Bioengineering Department, Key Contacts:

Lee Makowski, PhD
Professor and Department Chair
L.Makowski@northeastern.edu, (617) 373-3006

Mark Niedre, PhD
Associate Professor and Associate Chair for Research
M.Niedre@northeastern.edu, (617) 373-5410

Shiaoming Shi, PhD
Assistant Teaching Professor and Master of Science Advisor
s.shi@northeastern.edu, (617) 373-8743

Esther Cohen
Department of Bioengineering Business Manager
e.cohen@northeastern.edu, 617-373-7805

TBN
Administrative Coordinator
# Table of Contents

1. General Information ........................................................................................................................................5
   1.1 Graduate Programs and Degrees ........................................................................................................5
   1.2 Department Safety Training ....................................................................................................................5

2. Bioengineering Master of Science – Overview and Program Concentrations ........................................5
   2.1 Concentrations .......................................................................................................................................5
      Concentration in Medical Devices and Bioimaging ................................................................................5
      Concentration in Cell and Tissue Engineering .....................................................................................5
      Concentration in Biomechanics ..............................................................................................................6

2.2 Detailed MS Program Course Requirements ..........................................................................................6
   MS Concentration 1 – Medical Devices and Bioimaging (28 SH) ..............................................................6
   MS Concentration 2 - Cell and Tissue Engineering (28 SH) ..................................................................7
   MS Concentration 3 – Biomechanics (28 SH) ..........................................................................................7

2.3 MS Program Thesis Option Requirements ............................................................................................8

2.4 MS Program Project-Option Requirements ............................................................................................8

2.5 Graduate Certificate Options ................................................................................................................9

3. Bioengineering Ph.D. – Overview and Research Areas ..........................................................................10
   PhD Research Area 1: Imaging, Instrumentation, and Signal Processing ...............................................10
   PhD Research Area 2: Biomechanics, Biotransport and MechanoBiology ..............................................10
   PhD Research Area 3: Molecular, Cell, and Tissue Engineering ............................................................10
   PhD Research Area 4: Computational and Systems Biology ..................................................................10

3.1 Ph.D. Course Requirements ....................................................................................................................10
   3.1.1 Students Entering with BS ..............................................................................................................11
   3.1.2 Advanced Entry Students ..............................................................................................................12

3.2 Ph.D. Research Requirements ................................................................................................................12
   3.2.1 PhD Laboratory Rotation ..............................................................................................................12
   3.2.2 Finding a Research Advisor ........................................................................................................12
   3.2.3 Qualifying Exam (written and oral) ...............................................................................................13
   3.2.4 Ph.D. Dissertation Committee .......................................................................................................13
   3.2.5 Annual Committee Meetings and Dissertation Proposals ............................................................14
   3.2.6 Ph.D. Dissertation Defense ...........................................................................................................14

3.3 Example Ph.D. Timeline – Research Milestones ..................................................................................15

3.4 Ph.D. Funding .........................................................................................................................................15
   3.4.1 Teaching Assistantships ...............................................................................................................15
   3.4.2 Research Assistantships ..............................................................................................................15

Gordon Institute of Engineering Leadership .................................................................................................9
3.4.3 Arranging Payment ........................................................................................................15
4. Petition and Registration Override Procedures .................................................................17
5. Probation Policies and Procedures ....................................................................................18
6. Policies and Procedures for Course Transfer ....................................................................18
7. Policies and Procedures for Requesting Changes in the Graduate Program ..................18
8. Co-op & Experiential Learning .......................................................................................20
   8.1 Eligibility ..................................................................................................................20
   8.2 Applying for Co-op: .................................................................................................20
9. Campus Map ....................................................................................................................22
10. Other Useful links ..........................................................................................................24
11. Bioengineering Faculty and Staff ..................................................................................25
Appendix A. Bioengineering Department Safety Training .....................................................32
Appendix B. Suggested PhD Electives by Research Area and Master Electives List ............33
Appendix C. Laboratory Rotation Form (Following Page) ..................................................37
Appendix D. PhD Advisor Declaration Form (Following Page) .........................................39
Appendix E. Bioengineering Qualifying Exam, Structure and Criteria .................................41
   Timing and Organization .................................................................................................41
   II. Exam Structure and Requirements .............................................................................41
Appendix F. PhD Dissertation Committee Form (Following Page) .......................................44
Appendix G. Industrial PhD - Best Practices and Recommendations .................................0
   Coursework Requirements ..............................................................................................0
   Research Requirements .................................................................................................0

Updated August 15, 2019
1. General Information

Welcome to the Department of Bioengineering (‘BioE’) at Northeastern University! This document provides information for current and prospective students about graduate programs in the Department of Bioengineering, College of Engineering, Northeastern University. Graduate students are expected to read this document, be familiar with the rules and procedures, follow them, and refer to this guide when they have questions.

1.1 Graduate Programs and Degrees
The BioE Department offers two main graduate programs, a Master of Science (MS) in Bioengineering and Doctor of Philosophy (PhD) in Bioengineering. MS and PhD degree programs are only offered as full-time programs. Applicants with a BS or MS degree in bioengineering or related field can apply to the MS and PhD programs. It is not a requirement to hold an MS degree to apply to the PhD program.

1.2 Department Safety Training
All PhD students and MS students who plan to perform laboratory research are required to complete the basic Department of Bioengineering laboratory safety program, plus any additional lab-specific safety training. Students are strongly advised to complete this training in the first month following matriculation. The list of required online and in-class courses is provided in Appendix A of this handbook. For more information please contact the department safety officer Dr. Helen Markewich (h.markewich@northeastern.edu)

2. Bioengineering Master of Science – Overview and Program Concentrations
Students accepted to the Master of Science in Bioengineering program have three concentrations from which to choose:

- Concentration 1: Medical Devices and Bioimaging
- Concentration 2: Cell and Tissue Engineering
- Concentration 3: Biomechanics

A concentration is required. Each concentration has required courses and a list of technical electives. Students should select two to five courses, depending on the concentration, and whether he or she selects the thesis option, project option, or course-only option (please consult the detailed requirements for each concentration).

2.1 Concentrations

Concentration in Medical Devices and Bioimaging
The biomedical devices concentration is appropriate for students interested in the design of biomedical devices, as well as biomedical imaging and signal processing. Three courses are required for all students in this concentration, Design of Biomedical Instrumentation (BIOE 5810), Design, Manufacture, and Evaluation of Medical Devices (BIOE 5250), and Biomedical Imaging (BIOE 5235).

Concentration in Cell and Tissue Engineering
The cell and tissue engineering concentration is appropriate for students interested in molecular, cell, and tissue engineering. Two courses are required of all cell and tissue engineering students, Molecular Bioengineering (BIOE 5410) and Cellular Engineering (BIOE 5420). There is an extensive list of approved technical electives to choose from to complete the degree.
Concentration in Biomechanics

Students who join the biomechanics concentration will cover multiscale mechanics, including whole-body movement, mechanical properties of biomaterials, and fluid mechanics of physiological fluids. Two courses are required of all biomechanics concentration students, Multiscale Biomechanics (BIOE 5650) and Musculoskeletal Biomechanics (ME 5665).

2.2 Detailed MS Program Course Requirements

The following sections explain the course requirements for students entering the bioengineering Master Program. A total of 32 semester hours are required and a minimum 3.000 GPA. In addition to the core courses for each MS student, each concentration has its own academic track.

Required Core Courses (All Concentrations)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 7390</td>
<td>Seminar</td>
<td>0</td>
</tr>
<tr>
<td>BIOE 6100</td>
<td>Medical Physiology</td>
<td>4</td>
</tr>
<tr>
<td>BIOE 6000</td>
<td>Principals of Bioengineering</td>
<td>1</td>
</tr>
</tbody>
</table>

Concentration Specific Requirements

Complete requirements for one of the four MS concentrations as follow:

MS Concentration 1 – Medical Devices and Bioimaging (28 SH)

Required Course Work (12 SH)

A grade of C or higher is required.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EECE 5235</td>
<td>Biomedical Imaging</td>
<td></td>
</tr>
<tr>
<td>EECE 5250</td>
<td>Design, Manufacture, and Evaluation of Medical Devices</td>
<td></td>
</tr>
<tr>
<td>BIOE 5810</td>
<td>Design of Biomedical Instrumentation</td>
<td></td>
</tr>
</tbody>
</table>

And one of the following:

i) Course Work Option (16 SH)

Complete 16 semester hours from the course list (see below).

ii) Project Option

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 7890</td>
<td>Master’s Project</td>
<td>4</td>
</tr>
</tbody>
</table>
+ Complete 12 semester hours from the course list. 12 SH

iii) Thesis Option

Complete the following (repeatable) course twice:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 7990</td>
<td>Thesis</td>
<td>8</td>
</tr>
</tbody>
</table>
+ Complete 8 semester hours from the elective course list. 8 SH

Concentration 1 Electives Course List:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 5115</td>
<td>Dynamical Systems in Biological Engineering</td>
</tr>
<tr>
<td>BIOE 5320</td>
<td>Advanced Biomedical Measurements and Instrumentation</td>
</tr>
<tr>
<td>BIOE 5820</td>
<td>Biomaterials</td>
</tr>
<tr>
<td>BIOE 5850</td>
<td>Design of Implants</td>
</tr>
<tr>
<td>BIOE 7100</td>
<td>Special Topics in Biomedical Imaging and Signal Processing</td>
</tr>
<tr>
<td>BIOE 7250</td>
<td>Mathematical Methods in Bioengineering</td>
</tr>
<tr>
<td>BIOE 7400</td>
<td>Special Topics in Biomedical Devices</td>
</tr>
<tr>
<td>EECE 5648</td>
<td>Biomedical Optics</td>
</tr>
<tr>
<td>EECE 5664</td>
<td>Biomedical Signal Processing</td>
</tr>
<tr>
<td>EECE 7105</td>
<td>Optics for Engineers</td>
</tr>
<tr>
<td>EECE 7200</td>
<td>Linear Systems Analysis</td>
</tr>
</tbody>
</table>
MS Concentration 2 - Cell and Tissue Engineering (28 SH)

Required Course Work (8 SH)
A grade of C or higher is required.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 5410</td>
<td>Molecular Bioengineering</td>
</tr>
<tr>
<td>BIOE 5420</td>
<td>Cellular Engineering</td>
</tr>
</tbody>
</table>

And one of the following:

i) Course Work Option (20 SH)
   Complete 20 semester hours from the course list (see below).

ii) Project Option
   BIOE 7890 Master’s Project 4 SH
   + Complete 16 semester hours from the course list. 16 SH

iii) Thesis Option
   Complete the following (repeatable) course twice:
   BIOE 7990 Thesis 8 SH
   + Complete 12 semester hours from the course list. 12 SH

Concentration 2 Electives Course List:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 5250</td>
<td>Design, Manufacture, and Evaluation of Medical Devices</td>
</tr>
<tr>
<td>BIOE 5430</td>
<td>Principles and Applications of Tissue Engineering</td>
</tr>
<tr>
<td>BIOE 5820</td>
<td>Biomaterials</td>
</tr>
<tr>
<td>BIOL 5543</td>
<td>Stem Cells and Regeneration</td>
</tr>
<tr>
<td>BIOL 6301</td>
<td>Molecular Cell Biology</td>
</tr>
<tr>
<td>ME 5667</td>
<td>Solid Mechanics of Cells and Tissues</td>
</tr>
<tr>
<td>NNMD 5370</td>
<td>Nanomedicine Research Techniques</td>
</tr>
<tr>
<td>NNMD 5470</td>
<td>Nano/Biomedical Commercialization: Concept to Market</td>
</tr>
</tbody>
</table>

MS Concentration 3 – Biomechanics (28 SH)

Required Course Work (8 SH)
A grade of C or higher is required.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 5665</td>
<td>Musculoskeletal Biomechanics</td>
</tr>
<tr>
<td>BIOE 5650</td>
<td>Multiscale Biomechanics</td>
</tr>
</tbody>
</table>

And one of the following:

i) Course Work Option (20 SH)
   Complete 20 semester hours from the course list (see below).

ii) Project Option
   BIOE 7890 Master’s Project 4 SH
   + Complete 16 semester hours from the course list. 16 SH

iii) Thesis Option
Complete the following (repeatable) course twice:

BIOE 7990 Thesis 8 SH

+ Complete 12 semester hours from the course list. 12 SH

**Concentration 3 Electives Course List:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 5630</td>
<td>Physiological Fluid Mechanics</td>
</tr>
<tr>
<td>BIOE 7300</td>
<td>Special Topics in Biomechanics</td>
</tr>
<tr>
<td>BIOL 5601</td>
<td>Multidisciplinary Approaches in Motor Control</td>
</tr>
<tr>
<td>EECE 7200</td>
<td>Linear Systems Analysis</td>
</tr>
<tr>
<td>EECE 7203</td>
<td>Complex Variable Theory and Differential Equations</td>
</tr>
<tr>
<td>ME 5650</td>
<td>Advanced Mechanics of Materials</td>
</tr>
<tr>
<td>ME 5655</td>
<td>Dynamics and Mechanical Vibration</td>
</tr>
<tr>
<td>ME 5657</td>
<td>Finite Element Method</td>
</tr>
<tr>
<td>ME 5659</td>
<td>Control Systems Engineering</td>
</tr>
<tr>
<td>ME 5667</td>
<td>Solid Mechanics of Cells and Tissues</td>
</tr>
<tr>
<td>ME 7210</td>
<td>Elasticity and Plasticity</td>
</tr>
<tr>
<td>ME 7238</td>
<td>Advanced Finite Element Method</td>
</tr>
<tr>
<td>ME 7245</td>
<td>Fracture Mechanics and Failure Analysis</td>
</tr>
<tr>
<td>ME 7255</td>
<td>Continuum Mechanics</td>
</tr>
</tbody>
</table>

### 2.3 MS Program Thesis Option Requirements

For MS students choosing the Thesis Option, he/she must find a thesis advisor and complete 8 SH of BIOE 7990 (Thesis). This is usually done in two semesters, each semester 4 SH, but can also be done in one semester for 8 SH. If a student has completed 8 SH of BIOE 7990, but has no yet defended their thesis, he/she must enroll in BIOE 7996 (Master’s Thesis Continuation, 0 SH) until they successfully defend their thesis.

When you are ready to defend your thesis, you must form a “Thesis committee” in consultation with your advisor. The Committee must have at least three members, and at least two of which must be tenured or tenure-track BIOE faculty. After successful defense of your thesis, a letter grade will be assigned to BIOE 7990 (Master’s Thesis) by your advisor. Your MS thesis defense date and location must be announced at least one week before the date of the defense. Students should bring their signed **MS Thesis Signature form** to the Bioengineering office when complete.

An MS student may graduate once he/she has successfully defended his/her MS thesis, and fulfilled all course requirements. To graduate, one must have a cumulative GPA of at least 3.00 with no more than 9 semester hours of grades below B – in all courses applied to the degree.

### 2.4 MS Program Project-Option Requirements

For MS students choosing the Project Option, he/she must find a project advisor and complete 4 SH of BIOE 7890 (MS Project).

When you have completed your MS project, you must write a Project Report. A template for writing the Project Report can be found at BIOE Department website. Your report must be submitted to your project advisor and obtain his/her approval. The approved Project Report will be archived by both the BIOE Department as well as the project advisor.
An MS student can graduate once he/she has obtained his/her Project advisor’s approval of the Project report, and fulfilled all course requirements. To graduate, one must have an a cumulative GPA of at least 3.00 with no more than 9 semester hours of grades below B– in all courses applied to the degree.

2.5 Graduate Certificate Options
Students enrolled in a master's degree have the opportunity to also pursue one of the many engineering graduate certificate options in addition to or in combination with the MS degree. Students should consult their faculty advisor regarding these options.

Gordon Institute of Engineering Leadership

Master's Degree in Bioengineering with Graduate Certificate in Engineering Leadership
Students may complete a Master of Science in Bioengineering in addition to earning a Graduate Certificate in Engineering Leadership. Students must apply and be admitted to the Gordon Engineering Leadership Program in order to pursue this option. The program requires fulfillment of the 16-semester-hour-curriculum required to earn the Graduate Certificate in Engineering Leadership, which includes an industry-based challenge project with multiple mentors. The integrated 33-semester-hour degree and certificate will require 17 hours of advisor-approved bioengineering technical courses.
3. Bioengineering Ph.D. – Overview and Research Areas

Students performing a PhD through the department of Bioengineering will perform required coursework (Section 3.1), as well as cutting edge research (Section 3.2) with one of our core and affiliated faculty. The department features four research areas as follows. Students should consult the Bioengineering Research Map for more information about BioE faculty performing research in these areas.

PhD Research Area 1: Imaging, Instrumentation, and Signal Processing
The Imaging, Instrumentation and Signal Processing track reflects Northeastern University’s outstanding research profile in developing new technologies for visualizing biological processes and disease. Our department has active federally funded research spanning a broad spectrum of relevant areas in instrument design, contrast agent development, and advanced computational modeling and reconstruction methods. Example research centers include the Chemical Imaging of Living Systems Institute, the Translational Biophotonics Cluster, and the B-SPIRAL signal processing group.

PhD Research Area 2: Biomechanics, Biotransport and Mechanobiology
Motion, deformation, and flow of biological systems in response to applied loads elicit biological responses at the molecular and cellular levels that support the physiological function of tissues and organs and drive their adaptation and remodeling. To study these complex interactions, principles of solid, fluid, and transport mechanics must be combined with measures of biological function. The Biomechanics, Biotransport, & Mechanobiology track embraces this approach and leverages the strong expertise of Northeastern faculty attempting to tie applied loads to biological responses at multiple length and time scales.

PhD Research Area 3: Molecular, Cell, and Tissue Engineering
Principles for engineering living cells and tissues are essential to address many of the most significant biomedical challenges facing our society today. These application areas include engineering biomaterials to coax and enable stem cells to form functional tissue or to heal damaged tissue; designing vehicles for delivering genes and therapeutics to reach specific target cells to treat a disease; and, uncovering therapeutic strategies to curb pathological cell behaviors and tissue phenotypes. At a more fundamental level, the field is at the nascent stages of understanding how cells make decisions in complex microenvironments and how cells interact with each other and their surrounding environment to organize into complex three-dimensional tissues. Advances will require a multiscale experimental, computational and theoretical approaches spanning molecular-cellular-tissue levels and integration of molecular and physical mechanisms, including the role of mechanical forces.

PhD Research Area 4: Computational and Systems Biology
We aim to understand the rules governing emergent systems-level behavior and to use these rules to rationally engineer biological systems. We make quantitative measurements, often at the single cell level, to test different conceptual frameworks and discriminate amongst different classes of models. Our faculty are leaders in developing and applying both theoretical methods, e.g., control theory, and experimental methods, e.g., single-cell proteomics by mass-spec, to biological systems. At the organ and tissue levels, 3D scans acquired through medical imaging methods (e.g. US, CT, MRI, etc.) may be used to reconstruct virtual models of targeted systems. Non-invasive measures of the physiological function can then inform numerical simulations to predict the behavior of biological systems over time, with the goal of estimating the progression towards pathological endpoints or to test the efficacy of targeted surgical procedures and pharmaceutical treatments (e.g., drug delivery).

3.1 Ph.D. Course Requirements
The following sections explain the course requirements for students entering the bioengineering PhD program with a BS as well as students entering with a Masters (“Advanced Standing”). The normal course-load for Ph.D. students is 8-9 semester
hours (SH) per semester. In addition to course work, students must complete the qualifying, proposal, and PhD defense exam sequence described in detail in Section 3. Students should bear in mind that regular research progress is critical to timely completion of their PhD.

3.1.1 Students Entering with BS
Students entering the Bioengineering PhD program with a BS will take a total of 8 courses (32 SH). Three core bioengineering courses (12 SH), two restricted bioengineering technical electives (8 SH), and three unrestricted technical electives (12 SH). Those courses choices are outlined below:

I. Required Core Courses (12 SH):
   BIOE 6100 Medical Physiology
   BIOE 7000 Principles of Bioengineering
   BIOE 6200 Mathematical Methods in Bioengineering

II. Restricted Technical Electives (8 SH):
   BIOE 5235 Biomedical Imaging
   BIOE 5410 Molecular Bioengineering
   BIOE 5420 Cellular Engineering
   BIOE 5430 Principles and Applications of Tissue Engineering
   BIOE 5440 The Cell as a Machine
   BIOE 5630 Physiological Fluid Mechanics
   BIOE 5640 Computational Biomechanics
   BIOE 5650 Multiscale Biomechanics
   BIOE 5656 Fields, Forces, and Flows in Biological Systems
   BIOE 5810 Design of Biomedical Instrumentation
   BIOE 5820 Biomaterials
   ME 5665 Musculoskeletal Biomechanics

III. Unrestricted Technical Electives (12 SH):
   Any 3 courses on our master list of approved technical electives. This list is included in Appendix A. A list of suggested courses by research area is also included. Other courses may be taken by petition and with approval of Ph.D. Advisor and Ph.D. director.

IV. Professional Development Courses (0 SH):
   Complete the following (repeatable) course twice
   BIOE 7390 Seminar

V. Dissertation (0 SH):
   Complete the following (repeatable) course twice
   BIOE 9900 Dissertation
3.1.2 Advanced Entry Students
The curriculum for PhD students with advanced standing will be selected from the available core and elective courses under the guidance of the program director and the student's primary advisor. The advanced standing PhD degree requires a minimum of 16 semester hours (SH) of course work to be approved by the graduate director and a completed PhD dissertation. Advanced standing constitutes receipt of a relevant and accepted master's degree at a qualified institution.

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advisor-approved course work</td>
<td>16 SH</td>
</tr>
<tr>
<td>Advanced seminar (register and complete two semesters)</td>
<td>0 SH</td>
</tr>
<tr>
<td>Dissertation (register and complete two semesters)</td>
<td>0 SH</td>
</tr>
<tr>
<td>Minimum semester hours required</td>
<td>16 SH</td>
</tr>
</tbody>
</table>

The Master List of approved technical electives is included in Appendix B. A list of suggested courses by research area is also included. Electives for Advanced Entry students may be replaced with up to 12 SH of relevant independent studies Independent Study (BIOE 7978) by petition.

3.2 Ph.D. Research Requirements
In addition to coursework (Section 3.1), completion of the PhD degree requires students to successfully complete all of the requirements listed below. An example timeline for a PhD student entering with a BS degree is listed in Section 3.3.

3.2.1 PhD Laboratory Rotation
All Ph.D. students who are funded by Dean’s Fellowship (DF) or Teaching Assistant (TA) at the time of entry into the program are required to complete a rotation in a minimum of two department research laboratories. At least one of the two rotations must be performed in the laboratory of a core Bioengineering faculty member.

Students should make an appointment to speak with potential research advisors and confirm their willingness to advise and potentially support a student on research assistantship following the rotation. Potential advisors may be found through the Department website, through the Bioengineering Research Map, through the Department Research Fair in September, and by meeting with the PhD Program Director.

Students should complete the PhD Laboratory Rotation Form (Appendix C) and return it to the Administrative Coordinator of the department prior to each lab rotation.

The rotation timeline is as follows (September matriculation):
- September: Complete Department Safety Training (Section 1.2, Appendix A)
  and identify labs for rotation
- October-December: First Lab rotation
- January-March: Second Lab Rotation

3.2.2 Finding a Research Advisor
Completion of the research dissertation component of the PhD requires that they select a research advisor. A student has formally selected a research advisor when the PhD Research Advisor Declaration Form (Appendix D) is completed, signed by the student and the advisor, and filed with the Administrative Coordinator of the Bioengineering department. The research advisor can be any tenured, tenure-track, or affiliated Bioengineering faculty. All PhD students must have a research advisor.
within one calendar year after their matriculation at NU; otherwise, their status changes to MS course-only track. If, after change of status, these students can find a research advisor, their status will be reset to PhD.

Choice of research advisor that is a mutually “good match” is perhaps one of the most important decisions a PhD student will make. This is typically done on the student’s initiative, before or within the first semester of joining the PhD program. Students should plan to meet with prospective advisors, determine their willingness to take on new students, and ask about research in their labs. Example questions a student might ask in this meeting to determine the potential fit are:

- Are you taking on new students in your group?
- Do you have a specific project in mind? If so, is that project currently funded by a research grant?
- What other projects are going on in this the group? Are all the students in your group funded?
- What are the most important skills to be successful in your group?
- Would you be able to support me on research assistantship?
- How often do you meet with your students 1-on-1?
- Do you have regular lab meetings? Journal club?
- Do you normally pair a student up with a senior student?
- How big is your group? How many MS, Ph.D., Postdocs?
- Are you a ‘hands on’ advisor? If not, who would I go to for help?
- Can I meet with one of your current grad students?
- What journals does your group normally publish in?
- What conference does your group regularly attend?
- What is your policy on sending students to conferences?
- What are your expectations for graduation for a Ph.D. in terms of research output?

3.2.3 Qualifying Exam (written and oral)
In order to continue the PhD Program, students must pass a comprehensive qualifying examination in one of the four department research areas. The qualifying exam is normally taken in the fall semester of the student’s second year. In addition to satisfactory research progress and satisfactory academic standing, students will prepare a 6-page written document. This document needs to demonstrate independent, creative thinking and represent a clear conceptual departure from the student’s PhD thesis and the work of their thesis laboratory. The document should be distributed to his/her qualifying exam committee no later than 14 calendar days before the oral examination. Students who fail their qualifying exam on the first attempt may re-take the exam one in the following spring semester. Students may not take the qualifying exam more than twice. More detailed description of the qualifying exam structure and criteria are provided in Appendix C

Qualifying Exam Committee: The qualifying examination committee is composed of three members of the Department of Bioengineering faculty. At least two of three committee members will be from the student’s research area. The student's primary research advisor may not sit on the qualifying exam committee.

3.2.4 Ph.D. Dissertation Committee
Within two years of joining the Bioengineering PhD program, students will form their Dissertation committee. The committee should be composed of at least three members. The chair of the committee should be the student’s primary advisor, a member of the core Bioengineering faculty or a faculty member with affiliations to the Bioengineering Department. Two members of the committee must be core faculty from the department. Once students have formed their committee, they should complete the PhD Dissertation Committee Form Appendix D and file it with the Administrative coordinator of the department. Students will be required to meet with their PhD Dissertation Committee annually to confirm research progress.
**Dissertation Course Requirements**: Once the qualifying exam has been passed, the doctoral candidate must register in two consecutive semesters (may include full summer term) for Dissertation (BIOE 9990). Following completion of these semesters, the student must then register for Dissertation Continuation (BIOE 9996) in every semester (in each fall and spring term and also in the summer term if summer is the student's last semester) until the dissertation is completed. Students may not register for Dissertation Continuation (BIOE 9996) until they fulfill the two-semester sequence of Dissertation (BIOE 9990).

3.2.5 **Annual Committee Meetings and Dissertation Proposals**
Prior to a student’s first committee meeting, they are required to write a dissertation proposal in the form of an NIH-style R21 proposal research plan, to be distributed no later than 1 week prior to the meeting. Annual progress update meetings must be held annually. At the second to last meeting, held at least four months before the Dissertation Defense, the student must prepare and present a final proposal document. The student will be allowed to progress to the PhD Dissertation Defense upon successful defense of this proposal. Students must hold their first Dissertation Committee meeting no later than their third year.

To meet the full-time registration requirement for PhD students who have completed the majority of their course work and not yet reached PhD candidacy, a zero-credit course, Exam Preparation—Doctoral (BIOE 8960), can be taken if needed to fulfill the full-time course registration requirement. Exam Preparation—Doctoral (BIOE 8960) is an individual instruction course, billed at one semester hour, and graded S or U. Exam Preparation—Doctoral (BIOE 8960) does not have any course content, and students must register in a section for which their research advisor is listed as the “instructor.”

3.2.6 **Ph.D. Dissertation Defense**
All PhD candidates must complete and defend a dissertation of original research in bioengineering. The format of the defense will be that of an open presentation to the Northeastern Bioengineering community, followed by a closed meeting with their dissertation committee in which they are expected to answer all relevant questions regarding their work, its significance and its relationship to ongoing work across the broader research community.

The required PhD Dissertation Signature page can be found on the COE webpage here: [http://www.coe.neu.edu/sites/default/files/pdfs/coe/gse/DissertationSignature.pdf](http://www.coe.neu.edu/sites/default/files/pdfs/coe/gse/DissertationSignature.pdf)
3.3 Example Ph.D. Timeline – Research Milestones

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Fall</th>
<th>Find Research Advisor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td></td>
</tr>
<tr>
<td>Year 2</td>
<td>Fall</td>
<td>Qualifying exam</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>Makeup Qualifying exam</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>Form PhD committee</td>
</tr>
<tr>
<td>Year 3</td>
<td>Fall</td>
<td>First Committee Meeting</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Dissertation Proposal in R2I format</em></td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td></td>
</tr>
<tr>
<td>Year 4</td>
<td>Fall</td>
<td>Second Committee Meeting</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td></td>
</tr>
<tr>
<td>Year 5</td>
<td>Fall</td>
<td>Third Committee Meeting</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>PhD Dissertation Defense</td>
</tr>
</tbody>
</table>

3.4 Ph.D. Funding

It is the intent and track record of the Department of Bioengineering to ensure continuous funding to all Ph.D. students throughout the tenure of their studies. Most students take about 5 years to earn a Ph.D., and may be funded through a variety of mechanisms including RA and TA awards and external fellowships.

3.4.1 Teaching Assistantships

Teaching assistantships (TAs) are administered by the Department of Bioengineering under the direction of the Business Manager (Susan Wilcox). TAs are allocated to a mixture of incoming PhD and senior students advised by tenured and tenure-track Bioengineering faculty. TAs assist Bioengineering instructors in various aspects of teaching including running laboratories and grading assignments, and therefore requires matching of skills with course needs. Students who are funded by TA on entry are required to perform a laboratory rotation (Section 2.2.1) TA funding requests should be made by a student’s research advisor directly to the Business Manager.

3.4.2 Research Assistantships

Research assistantships (RAs) are paid by research advisors to students, normally from research grants to support their dissertation research. RAs are renewable on a semester basis, pending satisfactory research progress and availability of funding. Students should discuss expectations for satisfactory progress with their advisor, but can expect a minimum of 20 hours per week spent on research.

3.4.3 Arranging Payment

Step 1: If you are an international student and you do not have a Social Security Number, the Graduate School of Engineering will produce an “Engagement Form” for you. This form is provided to the Office of Global Services (OGS) on campus so that
they can process a Social Security Number for you. If you are a newly-admitted student, the “Engagement Form” will have been provided to the Office of Global Services for your arrival check-in. Otherwise, please request the Engagement Form from the Graduate School of Engineering.

Step 2: All students: Visit the Student Employment Office at 101 Curry Student Center and complete a Direct Deposit Authorization Form and a Form W-4 for tax purposes.

Step 3: All students: Your stipend will be paid directly into your bank account on the 15th and the 30th or 31st of each month during which you hold your assistantship. If your Direct Deposit has not yet been set up, you will collect your paper paycheck at the Human Resources office at 716 Columbus Avenue.
4. Petition and Registration Override Procedures

Please note the following:

1. Petitions/overrides for taking courses must be filed and approved BEFORE registration in the course.
2. Filing a petition/override does not mean that it will be approved, you need to receive the approval to go ahead.
3. Please file your petitions/overrides well in advance. Processing a petition/override takes at least 5 business days.
4. When submitting your petition/override make sure it is completed and signed by you. If you have a research advisor the form must be signed by him/her as well. If the signature of the instructor is needed (for override forms), please make sure that you obtain the signature.
5. All petitions/overrides must be submitted with a copy of your current transcripts. Unofficial transcripts are acceptable for this purpose.

Here are the steps for filing petitions/overrides:

1. To file a petition:
   (a) Download the petition form from here.
   (b) Complete the form, sign it, and get other necessary signatures as described in part 4 above.
   (c) Submit both to the front desk of the Graduate School (Snell 130)
2. To file a registration override form (these forms are used to register in courses that have restrictions:
   (a) Download the override form from here.
   (b) Complete the form and get the necessary signatures as explained in part 4 above.
   (c) If the form is for pre-requisite waiver, get the signature of the instructor too.
   (d) Submit both to front desk of the Graduate School (Snell 130)
5. Probation Policies and Procedures

One academic term with cumulative GPA below 3.000: Students with a cumulative GPA below 3.000 for one term are required to complete an Academic Probation Action Plan to be signed and approved by their academic advisor and submitted to the Graduate School within 7 business days from the start of the next academic term.

Two consecutive terms with cumulative GPA below 3.000: Students with a cumulative GPA below 3.000 for two consecutive terms will be dismissed from their degree program at the end of the second term. Students in this situation may submit an Academic Dismissal Appeal Form to the Graduate School to request a final one-term extension. The appeal will be reviewed by the student’s department.

Three consecutive terms with cumulative GPA below 3.000: Students with a cumulative GPA below 3.000 for three consecutive terms will automatically be dismissed from their degree program. In this case, the student may submit an appeal to the Associate Dean of the Graduate School per the University appeals process.

For more information, please refer to the College of Engineering website.

6. Policies and Procedures for Course Transfer

Graduate students can transfer a maximum of 9 SH (or equivalent) course work from other institutions. 4 SH of course work is defined as 45 hours of lecture. For credit transfer from other institutions, the following conditions must be satisfied:

1. Student should have a grade of at least B (or equivalent) in the course.
2. The course must be passed during the past seven years.
3. The course should not be part of the requirements of a degree received by the student in the past.
4. The course will be reviewed by the Graduate Affairs Committee and should be approved as equivalent to a graduate-level Northeastern course that students can take as part of their degree program.

The process for transfer credit requires filing a petition (see Section 4). The petition should be accompanied by the detailed syllabus of the course (including textbook information) and the equivalent NU course as well as sufficient evidence that the course has not been part of the requirements of a degree received by the student. Evidence should be noted on the transcripts or be sent in a letter/formal email from the Student Service Coordinator (or equivalent) confirming credits were not used towards a degree in the former institution.

7. Policies and Procedures for Requesting Changes in the Graduate Program

In general, changes to the graduate program are possible after completing at least one semester at Northeastern. This gives the students an opportunity to get accurate information about each program in order to make an informed decision. The only request for change in the program that is accepted during the first semester is change from full-time to part-time or from part-time to full-time. This change does not apply to those who hold an F-1 student visa.

1. Change from FT to PT or PT to FT. This is the only change that can be petitioned during the first semester. To request this change you need to file a petition as explained in Section 4. FT PhD students cannot change to PT before having a research advisor. Change from FT to PT for international students is only possible if it complies with the Office of Global Services rules.

For International Students Only: An approved change of program requires that a new I-20 be issued. It is the student’s responsibility to initiate the I-20 process. Instructions are provided on the official admission acceptance letter. Questions should be directed to the International Student and Scholar Institute on campus.

2. Change from PhD to MS: Students need to file a “Change in Degree Level” form and submit it with your transcripts to the front desk of the Graduate School. Students need to get the signature of their research advisor on this form.
8. **Co-op & Experiential Learning**

Coop and internship are forms of CPT (Curricular Practical Training) that allow full-time students to integrate a practical learning experience into their graduate program. Internship is an option for PhD students only to provide them with work experience that is integral to the student’s education, i.e., required for their dissertation research. Internship provides the opportunity to further the students’ training and knowledge in an area central to advancement of their research. It does not refer to an “internship” as used by companies, agencies and other institutions. Examples include students working at a company, government lab or other entity whereby the tasks, data, protocols, etc. will be brought back to NU and used in an integral way in the advisor’s lab and the student’s research. Coop is available to all graduate students and its goal is to provide students with actual work experience in their field of study and need not be research oriented (though it often is).

8.1 **Eligibility**

To start the co-op search process, College of Engineering graduate students must:

1. Be enrolled full-time at Northeastern University.
2. Meet all English-language requirements described in the table below.
3. Meet the minimum GPA for their program described in the table below, as applicable.
4. Have no disciplinary or academic probation issues and no incomplete courses (i.e., no I grade in their records).
5. Have at least one term left in their program after completing co-op (i.e., students must return to Northeastern to take courses for at least one term prior to graduating).
6. Have a valid I-20 (for international students).
7. Have completed their first full time semester with a minimum of 8SH completed.
8. Be enrolled in or have completed the Career Management for Engineers (ENCP 6000) or Introduction to Cooperative Education (ENCP 6100) course (depending on their major).
9. Complete a COE Co-op Application and receive Co-op Coordinator approval to initiate a co-op job search.

To participate in Co-op, College of Engineering graduate students must:

1. Meet the minimum semester-hour requirements of 16SH completed as described in the table below.
2. Successfully complete the Career Management for Engineers (ENCP 6000) or Introduction to Cooperative Education (ENCP 6100) (depending on their major).
3. Receive Co-op Coordinator approval prior to accepting a co-op job offer.
4. Meet all of the additional requirements as listed above for starting the co-op search process.

8.2 **Applying for Co-op:**

1. Graduate students must declare their intention to participate in the co-op process by completing an Application Form (found [here](#)). The Application Form should be completed and submitted in person to the student’s co-op coordinator early in the semester prior to co-op (appointments to do so can be scheduled through the MyNEU calendar).
2. When the student receives an offer of employment for a co-op, he/she should meet with their co-op faculty coordinator to discuss the opportunity prior to accepting the offer or agreeing to co-op dates. If not in NUcareers, an electronic copy of the employer information and position description should be submitted to the co-op faculty coordinator. An offer letter should also be submitted. The co-op faculty coordinator will place the student in NUcareers. For F-1 visa students, items 3–7 apply.
3. The co-op faculty coordinator will check the student’s I-20 end date. If the I-20 end date allows the co-op to be completed prior to the end date, students can submit a CPT Request downloadable from the OGS site. The co-op coordinator will approve the request or let the student know if edits need to be made and then send the final request to OGS for processing.
4. The Chair of the Graduate Affairs Committee will approve the request and forward to Graduate Student Services. The student will receive final approval by email.

For more information, visit the COE website
9. Campus Map

Web Address: https://www.northeastern.edu/campusmap/map/index.html
**Key Bioengineering Buildings:**

The Interdisciplinary Science & Engineering Complex (ISEC)
Many of the labs and the majority of our Bioengineering faculty have offices on the second and third floors. The Bioengineering department administrative offices are located in 206 ISEC.

Snell Engineering Center
The College of Engineering administrative office is located in room 130

Mugar Life Sciences Building
A number of Bioengineering labs are in Mugar.

Egan Research center
Raytheon Amphitheater is a popular spot for events. The building houses many other events and seminar rooms.

Curry Student Center
Shop in the Northeastern bookstore for textbooks and school supplies, and clothing adorned with the Northeastern logo. There is also the largest food court on campus and a Starbucks.

**Labs:**
Faculty members have lab spaces in the following areas:

- Asthagiri: 260-272 ISEC
- Bajpayee: 260B, 262C ISEC
- Bellini: 260-272 ISEC
- Chung: 020 ISEC
- Clark: 271 TF
- Dai: 260-272 ISEC
- Fang: 020 ISEC
- E. Levine: TBD
- H. Levine: TBD
- Li: TBD
- Makowski: 260-272 ISEC
- Niedre: 020 ISEC
- Oakes: 260-272 ISEC
- Parameswaran: 260-272 ISEC
- Ruberti: 260-272 ISEC
- Shefelbine: 260-272 ISEC
- Slavov: 211 Mugar

**Popular Coffee Spots**
Cafe Strega – ISEC Lobby
Dunkin Donuts - Hayden Hall, Shillman Hall
Starbucks Coffee – Curry Student Center
Pavement Coffeehouse - 44 Gainsborough St
Render Coffee - 563 Columbus Ave
Thinking Cup - 165 Tremont
Tatte Bakery and Cafè - 369 Huntington Ave
Oakleaf Cakes Bake Shop - 12 Westland Ave
Caffè Nero - 114 New Edgerly Rd

10. Other Useful links

- Academic Integrity
- Code of Student Conduct
- BioE Department Website
- BioE Facebook
- BioE Twitter
- BioE Instagram
- BioE LinkedIn
- Graduate School of Engineering
- Official University Calendars
- Registrar’s Office
- University Health and Counseling Services
- General Graduate Forms
- NU Graduate Catalogue
- BioE Forms
11. Bioengineering Faculty and Staff

**Anand Asthagiri**  
Associate Professor, Bioengineering  
The Asthagiri lab elucidates principals for engineering living cells and tissues. These design principals provide a foundation for tissue engineering and regenerative medicine. Understanding the disassembly of multicellular structures sheds new insights into cancer development and helps to identify therapeutic strategies to re-shape diseased tissue.  
226 ISEC, a.asthagiri@northeastern.edu

**Ambika Bajpayee**  
Assistant Professor, Bioengineering  
Targeted drug delivery to connective and charged tissues. Her lab utilizes concepts of nanomedicine and bio-electrostatics to design polypeptides and protein-based carriers for targeted and sustained delivery of small molecule drugs, protein growth factors, antibodies and genetic materials to specific intra-tissue and intra-cellular target sites inside connective tissues.  
216 ISEC, a.bajpayee@northeastern.edu

**Chiara Bellini**  
Assistant Professor, Bioengineering  
Diseases of the cardiovascular system; effects of cell mediated growth and remodeling processes on tissue and organ mechanics  
228 ISEC, c.bellini@northeastern.edu

**Samuel Chung**  
Assistant Professor, Bioengineering  
Researches central nervous system regeneration model in C. elegans; femtosecond laser surgery; user-friendly and low-cost fluorescence microscopy.  
218 ISEC, s.chung@northeastern.edu
Heather Clark
Professor, Bioengineering
Jointly appointed in Bioengineering & Chemistry and Chemical Biology.
Researches Optical nanosensors for biological analysis.
316 ISEC, H.Clark@northeastern.edu

Guohao Dai
Associate Professor, Bioengineering
Researches 3-D bioprinting technology, stem cells technology and vascular bioengineering.
224 ISEC, g.dai@northeastern.edu

Qianqian Fang
Assistant Professor, Bioengineering
Researches innovations in translational medical imaging devices to better diagnose cancers, low-cost point-of-care diagnostic tools to delivery life-saving medicines to the resource-poor regions, and high performance computing tools to facilitate the development of the next-generation imaging methods.
223 ISEC, q.fang@northeastern.edu

Michael Jaeggli
Mathworks Faculty Fellow and Assistant Teaching Professor, Bioengineering
206D ISEC, m.jaeggli@northeastern.edu
**Timothy Lannin**  
Assistant Teaching Professor, Bioengineering  
Professor Lannin’s previous research included work on automating image analysis of cancer cells, measuring the electrical properties of cancer cells to use electric fields to separate them from blood cells, and measuring the electrical properties of algae cells to optimize their output for biofuels.  
206A ISEC, t.lannin@northeastern.edu

**Erel Levine**  
Associate Professor, Bioengineering  
Researches the analysis of big biological data by developing statistical physics approaches to deep learning; statistical learning approaches to the dynamics, plasticity and evolvability of small regulatory RNA; host-pathogen interaction: in-host dynamics and inter-species systems biology  
e.levine@northeastern.edu

**Herbert Levine**  
University Distinguished Professor, Bioengineering and Physics  
Studies mechanics of motility at both single cell and multicellular levels, genetic and metabolic networks underlying phenotypic changes en route to cancer metastasis, effective detection by and activation of the adaptive immune system  
h.levine@northeastern.edu

**Jiahe Li**  
Assistant Professor, Bioengineering  
Researches synthetic biology, drug delivery, polymeric materials and vaccine  
225 ISEC, jiah.li@northeastern.edu
Lee Makowski
Professor and Chair, Bioengineering
Jointly appointed with Chemistry & Chemical Biology.
Researches image and signal processing as applied to biophysical data designed to answer fundamental questions about the molecular basis of living systems.
206B ISEC, L.Makowski@northeastern.edu

Mona Minkara
Assistant Professor of Bioengineering
Computational and Systems Biology
m.minkara@northeastern.edu

Mark Niedre
Associate Professor and Associate Chair For Research, Bioengineering
Prof. Niedre researches and finds interest in biomedical optics and non-invasive imaging, rare cell detection and tracking in the body, ultrafast time-domain diffuse optical imaging, image reconstruction and biomedical signal processing.
217 ISEC, m.niedre@northeastern.edu

Jessica Oakes
Assistant Professor, Bioengineering
Researches pulmonary physiology, biofluids and transport phenomenon, computational biomechanics, magnetic resonance imaging, and multi-scale modeling.
229 ISEC, j.oakes@northeastern.edu

Harikrishnan Parameswaran
Assistant Professor, Bioengineering
In-situ interactions of organized cellular structures in tissue with their extracellular matrix (ECM); airway smooth muscle-ECM interactions under static and dynamic stretch conditions.
219 ISEC, h.parameswaran@northeastern.edu
Sara Rouhanifard  
Assistant Professor, Bioengineering  
Interested in, and researching developing chemical approaches to track and quantify important RNA processing events and modifications in single cells; DNA: protein interactions that drive differences in gene expression; understanding differences in RNA expression and the impacts on disease and development.  
sa.rouhanifard@northeastern.edu

Jeffrey W. Ruberti  
Professor, Bioengineering  
Researches tissue engineering of load-bearing matrix (bone, cornea), bioreactor design, multi-scale mechanobiochemistry, statistical mechanics, energetics microscopy, high-resolution imaging; and biopolymer self-assembly.  
215 ISEC, j.ruberti@northeastern.edu

Sandra Shefelbine  
Associate Professor, Bioengineering  
Jointly appointed with Mechanical & Industrial Engineering  
Researches multi-scale bone biomechanics – how the structure and composition of bone influences its mechanical properties; mechano-adaptation of bone and joint – how tissue responds to mechanical signals.  
222 ISEC, s.shefelbine@northeastern.edu

Shiaoming Shi  
Assistant Teaching Professor, Bioengineering  
Cancer detection and drug discovery technologies  
230 ISEC, s.shi@northeastern.edu
Nikolai Slavov  
Assistant Professor, Bioengineering  
Researches single-cell proteomics, Ribosome-mediated translational regulation, and quantitative systems biology. Most recently Slavov lab developed a high-throughput method for single cell proteomics by mass spectrometry and used it to quantify proteome heterogeneity during cell differentiation.  
334 MU, n.slavov@northeastern.edu

Eduardo Sontag  
University Distinguished Professor, Bioengineering  
Jointly appointed in Electrical and Computer Engineering and Bioengineering. Researches feedback control theory, systems biology, cancer, and biomedicine.  
326 ISEC, e.sontag@northeastern.edu

Staff

Esther Cohen  
Business Manager  
e.cohen@northeastern.edu  
206C ISEC
Appendix A. Bioengineering Department Safety Training

All PhD students and MS students who plan to perform laboratory research are required to complete the basic Department of Bioengineering laboratory safety program, plus any additional lab-specific safety training. Students are strongly advised to complete this training in the first month following matriculation. For more information please contact the department safety officer Dr. Helen Markewich (h.markewich@northeastern.edu)
Appendix B. Suggested PhD Electives by Research Area and Master Electives List

**Area 1 – Imaging, Instrumentation, and Signal Processing**
- BIOE 5235  Biomedical Imaging
- BIOE 5810  Design of Biomedical Instrumentation
- EECE 5606  Micro- and Nanofabrication
- EECE 5639  Computer Vision
- EECE 5642  Data Visualization
- EECE 5644  Machine Learning
- EECE 5648  Biomedical Optics
- EECE 5664  Biomedical Signal Processing
- EECE 5666  Digital Signal Processing
- EECE 7105  Optics for Engineers
- EECE 7200  Linear Systems Analysis
- EECE 7202  Electromagnetic Theory 1
- EECE 7203  Complex Variable Theory and Differential Equations
- EECE 7204  Applied Probability and Stochastic Processes
- EECE 7211  Nonlinear Control
- EECE 7271  Computational Methods in Electromagnetics

**Area 2 - Biomechanics, Biotransport and MechanoBiology**
- BIOE 5650  Multiscale Biomechanics
- BIOE 5656  Fields, Forces, and Flows in Biological Systems
- BIOE 5820  Biomaterials
- BIOL 5601  Multidisciplinary Approaches to Motor Control
- BIOL 5587  Comparative Neurobiology
- IE 7280  Statistical Methods in Engineering
- IE 7315  Human Factors
- ME 5250  Robot Mechanics and Control
- ME 5650  Advanced Mechanics of Material
- ME 5655  Dynamics and Mechanical Vibration
- ME 5657  Finite Element Method
- ME 5659  Control Systems Engineering
- ME 5665  Musculoskeletal Biomechanics
- ME 7210  Elasticity and Plasticity
- ME 7238  Advanced Finite Element Method
- ME 7255  Continuum Mechanics
+ PT 5139  Lab
- PT 5150  Motor Control, Development and Learning

**Area 3 – Molecular, Cell, and Tissue Engineering**
- BIOE 5410  Molecular Bioengineering
- BIOE 5430  Principles and Applications of Tissue Engineering
- BIOL 5543  Stem Cells and Regeneration
- BIOE 5650  Multiscale Biomechanics
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 5820</td>
<td>Biomaterials</td>
</tr>
<tr>
<td>BIOL 6401</td>
<td>Research Methods and Critical Analysis in Molecular Cell Biology</td>
</tr>
<tr>
<td>CHEM 5612</td>
<td>Principles of Mass Spectrometry</td>
</tr>
<tr>
<td>CHME 5699</td>
<td>Nanomaterials</td>
</tr>
<tr>
<td>CHME 5699</td>
<td>Advanced topics in Biomaterials</td>
</tr>
<tr>
<td>CHME 5630</td>
<td>Biochemical Engineering</td>
</tr>
<tr>
<td>CHME 5699</td>
<td>Bioanalytical Sensors</td>
</tr>
<tr>
<td>PMST 6254</td>
<td>Advanced Drug Delivery System</td>
</tr>
<tr>
<td>PHSC 6214</td>
<td>Experimental Design and Biostatics</td>
</tr>
</tbody>
</table>

**Area 4 – Computational and Systems Biology**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOE 5115</td>
<td>Dynamical Systems in Biological Engineering</td>
</tr>
<tr>
<td>BIOE 7500</td>
<td>Methods and Logic in Systems Biology</td>
</tr>
</tbody>
</table>
Appendix B Continued - Master List of Approved BioE PhD Electives

BIOE 5235  Biomedical Imaging
BIOE 5250  Design, Manufacture, and Evaluation of Medical Devices
BIOE 5320  Advanced Biomedical Measurements and Instrumentation
BIOE 5380  Advanced Biomolecular Dynamics and Control
BIOE 5410  Molecular Bioengineering
BIOE 5420  Cellular Engineering
BIOE 5430  Principles and Applications of Tissue Engineering
BIOE 5440  The Cell as a Machine
BIOE 5450  Stem Cell Engineering
BIOE 5630  Physiological Fluid Mechanics
BIOE 5640  Computational Biomechanics
BIOE 5650  Multiscale Biomechanics
BIOE 5656  Fields, Forces, and Flows in Biological Systems
BIOE 5810  Design of Biomedical Instrumentation
BIOE 5820  Biomaterials
BIOE 7100  Special Topics in Biomedical Imaging and Signal Processing
BIOE 7200  Special Topics in Cell and Tissue Engineering
BIOE 7300  Special Topics in Biomechanics
BIOE 7500  Methods and Logic in Systems Biology
BIOL 5307  Biological Electron Microscopy
BIOL 5543  Stem Cells and Regeneration
BIOL 5601  Multidisciplinary Approaches in Motor Control
BIOL 6300  Biochemistry
BIOL 6301  Molecular Cell Biology
BIOL 6401  Research Methods and Critical Analysis in Molecular Cell Biology
CAEP 6202  Research, Evaluation, and Data Analysis
CHEM 5620  Protein Chemistry
CHEM 5621  Principles of Chemical Biology for Chemists
CHEM 5638  Molecular Modeling
CHEM 5660  Analytical Biochemistry
CHEM 7247  Advances in Nanomaterials
CHEM 7317  Analytical Biotechnology
CHME 5630  Biochemical Engineering
CS 5100  Foundations of Artificial Intelligence
CS 5200  Database Management Systems
CS 5310  Computer Graphics
CS 5330  Pattern Recognition and Computer Vision
CS 5335  Robotic Science and Systems
CS 5400  Principles of Programming Language
CS 5600  Computer Systems
CS 5800  Algorithms
CS 6140  Machine Learning
CS 6200  Information Retrieval
CS 6410  Compilers
EECE 5606  Micro- and Nanofabrication
EECE 5642  Data Visualization (new)
EECE 5648  Biomedical Optics
EECE 5664  Biomedical Signal Processing
EECE 7200  Linear Systems Analysis
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EECE 7202</td>
<td>Electromagnetic Theory 1</td>
</tr>
<tr>
<td>EECE 7203</td>
<td>Complex Variable Theory and Differential Equations</td>
</tr>
<tr>
<td>EECE 7204</td>
<td>Applied Probability and Stochastic Processes</td>
</tr>
<tr>
<td>EECE 7205</td>
<td>Fundamentals of Computer Engineering</td>
</tr>
<tr>
<td>EECE 7211</td>
<td>Nonlinear Control</td>
</tr>
<tr>
<td>EECE 7213</td>
<td>System Identification and Adaptive Control</td>
</tr>
<tr>
<td>EECE 7214</td>
<td>Optimal and Robust Control</td>
</tr>
<tr>
<td>EECE 7271</td>
<td>Computational Methods in Electromagnetics</td>
</tr>
<tr>
<td>EECE 7310</td>
<td>Modern Signal Processing</td>
</tr>
<tr>
<td>EECE 7323</td>
<td>Numerical Optimization Methods</td>
</tr>
<tr>
<td>EECE 7337</td>
<td>Information Theory</td>
</tr>
<tr>
<td>EECE 7352</td>
<td>Computer Architecture</td>
</tr>
<tr>
<td>EECE 7353</td>
<td>VLSI Design</td>
</tr>
<tr>
<td>EECE 7364</td>
<td>Mobile and Wireless Networking</td>
</tr>
<tr>
<td>EECE 7368</td>
<td>High-Level Design of Hardware-Software Systems</td>
</tr>
<tr>
<td>IE 7315</td>
<td>Human Factors Engineering</td>
</tr>
<tr>
<td>ME 5650</td>
<td>Advanced Mechanics of Materials</td>
</tr>
<tr>
<td>ME 5655</td>
<td>Dynamics and Mechanical Vibration</td>
</tr>
<tr>
<td>ME 5657</td>
<td>Finite Element Method</td>
</tr>
<tr>
<td>ME 5659</td>
<td>Control Systems Engineering</td>
</tr>
<tr>
<td>ME 5665</td>
<td>Musculoskeletal Biomechanics</td>
</tr>
<tr>
<td>ME 6200</td>
<td>Mathematical Methods for Mechanical Engineers 1</td>
</tr>
<tr>
<td>ME 6260</td>
<td>Introduction to Microelectromechanical Systems (MEMS)</td>
</tr>
<tr>
<td>ME 7210</td>
<td>Elasticity and Plasticity</td>
</tr>
<tr>
<td>ME 7238</td>
<td>Advanced Finite Element Method</td>
</tr>
<tr>
<td>ME 7245</td>
<td>Fracture Mechanics and Failure Analysis</td>
</tr>
<tr>
<td>ME 7255</td>
<td>Continuum Mechanics</td>
</tr>
<tr>
<td>ME 7275</td>
<td>Essentials of Fluid Dynamics</td>
</tr>
<tr>
<td>NNMD 5470</td>
<td>Nano/Biomedical Commercialization: Concept to Market</td>
</tr>
<tr>
<td>OR 6205</td>
<td>Deterministic Operations Research</td>
</tr>
<tr>
<td>PHSC 5100</td>
<td>Concepts in Pharmaceutical Science</td>
</tr>
<tr>
<td>PHSC 6210</td>
<td>Drug Design, Evaluation, and Development</td>
</tr>
<tr>
<td>PHSC 6218</td>
<td>Biomedical Chemical Analysis</td>
</tr>
<tr>
<td>PHSC 6290</td>
<td>Biophysical Methods in Drug Discovery</td>
</tr>
<tr>
<td>PHYS 7301</td>
<td>Classical Mechanics/Math Methods</td>
</tr>
<tr>
<td>PHYS 7321</td>
<td>Computational Physics</td>
</tr>
<tr>
<td>PHYS 7741</td>
<td>Biological Physics 2</td>
</tr>
<tr>
<td>PMST 6250</td>
<td>Advanced Physical Pharmacy</td>
</tr>
<tr>
<td>PMST 6252</td>
<td>Pharmacokinetics and Drug Metabolism</td>
</tr>
<tr>
<td>PMST 6254</td>
<td>Advanced Drug Delivery System</td>
</tr>
<tr>
<td>PT 5138</td>
<td>Neuroscience</td>
</tr>
<tr>
<td>PT 5139</td>
<td>Lab for PT 5138</td>
</tr>
<tr>
<td>PT 5150</td>
<td>Motor Control, Development, and Learning</td>
</tr>
<tr>
<td>PT 5151</td>
<td>Lab for PT 5150</td>
</tr>
<tr>
<td>SLPA 5111</td>
<td>Anatomy and Physiology of the Auditory System</td>
</tr>
<tr>
<td>SLPA 6301</td>
<td>Speech Science</td>
</tr>
</tbody>
</table>
Graduate Student Lab Rotation Allocation Form
Rotation mentors must be a Core Faculty or Affiliated Faculty of the Bioengineering Department. The rotation is an opportunity to determine if the lab is a good ‘fit’ for both mentor and the student. Students are expected to do 2 rotations and should choose a mentor and program by the beginning of Spring Term.

MENTOR
Name ____________________________________
Primary Admin Dept. _______________________
Phone ___________ Email _________________
Graduate Program Affiliation (mark all that apply)

FUNDING (check one)
☐ I have funding to support this student if he/she joins my lab.
   Grant number: ______________ Expiration date: _____________
☐ Grant application is submitted/scored. I expect to have funding to support this student.
☐ I will not have funding, but my department has agreed to support this student for years.
☐ I will not have funding to support this student joining my lab.
   If you will not have funding, you and the student should discuss, and explain below, why you think this rotation is justified (e.g. the student wishes to learn a specific technique)

STUDENT
Name ___________________________
NUID ___________________________
This is my … (check one)
☐ 1st Rotation
☐ 2nd Rotation
☐ Additional

PROJECT (check one)
Please provide a brief description of the project the student will be working on during their rotation.

SIGNATURES

Mentor ____________________________________ Date ______________________

Graduate Student Advisor __________________________ Date ______________________

Student ____________________________________ Date ______________________
Appendix D. PhD Advisor Declaration Form (Following Page)
Northeastern University
Department of Bioengineering

PhD Advisor Declaration/Advisor Change Request Form

Student Name ________________________________________________________________

NUID# ________________________________ E-mail Address __________________________

Advisor Declaration

Advisor Name (print) ____________________________________________________________

Department _________________________________________________________________

Semester/Year Advisor’s RA Support to Begin ______________________________________

*Advisor’s Index Number(s) for first two semesters of RA support ______________________

Proposed Advisor’s Signature ___________________________ Date ______________

Advisor Change Request

Current Advisor Name (print) ____________________________________________________

Department _________________________________________________________________

Current Advisor’s Signature ___________________________ Date ______________

Proposed New Advisor’s Name (print): ____________________________________________

Department _________________________________________________________________

Proposed New Advisor’s Signature: ___________________________ Date ______________

Semester/Year New Advisor’s RA Support to Begin _________________________________

*New Advisor’s Index Number(s) for first two semesters of RA support __________________

Proposed New Advisor’s Signature: ___________________________ Date ______________

Student Signature __________________________________________ Date: __________

Approved by Bioengineering Graduate Director __________________________ Date _______

*Note to Advisor: Index numbers for advisor’s support of subsequent semesters will be required at the time of SGA appointment requests.

After completing this form, submit it to the Business Manager, Bioengineering Office, ISEC 206, and save a copy for your records.
Appendix E. Bioengineering Qualifying Exam, Structure and Criteria

Timing and Organization

i) To be taken in Fall of 2nd year (typical)

ii) In one of 4 subject areas
   1) Imaging, Instrumentation, and Signal Processing
   2) Biomechanics, Biotransport and MechanoBiology
   3) Molecular, Cell, and Tissue Engineering
   4) Computational and Systems Biology

iii) Exam committee will be 3 core BioE faculty

iv) Evaluation process:
   1) There will be a tentative evaluation during the exam (evaluation sheet).
   2) At the end of ‘exam period’ the committee meets and decides on pass/fail for each student
   3) The advisor may attend the meeting and provide input on the student’s research progress. The advisor may also provide their input in writing before the meeting.

v) There will be a makeup exam in the Spring semester.

vi) Students may take the exam only twice.

II. Exam Structure and Requirements

i) The qualifying exam committee will provide a list of 6 papers in the students’ subject area

ii) Students will submit their top 3 choices based on their interest and knowledge. They will be assigned 1 paper (best match) approximately 4 weeks before the exam.

iii) Students will prepare a 6-page (maximum) written document 2 weeks before the oral exam

iv) The written document will be in two parts:
   1) Summary, review and critique of the paper* (3 pages)
   2) A short research proposal (1-2 Aims) that builds on the selected paper (3 pages)

v) The oral exam will be maximum 2 hours in length. The student will present and be questioned on their written document.

vi) Immediately following the exam, the committee will complete the preliminary evaluation form. The evaluation rubric for the exam is included on the next pages for the student’s reference.

vii) Students will not be informed of the result of the exam until after the final meeting. Advisors have the opportunity to provide input at or before the final review meeting.
Bioengineering Qualification Exam Evaluation Sheet

Student:  
Date:  
Examiners Present:  

General Instructions:
• This assessment should be completed immediately after the oral qualification exam without the student present.
• Oral exam will be conducted in two parts, i) comprehension of the selected paper, and, ii) the proposal.
• Students will be assigned a score from 1 to 9 for each section,
  $1 = \text{"outstanding"},$ $9 = \text{"unacceptable"},$ $5 = \text{"average"}$
• Students will not be informed of the exam result on the day of the exam.

Exam Part 1 – Journal Paper:

1a) Did the student demonstrate understanding the underlying scientific premise of the paper?
   
   1  2  3  4  5  6  7  8  9

1b) Did the student understand the relevant methods, assays, imaging modalities etc. involved in the experiments?
   
   1  2  3  4  5  6  7  8  9

1c) Did the student understand the key results and their scientific significance?
   
   1  2  3  4  5  6  7  8  9

1d) Could the student describe the limitations and potential extensions of the paper?
   
   1  2  3  4  5  6  7  8  9

1e) Overall, what was the students level of comprehension of their selected paper?
   
   1  2  3  4  5  6  7  8  9

1f) Other comments for Part 1:
Exam Part 2 – Proposal:

2a) Significance
Did the proposal address an important problem or a barrier to progress in the field? If the aim(s) of the project is achieved, how will scientific knowledge, and/or technical capability, be improved? (from NIH)

2b) Innovation
Does the proposal utilize novel theoretical concepts, approaches or methodologies, instrumentation, or interventions? (from NIH)

2c) Scientific approach and rigor:
Was the overall strategy, methodology, and analyses well-reasoned and appropriate to accomplish the specific aims of the project? Are potential problems, alternative strategies, and benchmarks for success presented? (from NIH)

2d) Quality of oral presentation:
Clarity, quality of presentation materials etc.

2e) Quality of written proposal:
Proper references, grammar, structure, adherence to page limits:

2f) Overall proposal assessment:

2g) Other comments for part 2:

Preliminary Exam Result: Fail Pass
Appendix F. PhD Dissertation Committee Form (Following Page)
Northeastern University Department
of Bioengineering Doctoral Degree
in Bioengineering Ph.D.

Dissertation Committee Form

Name: __________________________________________
Date: ________________________________
NUID: ________________________________

Dissertation Committee Composition:
The Dissertation Committee composition will adhere to the following guidelines: The dissertation committee should be composed of a minimum of three members, two of whom must be selected from the list of bioengineering affiliated faculty. In addition, one of the two affiliated faculty must have a primary appointment in the College of Engineering.

Committee Member Name (print):________________________ Department: ______ Signature: ________________
Committee Member Name (print):________________________ Department: ______ Signature: ________________
Committee Member Name (print):________________________ Department: ______ Signature: ________________
Committee Member Name (print):________________________ Department: ______ Signature: ________________
Committee Member Name (print):________________________ Department: ______ Signature: ________________

Student’s Signature_________________________________________________________ Date: ________________
Approved by Bioengineering Graduate Director___________________________ Date: ________________

After completing this form submit it to Esther Cohen in the Bioengineering Office (206 ISEC) and save a copy for your records.
Appendix G. Industrial PhD - Best Practices and Recommendations

Coursework Requirements
The coursework requirements for Industrial PhD students follow the normal degree requirements (Bioengineering Graduate Handbook Section 3.1).

*Advanced Entry Students:* Most Industrial PhD students have ‘advanced entry’ (AE) status, meaning that they have an MS in a related field, which significantly reduces course requirements (16 Semester Hours or 4 Courses). Some AE Industrial PhD students are unable to be physically on campus where most of our department courses are offered. In these cases, we recommend that AE Industrial PhD students take 3 courses (12 SH) in Independent Study (BIOE 7978) with non-dissertation advisor faculty in different areas of research in our department. These can be literature reviews that can be done offsite on the students’ own time, and will allow breadth and depth for the course requirements. Please note that the Independent Study course may be taken at most 3 times. It is recommended that AE students take Principles of Bioengineering (BIOE 7000) as the remaining 4 SH. There are also a small number of online courses that can be taken.

*Regular-Entry Students:* Industrial PhD students entering with BS only (non-AE) are required to take a 32 Semester Hour course-load as specified in the Graduate Student Handbook. To meet this, students typically must be on campus about 20 hours per week for at least the first two years of their PhD.

PhD students are also required to take the Advanced Seminar Course (BIOE 7390) at least twice. We intend to record and stream department seminars through the Blackboard/Tegrity system beginning Fall 2019. Offsite students may choose register for the course and view the seminars online. Student are required to write a brief summary of the seminar which will be evaluated by the course administrator.

Research Requirements
The core of the PhD program is research and scholarship. Qualifying exams, committee meetings, annual reviews and defenses must be performed “as normal” as described Graduate Handbook Section 3.2.

Research performed by PhDs who are employed at an outside company may present a number of unique challenges with respect to publication, conference presentations, and intellectual property. It is critical that students and potential PhD advisors discuss these issues at the beginning of the PhD. As a general rule, the PhD research should be research performed beyond the student’s job-related research so that it may be freely publicly discussed.

This discussion should be documented in a letter, which will be signed by the student and PI, and reviewed by the Bioengineering Graduate Study Committee. Some considerations include:

- *Where will the research be performed?*
- *What are expectations for journal and conference publications?*
- *Will the student be able to present the research at internal seminars and meetings, as well as at academic conferences?*

Northeastern University has an Industrial PhD Agreement template which can be obtained from the department of Bioengineering office or the Graduate Director. This should be completed and signed before beginning the PhD. Northeastern University has existing policies on IP and licensing with which both the student and advisor should be aware.

Further questions should be addressed to the department of Bioengineering Graduate Director: Mark Niedre, Associate Chair for Research and Graduate Studies, m.niedre@neu.edu