Rapid advances in understanding the fundamental processes of disease have opened up new opportunities to advance human health through research that integrates biology, engineering, physics, and computer science. The doctoral program will prepare leaders in bioengineering in this broader, integrative sense of the discipline. A major distinguishing feature of the curriculum is its emphasis on understanding how biomedical technology is translated from bench to bedside. Graduates from this program will eventually serve at universities, industry or government in a variety of roles, including scientific research, technology development, and regulatory affairs.

Available Concentrations
Four concentration areas are offered, aligned with current faculty research expertise:

- Biomedical Imaging
- Data-driven Biomechanical Modeling
- Nano-scale Bioengineering
- NeuroEngineering

Admissions & Policies

Admissions
Application Requirements
In addition to fulfilling Mason’s admission requirements for graduate study, applicants should:

- Have a baccalaureate degree in engineering or the sciences from an accredited program with a reputation for high academic standards and an earned GPA of 3.3 or better in their highest-level engineering-related credits.
- Provide official GRE Scores: Quantitative (>70% percentile), Verbal (>50% percentile), and Analytical (>50% percentile).
- Provide three letters of recommendation, preferably from academic references or references in industry or government who are familiar with the applicant’s professional accomplishments.
- Provide a resume and detailed statement of career goals and professional aspirations.
- Demonstrate interest in combining engineering and the natural sciences with discovery and application in the life science; i.e., via a degree which reflects the desired combination (such as bioengineering, biophysics); a degree in engineering or the natural sciences which includes course work in life sciences; a degree in biology which includes course work in mathematics, physics, or engineering; a project or research experience with combined complementary expertise.

- For international students only: Official TOEFL scores with a minimum requirement of 570 (paper-based), 230 (computer-based), or 88 points total AND no less than 20 points in each subsection (internet-based).

Policies
Reduction of Credit
Students must complete a minimum of 72 graduate credits, which may be reduced by a maximum of 30 credits from a related master’s degree. Reduction of credit requires the approval of the program director or designee and the dean or designee of the school. They determine how many credits are eligible for the reduction of credit.

For students to remain eligible for the PhD program, they must maintain a “B” average. Grades of “C” or lower in courses cannot be counted towards degree completion.

Program Requirements
The bioengineering PhD program requires successful completion of coursework detailed in a plan of study, qualifying examination, dissertation proposal, and final dissertation defense. Additional training requirements include seminar attendance, ethics training, and mentoring and teaching experience. All the general requirements for doctoral degrees at Mason apply to this program as well.

Requirements
Degree Requirements
Total credits: 72-73

Core Science

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology Core</td>
<td></td>
<td>3-4</td>
</tr>
<tr>
<td>Select one from the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOL 682</td>
<td>Advanced Eukaryotic Cell Biology</td>
<td></td>
</tr>
<tr>
<td>BMED 601</td>
<td>Cell and Molecular Physiology</td>
<td>1</td>
</tr>
<tr>
<td>BMED 605</td>
<td>Introduction to Human Anatomy</td>
<td></td>
</tr>
<tr>
<td>RHBS 710</td>
<td>Applied Physiology I</td>
<td></td>
</tr>
<tr>
<td>Or equivalent courses approved by the student’s advisor and director of the program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computation/Mathematics Core</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Select two from the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECE 528</td>
<td>Introduction to Random Processes in Electrical and Computer Engineering</td>
<td></td>
</tr>
<tr>
<td>ECE 535</td>
<td>Digital Signal Processing</td>
<td></td>
</tr>
<tr>
<td>MATH 685</td>
<td>Numerical Analysis</td>
<td></td>
</tr>
<tr>
<td>Or equivalent courses approved by the student’s advisor and director of the program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Credits</td>
<td></td>
<td>9-10</td>
</tr>
</tbody>
</table>

1 Students who elect to take BMED 601 Cell and Molecular Physiology in the Biology Core will complete a minimum of 73 credit hours.
## Core Bioengineering

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BENG 501</td>
<td>Bioengineering Research Methods</td>
<td>3</td>
</tr>
<tr>
<td>BENG 551</td>
<td>Translational Bioengineering</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Credits 6

## Technical Electives

These graduate courses develop additional technical expertise in a student’s PhD concentration, and provide background for career skills in the student’s chosen path for professional development. A minimum of 9 credits should be at the 600-level or higher. These technical electives should cover scientific and/or technical (12 credits) and career (3 credits) skills, as detailed below:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
</table>

### Scientific and/or Technical Skills

Select 4 courses 1 12

Total Credits 12

1 To be chosen under the guidance and approval of the student’s advisor.

### Career Skills

One course will be focused on developing career skills relevant to college level teaching, entrepreneurship, or health care policy.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Entrepreneurial</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PUBP 781</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Entrepreneurship and Economic Development</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Health Care Policy</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HAP 715</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Health Economics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HAP 742</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Health Policy Development and Analysis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HAP 762</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Cost-Effectiveness for Health Care Management and Policy Decisions</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Teaching</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HE 602</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>College Teaching</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HE 704</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>The Scholarship of Teaching and Learning</td>
<td></td>
</tr>
</tbody>
</table>

Total Credits 3

## Concentrations

Select one concentration and complete the requirements therein.

### Biomedical Imaging (BMI)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BENG 538</td>
<td>Medical Imaging</td>
<td>3</td>
</tr>
<tr>
<td>BENG 537</td>
<td>Introduction to Medical Image Processing</td>
<td>3</td>
</tr>
<tr>
<td>BENG 738</td>
<td>Advanced Medical Image Processing</td>
<td>3</td>
</tr>
</tbody>
</table>

### Electives

Select three more upper-level courses under the guidance and approval of the student’s advisor. 1

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BENG 636</td>
<td>Advanced Biomedical Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>BENG 830</td>
<td>Seminar in Biomedical Imaging</td>
<td>3</td>
</tr>
<tr>
<td>CS 584</td>
<td>Theory and Applications of Data Mining</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Credits 18

1 At least two of the three classes must be at the 700-800 level.

### Concentration in Data-Driven Biomechanical Modeling (DDBM)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BENG 538</td>
<td>Medical Imaging</td>
<td>3</td>
</tr>
<tr>
<td>BENG 550</td>
<td>Advanced Biomechanics</td>
<td>3</td>
</tr>
<tr>
<td>BENG 750</td>
<td>Modeling and Simulation of Human Movement</td>
<td>3</td>
</tr>
</tbody>
</table>

### Electives

Select three more upper-level courses under the guidance and approval of the student’s advisor. 1

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BENG 636</td>
<td>Advanced Biomedical Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>BENG 725</td>
<td>Computational Motor Control</td>
<td>3</td>
</tr>
<tr>
<td>BENG 738</td>
<td>Advanced Medical Image Processing</td>
<td>3</td>
</tr>
<tr>
<td>BENG 850</td>
<td>Seminar in Biomechanics</td>
<td>3</td>
</tr>
<tr>
<td>CS 795</td>
<td>Advanced Topics in CS</td>
<td>3</td>
</tr>
<tr>
<td>CSI 742</td>
<td>The Mathematics of the Finite Element Method</td>
<td>3</td>
</tr>
<tr>
<td>RHBS 711</td>
<td>Applied Physiology II</td>
<td>3</td>
</tr>
<tr>
<td>RHBS 746</td>
<td>Movement Control and Learning</td>
<td>3</td>
</tr>
<tr>
<td>STAT 662</td>
<td>Multivariate Statistical Methods</td>
<td>3</td>
</tr>
<tr>
<td>SYST 664</td>
<td>Bayesian Inference and Decision Theory</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Credits 18

1 At least two of the three classes must be at the 700-800 level.

### Concentration in Nano-Scale Bioengineering (NBNR)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BENG 541</td>
<td>Biomaterials</td>
<td>3</td>
</tr>
<tr>
<td>BENG 641</td>
<td>Advanced Nanotechnology in Health</td>
<td>3</td>
</tr>
<tr>
<td>BENG 745</td>
<td>Biomedical Systems and Microdevices</td>
<td>3</td>
</tr>
</tbody>
</table>

### Electives

Select three more upper-level courses under the guidance and approval of the student’s advisor. 1

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BENG 840</td>
<td>Seminar in Nano-scale Bioengineering</td>
<td>3</td>
</tr>
<tr>
<td>BINF 740</td>
<td>Introduction to Biophysics</td>
<td>3</td>
</tr>
<tr>
<td>ECE 738</td>
<td>Advanced Digital Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>ECE 754</td>
<td>Optimum Array Processing I</td>
<td>3</td>
</tr>
<tr>
<td>OR 842</td>
<td>Models of Probabilistic Reasoning</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 612</td>
<td>Physics of Modern Imaging</td>
<td>3</td>
</tr>
<tr>
<td>PSYC 757</td>
<td>Advanced Topics in Statistical Analysis</td>
<td>3</td>
</tr>
<tr>
<td>PSYC 768</td>
<td>Advanced Topics in Cognitive Science</td>
<td>3</td>
</tr>
<tr>
<td>STAT 760</td>
<td>Advanced Biostatistical Methods</td>
<td>3</td>
</tr>
<tr>
<td>SYST 842</td>
<td>Models of Probabilistic Reasoning</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Credits 18

1 At least two of the three classes must be at the 700-800 level.
The exam will consist of a written research report submitted by the student, a research presentation by the student based on the report, and an oral exam by the committee.

Upon starting the PhD program, the student in consultation with their advisor will define a plan of study and a research topic for the qualifying exam. The topic could be a short original research project, or a review of relevant research in the student’s area. The qualifying exam committee will provide the student a list of readings that the student is expected to master. The student will be expected to submit a research report to the committee and give a research presentation. The report and presentation should demonstrate the student’s ability to articulate a research question or a testable hypothesis, an understanding of the significance of the work informed by a critical review of the relevant literature, an understanding of the relevant research methods, and the ability to analyze and interpret relevant data. Following the research presentation, the committee will administer a closed-door oral exam that will probe in depth of the student’s understanding of the relevant concepts.

The Bioengineering PhD Committee will review the plan of study, the recommendation of the qualifying exam committee and the students’ academic record. Based on this information, the PhD Committee will determine whether or not the student is qualified for the PhD program. If the student does not qualify on their first try, they will be allowed to repeat the exam in the following semester, but the same committee will administer the exam. A student who fails to qualify on their second try will be removed from the program.

Dissertation Proposal

Each student must prepare a written dissertation proposal. While preparing this proposal, the student enrolls in BENG 998 Doctoral Dissertation Proposal. The proposal must be made available to the committee at least two weeks in advance of the presentation. The proposal must be presented to and approved by the dissertation committee. The committee determines whether the proposal has merit and can lead to significant contributions to the area and whether the student has the knowledge and skills to complete the proposed work successfully and in a timely manner. Students may present their dissertation proposal only after passing the qualifying exam, and the presentation may not be on the same day as the qualifying exam. If the student fails to defend the proposal, the student may present a dissertation proposal a second time at a later date. Failure in the second attempt results in dismissal from the program. On completing this requirement successfully, the student is advanced to candidacy for the PhD degree.

Advancement to Candidacy

Each student must present and defend a written dissertation proposal to advance to candidacy. The student is eligible to advance to candidacy after passing the qualifying exam, and satisfactorily completing the required courses in an approved plan of study filed by the student, and completing a minimum of 6 credits of BENG 998 Doctoral Dissertation Proposal. All students must advance to candidacy within four years after initial enrollment in the program, unless special waiver is granted by the PhD committee for extenuating circumstances. If the student has not demonstrated satisfactory progress to the PhD committee by the end of the 4th year, they can be terminated from the program.

The proposal should at a minimum clearly articulate the research question and the specific aims of the research, provide a critical review of the literature and present the rationale and the significance of the research in addressing a gap in scientific knowledge, describe the
research methods and study design in sufficient detail and present preliminary results demonstrating the feasibility of the research.

The proposal must be made available to the committee at least two weeks in advance of the presentation. The committee determines whether the proposal has merit and can lead to significant original contributions to the area.

Following the research presentation, the dissertation committee will ask the students a number of questions in a closed session to evaluate the students understanding of the relevant literature and methods that are broadly related to the chosen area of research, and whether the student has the knowledge and skills to complete the proposed work successfully and in a timely manner. If the dissertation committee feels that the student is not adequately prepared, they may recommend remedial measures, including additional coursework to address any gaps in knowledge, or modification of the aims of the proposal. The student can appear for advancement to candidacy a second time anytime within one year. Failure in the second attempt results in dismissal from the program. On completing this requirement successfully, the student is advanced to candidacy for the PhD degree.

Dissertation Research

Students are expected to complete 24 credits of BENG 998 Doctoral Dissertation Proposal and BENG 999 Doctoral Dissertation towards their degree. Students cannot enroll in BENG 998 Doctoral Dissertation Proposal before they have passed the qualifying exam. Students cannot enroll in BENG 999 Doctoral Dissertation before they have advanced to candidacy. Students who advanced to candidacy after the add period for a given semester must wait until the following semester to register for BENG 999 Doctoral Dissertation. Students cannot advance to candidacy and defend their dissertation during the same semester. In special cases, waivers may be granted by the PhD committee. Once enrolled in BENG 999 Doctoral Dissertation, students must maintain continuous registration in BENG 999 Doctoral Dissertation each semester until graduation, excluding summers. Students who defend in the summer must be registered for at least 1 credit of BENG 999 Doctoral Dissertation during that summer term.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select 24 credits from the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BENG 998</td>
<td>Doctoral Dissertation Proposal (9 credit minimum, 12 credit maximum)</td>
<td>24</td>
</tr>
<tr>
<td>BENG 999</td>
<td>Doctoral Dissertation (12 credit minimum)</td>
<td></td>
</tr>
<tr>
<td>Total Credits</td>
<td></td>
<td>24</td>
</tr>
</tbody>
</table>

Dissertation Committee Selection

Each student must form a dissertation committee, comprising four or five individuals, including the members selected for the qualifying exam. A minimum of two members of the committee must be tenured or tenure-track faculty in the Department of Bioengineering. One member must be from outside the department. The chair of the dissertation committee must be tenured or tenure-track faculty in the Department of Bioengineering. The dissertation director can be a member of the Bioengineering graduate faculty with primary appointment outside of the Department of Bioengineering. The committee and the chair must be approved by the chair of the Department of Bioengineering.

Dissertation Preparation and Defense

While preparing the dissertation, the candidate enrolls in BENG 999 Doctoral Dissertation. The candidate can proceed to a public defense of the dissertation once their dissertation has been approved by the dissertation committee.

The dissertation must make significant contributions to its area as evidenced by refereed journal and/or conference publications. All students are expected to defend their dissertation within three years after defending their proposal, unless special waiver is granted by the PhD committee for extenuating circumstances.

The defense must be announced at least two weeks in advance. The dissertation draft must be submitted to the library and made publicly available at least two weeks in advance of the defense. The entire dissertation committee must be present at the defense, unless an exception is approved by the director of the PhD in Bioengineering Program in advance of the defense. If the candidate fails to defend the dissertation, the candidate may request a second defense, following the same procedures as for the initial defense. There is no time limit for this request other than general time limits for the doctoral degree. A candidate who fails a second attempt to defend the dissertation is terminated from the program.

Additional Training Requirements

Bioengineering Seminar

All PhD students are required to attend a minimum of 3 departmental seminars per semester. Students will sign an attendance sheet available at the end of each seminar.

Ethics Training

Prior to beginning research studies in a Bioengineering laboratory, all PhD students must complete the on-line Collaborative Institutional Training Initiative (CITI) Responsible Conduct of Research course. CITI training modules provide students with an understanding of conflicts of interest, research misconduct, peer review, and authorship.

Bioengineering Mentorship

All PhD students are required to participate in mentoring at least one undergraduate Bioengineering senior design team for a duration of 1 year. PhD students work with the faculty advisor for the senior design team and are expected to apply translational and entrepreneurial concepts towards the mentorship of the team.

Teaching Requirement

All PhD students are required to participate in teaching activities in consultation with their major advisors. Teaching opportunities include presenting lectures, conducting recitation sessions, serving as a teaching assistant, working as a laboratory assistant, participating in teaching workshops, preparing course materials, and other related activities approved by the student’s advisor.