirement execution sequence for the student to follow. This form is used to track the student's progress, and is updated and annotated at least once a year as the student completes the various benchmarks in the program.

If a student's circumstances change, s/he can change tracks by revising the Plan of Study form and obtaining the requisite approval signatures. However, when considering whether to change one's track, the student should note that:
• "Thesis" credits (ENGR 9996) can only be applied toward the Thesis M.S.Bioe. degree program and cannot be applied to either the Project or Coursework Tracks.
• "Project" credits (ENGR 9995) can only be applied toward the Project M.S.Bioe. degree program and cannot be used for either the Coursework or Thesis Tracks.

In all three options, the didactic coursework may include up to, but no more than, 3 s.h. of ENGR 9182 Independent Study I or 3 s.h. of BIOE 9991 Directed Research. Furthermore, students who wish to take graduate coursework in Temple University schools/colleges other than the College of Engineering will need to obtain the appropriate written approvals on their Plan of Study form.

Culminating Events: Depends on the student's choice of track: Thesis, Project, or Coursework.

Thesis Option:
The master's thesis is the culminating event in the Thesis Track and is typically undertaken during the last two successive terms of study. Successful completion requires the following:

1. Thesis Proposal — ENGR 9996 Thesis I (3 s.h.)
   The student assembles a committee of three or more faculty members, including her/his advisor, who is typically a full-time Bioengineering faculty member. The student's Plan of Study should be updated, if necessary, to indicate the advisor's name.
   Under the guidance of the advisor and committee, the student prepares a research proposal and presents her/his proposal in an open College-wide seminar. The student is responsible for scheduling the proposal and posting an announcement at least 10 business days in advance of this seminar. Ordinarily, the proposal seminar is immediately followed by a meeting of the student's advisory committee in which the student is closely questioned about the details and strategy of the proposed research. The proposal is then accepted by the committee, accepted by the committee with revisions, or rejected by the committee.
   The student's advisory committee also jointly determines the letter grade (A-F) for Thesis I at the end of the term. The student must pass Thesis I before registering for Thesis II. If the student fails Thesis I, s/he may either re-register for Thesis I in the next regular term and repeat the entire proposal process (noting that a second failure will result in automatic dismissal from the University) or consider switching to the Project or Coursework Track, with the relevant updating of the Plan of Study form.

2. Thesis Defense — ENGR 9996 Thesis II (3 s.h.)
   The student should register for Thesis II in the term that s/he is prepared to defend the thesis. The thesis document should be prepared in a format compliant with University standards. (See Graduate School Policy 02.26.12.02 [http://www.temple.edu/grad/policies/gradpolicies.htm] ) The student should provide her/his committee with a copy of the completed thesis at least two weeks before the date of the thesis defense. The thesis is scheduled during a regular academic term, including summer terms. It should not be scheduled during study days, final exams, or the breaks between terms. The student should arrange for, and post an announcement of, the thesis defense at least 10 business days in advance of the defense. Furthermore, if the student is to graduate in the same term that s/he defends the thesis, the defense should be scheduled no later than 30 days prior to the end of the term to allow for document revisions in keeping with Graduate School deadlines, as specified at www.temple.edu/dissertationhandbook/deadlines.html.
   The thesis defense is an open College seminar in which the student presents the concepts and results of her/his research. Normally, this presentation is immediately followed by a meeting of the thesis committee, which closely examines the student's research. The committee can accept the thesis as provided, accept the thesis with revisions, or not accept the thesis. If the thesis is accepted, the committee jointly decides on a letter grade for Thesis II. If the thesis is not accepted, but the committee decides to not fail the student:
   a. an "R" grade is assigned to Thesis II;
   b. the student registers in each subsequent term for one credit of ENGR 9991 Directed Research until s/he is again prepared to attempt the defense; and
   c. the entire open-seminar defense procedure described above is carried out in the term that the student is prepared to defend the thesis.

Project Option:
The project is the culminating event in the Project Track. It is normally carried out in the student's last term of study. The student selects an advisor (usually a full-time faculty member in the Bioengineering Department), registers for ENGR 9995 Project, and conducts a one-term research activity under the supervision of the advisor. Near the end of the term, the student prepares a report of her/his findings and presents the study in an open departmental seminar. Both the seminar and the written report are used to determine the student's grade for ENGR 9995. The grade is jointly determined by the advisor and a second grader selected by the Bioengineering Graduate Program Director, as recorded in the Plan of Study.

Coursework Option:
No culminating event is warranted for the Coursework Track.

Contacts

Program Web Address:
http://engineering.temple.edu/bioengineering/grad

Department Information:
Bioengineering Department
BIOE 5301. Biosignals. 3 Credit Hours.
This course offers a deep overview of the signals in the Biomedical fields. Signals are studied in several modalities, including time frame, frequency frame, and statistical frame. A deep analysis of filters and analysis tools is included together with some basic techniques of storing and pattern interpretation techniques. Furthermore, the course gives to the student the necessary knowledge to realize a complete Data Acquisition, Analysis and Logging using LabView as a tool. The laboratory activities include the development of a complete system to do acquisition, analysis, report and logging of data incoming from sensors.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOE 5311. Entrepreneurial Studies in Regenerative Medicine - From Idea to Medical Practice. 3 Credit Hours.
This course provides a practical overview of all stages of development of medical devices in regenerative medicine, from idea to launch of a company and commercialization of the product into international markets to address unmet medical needs. We will review the initial idea, based on an unmet medical need, review issues of intellectual property creation, determination of target markets, pre-clinical and clinical development, and different regulatory pathways leading to product approval and market introduction. We will discuss issues of company formation, financing and management, as well as target markets and avenues towards revenue generation.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOE 5321. Biosensors. 3 Credit Hours.
This course offers an in-depth overview of several sensors used in the Biomedical Fields. The sensors are analyzed from an engineering point of view going from the physical principles to the necessary filtering and linearization studying the characteristics of output signals. The course also gives the student the necessary basis for Data Acquisition using LabView as a tool. The laboratory activities include the connection of sensors, the study of amplification, linearization and interpretation of data.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOE 5333. Applied Biospectroscopy. 3 Credit Hours.
This course introduces the basics of light propagation in tissue and other turbid media, vibrational spectroscopy, absorption and fluorescence, and emerging spectoscopic applications. Emphasis is on applications for assessment of biomolecules, engineered tissues and clinically-relevant analyses including musculoskeletal disease and cancer diagnosis. Multivariate analyses for complex spectral data sets will also be introduced.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
BIOE 5421. Capstone Elective: Bionanotechnology. 3 Credit Hours.
This course is intended for graduate students interested in acquiring knowledge involving nanometer-sized objects frequently utilized within the biomedical sciences and engineering areas. The aim of the class is to introduce fundamental concepts critical in the design, preparation, analysis, and usage of bionanotechnology (or nanobiotechnology) and its multiple bottom-up and top-down approaches. Multiple nanomaterials categories, such as nanoparticles, nanotubes, biomacromolecules, synthetic polymers, and self-assembled structures, will be covered in detail along with their applications.

Department restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOE 5441. Biomechanics. 3 Credit Hours.
Prerequisites: [BIOE 2101 (Engineering Principles of Physiological Systems) with a minimum grade of C-, or BIOE 5737 (Systems Physiology for Engineers) with a minimum grade of B-, or equivalent course] and [BIOE 2312 (Mechanics for Bioengineering I) with a minimum grade of C-, or (ENGR 2331 (Engineering Statics) with a minimum grade of C- and ENGR 2333 (Mechanics of Solids) with a minimum grade of C-), or equivalent course] and [BIOE 3312 (Mechanics for Bioengineering II) with a minimum grade of C-, or ENGR 2332 (Engineering Dynamics) with a minimum grade of C-, or equivalent course]
This course will provide students with an understanding of the mechanics of cells, tissue, and organ systems as well as methods for their analyses. Topics will include motion-actuating, force generating, and load-supporting mechanisms in the musculoskeletal system, as explained from basic engineering principles. We will also cover experimental and analytical approaches to designing load bearing implants and prosthetic devices.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
College Restrictions: Must be enrolled in one of the following Colleges: Engineering
Repeatability: This course may not be repeated for additional credits.

BIOE 5451. Biomedical Imaging. 3 Credit Hours.
This course focuses on principles of diagnostic radiological imaging physics, including X-ray, computed tomography, and nuclear medicine, as well as optical imaging, ultrasound and magnetic resonance imaging modalities. The interaction of these modalities with tissues and detectors to produce useful image contrast will be presented, and students will gain an understanding of the basic physics of image acquisition and algorithms for image generation. Signal and noise characteristics, image quality and image reconstruction algorithms will also be covered. Image processing through MATLAB programming will be covered in class and in assignments.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOE 5461. Principles of Tissue and Regenerative Engineering. 3 Credit Hours.
This course will introduce fundamental concepts of tissue engineering and regenerative medicine, focusing biomaterials used for scaffolds, mechanisms of cell-biomaterial interactions, biocompatibility and foreign body response, cellular engineering, and tissue biomechanics. Principles of cell/developmental and stem cell biology will be introduced, which will enable the students to apply a multidisciplinary approach to engineering select tissues and organs, such as the musculoskeletal system, cardiovascular tissues, the nervous system, and to design artificial organs. These topics will also be discussed in the context of scale-up, manufacturing, ethical and regulatory concerns.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.

BIOE 5501. Regenerative Engineering. 3 Credit Hours.
This course is a continuation of fundamental concepts introduced in Principles of Tissue and Regenerative Engineering focusing on developmental biology used in tissue engineering and regenerative medicine. Principles of cell development/biology, cell-cell interactions, signal transduction, and stem cell biology will be discussed with applications to regenerative medicine. These topics will also be discussed in the context of scale-up, manufacturing, ethical and regulatory concerns.

Department restrictions: Must be enrolled in one of the following Departments: Engineering:Bio Engineering
Field of Study Restrictions: Must be enrolled in one of the following Majors: Bioengineering
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits
Pre-requisites:
(BIOE 5461 Minimum Grade of B-) May not be taken concurrently
AND (BIOE 5721 Minimum Grade of B-) May not be taken concurrently.

BIOE 5719. Introduction to Bioengineering. 3 Credit Hours.
This course offers an introduction to biomedical engineering, a diverse and evolving field that integrates engineering principles, life sciences, clinical medicine, research and engineering design, with the overall goal of improving health care and quality of life. Professors with expertise in specific fields of biomedical engineering will present lectures and discussions on a broad range of topics, including tissue engineering and regenerative medicine, biomaterials, biomechanics, bioinstrumentation, biomedical imaging and optics, and signal processing.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate
Repeatability: This course may not be repeated for additional credits.
BIOE 5721. Cell Biology for Engineers. 3 Credit Hours.
This course introduces biological concepts in modern cellular and molecular biology to engineering students. Topics will include the chemical composition of cells, bioenergetics and metabolism, structure and function of the plasma membrane, transport across membranes, the cytoplasmic membrane system, the extracellular matrix, interactions between cells and their environment, the cytoskeleton and cell motility, sensory systems, and cell signaling. In addition, an introduction to basic anatomy and physiology of vertebrates will include the skeletal system, muscle system, cardiovascular system, and nervous system.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate

**Repeatability:** This course may not be repeated for additional credits.

BIOE 5737. Systems Physiology for Engineers. 3 Credit Hours.
Systems Physiology is designed for graduate students majoring in engineering and for others interested in studying physiological processes from the molecular level to the organ/systems level. Among the topics covered are: scaling, respiration, circulation, cardiac process, renal function, muscle function, neuromuscular junction, neural processes, and temperature regulation. The course stresses the application of energetic and informational principles to the study of the body.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate

**Repeatability:** This course may not be repeated for additional credits.

BIOE 5741. Biomaterials for Engineers. 3 Credit Hours.
This course introduces engineering students to materials as they interact with biological systems, primarily in medicine. Topics will include a review of properties of materials, the classes of materials, tissues that come into contact with materials, the degradation of materials in the biological environment, the application of materials for specific uses, tissue engineering, and biomaterials standards and regulations.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate

**Repeatability:** This course may not be repeated for additional credits.

BIOE 9182. Independent Study. 1 to 6 Credit Hour.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate

**Repeatability:** This course may be repeated for additional credit.

BIOE 9991. Directed Research. 1 to 3 Credit Hour.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate

**Repeatability:** This course may be repeated for additional credit.

BIOE 9994. BioEngineering Preliminary Examination Preparation. 1 to 6 Credit Hour.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate

**Repeatability:** This course may be repeated for additional credit.

BIOE 9995. BioEngineering Project Research. 1 to 6 Credit Hour.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate

**Repeatability:** This course may be repeated for additional credit.

BIOE 9996. BioEngineering Thesis Research. 1 to 6 Credit Hour.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate

**Repeatability:** This course may be repeated for additional credit.

BIOE 9998. Bioengineering Pre-Dissertation Research. 1 to 6 Credit Hour.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate

**Repeatability:** This course may be repeated for additional credit.

BIOE 9999. BioEngineering Dissertation Research. 1 to 6 Credit Hour.

**Level Registration Restrictions:** Must be enrolled in one of the following Levels: Graduate

**Repeatability:** This course may be repeated for additional credit.