INTERDISCIPLINARY STUDIES: SPECIALIZATION IN TRANSLATIONAL BIOENGINEERING (PHD)

Doctor of Philosophy in Interdisciplinary Studies, specialization in Translational Bioengineering
Unit: Graduate School (http://louisville.edu/graduate/) (GI)
Program Webpage (https://louisville.edu/translational-bioengineering/) (GI)
Academic Plan Code(s): IS_PHDTBE

Program Information
The Interdisciplinary Studies in Translational Bioengineering (ISSTBE) PhD program is designed to provide multidisciplinary training in translational bioengineering preparing students to lead research and development in academia, industry and governmental agencies and/or to advance bioengineering technologies through start-up companies as entrepreneurs or within established biomedical companies. This program is a collaborative effort between J.B. Speed School of Engineering, the School of Medicine, the School of Dentistry, and the College of Business.

In this PhD program, students will have the opportunity to pursue graduate-level training in one of three tracks:

- Traditional Bioengineering Research
- Clinical Translational Research
- Advancement of Bioengineering Technologies through Entrepreneurship

Students must also choose one of the following concentration areas:

- Bioelectronics and Biomedical Devices
- Bioimaging and Biocomputational Modeling
- Biomechanics and Rehabilitation
- Molecular and Tissue Engineering

Students will initially be assigned an advisor to aid in course selection, to identify a primary research mentor and to choose a laboratory where they will conduct their research. Dissertation committee members will be assembled from participating faculty in the Schools of Engineering, Dentistry or Medicine, or the College of Business, representing opportunities to conduct research within a broad range of bioengineering topics and/or develop technology for a wide variety of clinical applications. Students who successfully complete the program will demonstrate excellence in designing and conducting research leading to an intellectual contribution to the field, demonstrate in-depth knowledge of their concentration area and associated scientific literature, have an understanding of the clinical relevance and ethical implications of their research, have the ability to critically analyze, evaluate and interpret research methods and findings, and have the ability to effectively communicate knowledge of their concentration area.

Admission Requirements
The Graduate School has rigorous standards for admission into doctoral programs, and those standards apply to the ISSTBE PhD program as well. Applicants must meet Graduate School admission requirements along with additional program requirements.

Applicants must, as a minimum, have completed a bachelor’s degree in Engineering or similar fields such as Medical Physics from an accredited program with a 3.25 cumulative grade point average to be considered for admission. The ideal applicant will have completed a master’s degree in engineering (MS or MEng) at the time of application.

Applicants must submit the following:

a. Graduate Application (http://louisville.edu/graduate/apply/)
b. Official transcripts of all college-level courses
c. Three letters of recommendation
d. A written statement by the applicant describing previous experience related to bioengineering, and how the PhD in Translational Bioengineering will allow them to fulfill their career goals as identified by their focus area of interest.
e. Students whose native language is non-English or degree is from a non-US accredited institution are required to submit TOEFL scores (administered by the Educational Testing Service). A minimum TOEFL score of 79 or higher on the internet-based test is required. Alternatively, a minimum of 6.5 on the International English Language Testing System will be accepted or a Duolingo score of 105.
f. Resume/CV required
g. Optional Graduate Record Exam (GRE).

Program Requirements
To earn the Doctor of Philosophy in Interdisciplinary Studies with a specialization in Translational Bioengineering (ISSTBE), students are required to successfully complete the following:

- 47 credit hours of course work beyond their bachelor’s degree (18 Core credit hours, nine (9) Concentration credit hours, 20 Specialization credit hours)
- Participate in the Bioengineering Seminar Series (75 percent attendance rate and one presentation/year as a Doctoral Candidate)
- Pass the Preliminary Examination
- Pass the Comprehensive Examination
- Successfully defend a dissertation
- Submit three or more peer-reviewed journal papers representing their original dissertation research

Coursework

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
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<tbody>
<tr>
<td>BE 601</td>
<td>Bioengineering Seminar</td>
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<tr>
<td>BE 603</td>
<td>Bioengineering Research Ethics</td>
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<tr>
<td>BE 621</td>
<td>Bioinstrumentation</td>
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</tr>
<tr>
<td>BE 654</td>
<td>Advanced Physiology for Engineers</td>
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<tr>
<td>BE 695</td>
<td>Bioengineering Research Design &amp; Methods</td>
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<tr>
<td>ME 565</td>
<td>Advanced Engineering Mathematics I</td>
<td>1</td>
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</table>

Concentration Area - nine (9) credit hours in one of the following areas

Molecular and Tissue Engineering
<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
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<tbody>
<tr>
<td>ASNB 602</td>
<td>Fundamentals of Neuroscience</td>
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<tr>
<td>ASNB 614</td>
<td>Molecular Neuroscience</td>
<td>4</td>
</tr>
<tr>
<td>ASNB 617</td>
<td>Seminar on Developmental Neurobiology</td>
<td>3</td>
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<tr>
<td>ASNB 671</td>
<td>General and Oral Histology</td>
<td>5</td>
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<tr>
<td>BE 522</td>
<td>Biomedical Acoustics</td>
<td>3</td>
</tr>
<tr>
<td>BE 524</td>
<td>LabVIEW for Bioengineers</td>
<td>3</td>
</tr>
<tr>
<td>BE 540</td>
<td>Machine Learning in Medicine</td>
<td>3</td>
</tr>
<tr>
<td>BE 542</td>
<td>Medical Image Computing</td>
<td>3</td>
</tr>
<tr>
<td>BE 552</td>
<td>Introduction to Tissue Engineering</td>
<td>3</td>
</tr>
<tr>
<td>BE 553</td>
<td>Nanoscale Bioengineering: Application and Methodology of Nanobiomaterials in Bioengineering</td>
<td>3</td>
</tr>
<tr>
<td>BE 581</td>
<td>Advanced Computer-Aided Design and Manufacturing for Bioengineers</td>
<td>3</td>
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<tr>
<td>BE 600</td>
<td>Advanced Topics in Bioengineering</td>
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<tr>
<td>BE 605</td>
<td>Tissue and Molecular Biology Techniques Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>BE 630</td>
<td>Biomechanical Computer Modeling and Simulation of Human Movement</td>
<td>3</td>
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<tr>
<td>BE 639</td>
<td>Injury Biomechanics</td>
<td>3</td>
</tr>
<tr>
<td>BE 640</td>
<td>Computational Methods for Medical Image Analysis</td>
<td>3</td>
</tr>
<tr>
<td>BE 650</td>
<td>Advanced Biomaterials</td>
<td>3</td>
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<tr>
<td>BE 658</td>
<td>Rehabilitation Engineering and Assistive Technology</td>
<td>3</td>
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<tr>
<td>BE 683</td>
<td>Artificial Organs</td>
<td>3</td>
</tr>
<tr>
<td>BIOL 612</td>
<td>Advanced Endocrinology</td>
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<tr>
<td>BIOC 611</td>
<td>Techniques in Biomolecular Interactions</td>
<td>4</td>
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<tr>
<td>BIOC 645</td>
<td>Advanced Biochemistry I</td>
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<tr>
<td>BIOC 675</td>
<td>Cancer Biology</td>
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<td>BIOC 680</td>
<td>Biomolecular Interactions</td>
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<td>BIOL 612</td>
<td>Advanced Endocrinology</td>
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<tr>
<td>CSE 535</td>
<td>Database Systems</td>
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<td>CSE 545</td>
<td>Artificial Intelligence</td>
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<td>CSE 619</td>
<td>Design and Analysis of Computer Algorithms</td>
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<tr>
<td>CSE 622</td>
<td>Simulation and Modeling of Discrete Systems</td>
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<tr>
<td>CSE 627</td>
<td>Digital Image Processing</td>
<td>3</td>
</tr>
<tr>
<td>CSE 628</td>
<td>Computer Graphics</td>
<td>3</td>
</tr>
<tr>
<td>CSE 632</td>
<td>Data Mining</td>
<td>3</td>
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</table>

**Minimum Total Hours**: 47

**Specialization Area Guided Electives**

Courses in Specialization must be unique from those taken to fulfill the Concentration Requirement, and must follow either Track A, B or C below. Students must work with their advisor to establish a Plan of Study for Specialization Courses. All Specialization courses must be approved by the student's advisor prior to registration.

**Track A**

Traditional Bioengineering Research PhD: 18 credit hours from those listed below with a minimum of six (6) credit hours in engineering courses + Teaching Practicum (two (2) credit hours)

**Track B**

Clinical-Translation Research PhD: 12 credit hours from list below designated as BIOC, ASNB, PSYC, BIOL, MBIO, OBIO, OBIO or EXP; remaining six (6) credit hours from BE, CECS, ECE, IE, or ME + Clinical Practicum (two (2) credit hours).

**Track C**

Advancing Bioengineering Technologies through Entrepreneurship PhD: 12 credit hours from list below designated as ENTR or IMBA; remaining six (6) credit hours from BE, CECS, ECE, IE, ME + Teaching Practicum (two (2) credit hours).
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tr>
<td>CSE 633</td>
<td>Computer Vision</td>
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</tr>
<tr>
<td>CSE 635</td>
<td>Data Mining with Linear Models</td>
<td>3</td>
</tr>
<tr>
<td>CSE 660</td>
<td>Introduction to Bioinformatics</td>
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</tr>
<tr>
<td>ECE 520</td>
<td>Digital Signal Processing</td>
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<td>Digital Signal Processing Laboratory</td>
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<td>ECE 523</td>
<td>Introduction to Biometrics</td>
<td>3</td>
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<tr>
<td>ECE 543</td>
<td>Fundamentals of Microfabrication and MEMS</td>
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<tr>
<td>ECE 544</td>
<td>Microfabrications/MEMS Laboratory</td>
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<tr>
<td>ECE 564</td>
<td>Fundamentals of Autonomous Robots</td>
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<td>ECE 565</td>
<td>Fundamentals of Autonomous Robots Lab</td>
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<td>ECE 614</td>
<td>Deep Learning</td>
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<td>ECE 661</td>
<td>Sampled-Data Control Systems</td>
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<td>ECE 662</td>
<td>Introduction to Optimum Control</td>
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<tr>
<td>ECE 676</td>
<td>Foundations of Polymer MEMS</td>
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<tr>
<td>ENTR 702</td>
<td>Research Design I</td>
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<td>ENTR 741</td>
<td>Research Design II</td>
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<tr>
<td>ENTR 747</td>
<td>Corporate Entrepreneurship and Innovation</td>
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<td>IE 563</td>
<td>Experimental Design in Engineering</td>
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<tr>
<td>MBIO 601</td>
<td>Molecular Microbiology</td>
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<td>MBIO 602</td>
<td>Immunology</td>
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<td>MBIO 610</td>
<td>Methods and Analysis in the Biomedical Sciences</td>
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<td>MBIO 618</td>
<td>Topics in Advanced Microbiology</td>
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<td>ME 566</td>
<td>Advanced Engineering Mathematics II</td>
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<tr>
<td>ME 638</td>
<td>Computational Methods in Fluid Flow and Heat Transfer</td>
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<td>ME 640</td>
<td>Optimum Design Methods</td>
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<tr>
<td>ME 644</td>
<td>Mechatronics</td>
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<td>ME 647</td>
<td>Advanced Design Methods</td>
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<td>ME 650</td>
<td>Biofluid Mechanics</td>
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<td>ME 651</td>
<td>Kinematics and Kinetics of Human Movement</td>
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<td>ME 652</td>
<td>Advanced Human Biodynamics</td>
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<td>ME 671</td>
<td>Advanced Fluid Mechanics</td>
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<td>ME 675</td>
<td>Advanced Topics in Mechanical Engineering</td>
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<tr>
<td>OBIO 611</td>
<td>Craniofacial Osteology</td>
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<tr>
<td>OBIO 612</td>
<td>Craniofacial Diagnostic Imaging</td>
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<td>OBIO 617</td>
<td>Advanced Oral Pathology</td>
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<td>OIID 604</td>
<td>Oral Microbiology</td>
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</tr>
<tr>
<td>PHZB 611</td>
<td>Advanced Human Cardiovascular Physiology</td>
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</tbody>
</table>

Area courses. The Preliminary Examination includes written and oral components. The written portion of the exam gauges student competency in fundamental bioengineering topics covered in their courses. ISSTBE affiliated faculty will submit and grade questions in their respective areas of expertise for the written portion of the Preliminary Examination. The oral portion of the examination is a formal presentation comprised of the student’s critique of a peer-reviewed journal paper selected from the student’s area of concentration, delivered to the ISSTBE Program Director and a subset of faculty with expertise in the respective concentration having Graduate Faculty status. Students are allowed no more than two opportunities to take the Preliminary Examination (oral or written components).

**Comprehensive Examination**

To qualify for candidacy, students must pass the Preliminary Examination, maintain a minimum GPA of 3.0 and pass the Comprehensive Examination. The Comprehensive Examination requires the student to prepare a written dissertation research proposal (following an external funding agency format) that is presented, defended and approved by their Dissertation Committee. The Dissertation Committee approval constitutes passing both the written and oral portions of the Comprehensive Examination. The written portion is comprised of the student’s dissertation proposal document and the oral portion consists of the student’s presentation and defense of their dissertation proposal, including response to questions posed by their Dissertation Committee. The Dissertation Committee will evaluate written and oral performance on the Comprehensive Examination separately as a Pass, Conditional Pass, or Fail. Students receiving a Conditional Pass must satisfactorily meet conditions set forth by the Dissertation Committee in order to Pass. Students failing either or both portions of the Comprehensive Examination will be permitted to repeat the respective portion(s) once.

Students must meet with their Dissertation Committee at least once per year during the remainder of their PhD program, culminating in the Dissertation Defense.

**Dissertation Committee**

By the end of the first semester, it is expected that the student has identified their Dissertation Chair. The student (under the guidance of his or her advisor) must select a Dissertation Committee of five or more persons, for approval by the Program Director. The committee must consist of the student’s advisor from the Department of Bioengineering (who will act as the Dissertation Committee Chair), at least two additional faculty members from within the Department of Bioengineering, at least one faculty member from a partnering School or College, and at least one additional faculty member from outside the Department of Bioengineering.

**Preliminary Examination**

The PhD Preliminary Examination will be offered once per year and is to be taken by students upon completion of Core courses (with the exception of Bioengineering Seminar credits) and Concentration