

# 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/>)

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 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:

1. Graduate Application (<http://louisville.edu/graduate/apply/>)
2. Official transcripts of all college-level courses
3. Three letters of recommendation
4. A written statement by the applicant describing previous experience related to bioengineering
5. A statement as to how the PhD ISSTBE will allow them to fulfill their career goals as identified by their focus area of interest
6. Official Graduate Record Exam (GRE) verbal, quantitative, and writing assessment-analytical scores. Competitive scores on the verbal and quantitative sections will be required for admission.
7. 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.

## 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

Code	Title	Hours
<b>Core Requirements</b>		<b>18</b>
BE 601	Bioengineering Seminar	
BE 603	Bioengineering Research Ethics	
BE 621	Bioinstrumentation	
BE 654	Advanced Physiology for Engineers	
BE 695	Bioengineering Research Design & Methods	
ME 565	Advanced Engineering Mathematics I	
<b>Concentration Area - nine (9) credit hours in one of the following areas</b>		<b>9</b>

*Molecular and Tissue Engineering*

BE 553	Nanoscale Bioengineering: Application and Methodology of Nanobiomaterials in Bioengineering
BE 552	Introduction to Tissue Engineering
BE 605	Tissue and Molecular Biology Techniques Laboratory
BE 650	Advanced Biomaterials
BIOC 611	Techniques in Biomolecular Interactions
BIOC 668	Molecular Biology
BIOC 680	Biomolecular Interactions
<i>Bioimaging and Biocomputational Modeling</i>	
BE 542	Medical Image Computing
BE 540	Machine Learning in Medicine
BE 685	Modeling of Biological Phenomena
BE 640	Computational Methods for Medical Image Analysis
CSE 622	Simulation and Modeling of Discrete Systems
CSE 627	Digital Image Processing
<i>Bioelectrical and Biomedical Devices</i>	
BE 524	LabVIEW for Bioengineers
BE 581	Advanced Computer-Aided Design and Manufacturing for Bioengineers
BE 611	Cardiovascular Dynamics
BE 650	Advanced Biomaterials
BE 683	Artificial Organs
ECE 543	Fundamentals of Microfabrication and MEMS
ME 640	Optimum Design Methods
ME 647	Advanced Design Methods
<i>Biomechanics and Rehabilitation</i>	
BE 630	Biomechanical Computer Modeling and Simulation of Human Movement
ME 651	Kinematics and Kinetics of Human Movement
BE 611	Cardiovascular Dynamics
BE 639	Injury Biomechanics
BE 658	Rehabilitation Engineering and Assistive Technology
ME 650	Biofluid Mechanics
ME 652	Advanced Human Biodynamics
ME 638	Computational Methods in Fluid Flow and Heat Transfer
<b>Specialization Area Elective Coursework (see below)</b>	<b>20</b>
<b>Minimum Total Hours</b>	<b>47</b>

## 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, MBI, 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).

Code	Title	Hours
<b>Guided Electives</b>		<b>20</b>
ASNB 602	Fundamentals of Neuroscience	4
ASNB 614	Molecular Neuroscience	4
ASNB 617	Seminar on Developmental Neurobiology	3
ASNB 671	General and Oral Histology	5
BE 522	Biomedical Acoustics	3
BE 524	LabVIEW for Bioengineers	3
BE 540	Machine Learning in Medicine	3
BE 542	Medical Image Computing	3
BE 552	Introduction to Tissue Engineering	3
BE 553	Nanoscale Bioengineering: Application and Methodology of Nanobiomaterials in Bioengineering	3
BE 581	Advanced Computer-Aided Design and Manufacturing for Bioengineers	3
BE 600	Advanced Topics in Bioengineering	1-6
BE 605	Tissue and Molecular Biology Techniques Laboratory	3
BE 611	Cardiovascular Dynamics	3
BE 630	Biomechanical Computer Modeling and Simulation of Human Movement	3
BE 639	Injury Biomechanics	3
BE 640	Computational Methods for Medical Image Analysis	3
BE 650	Advanced Biomaterials	3
BE 658	Rehabilitation Engineering and Assistive Technology	3
BE 683	Artificial Organs	3
BE 692	Bioengineering Clinical Rotation	2
BE 693	Independent Study in Bioengineering	1-6
BIOC 611	Techniques in Biomolecular Interactions	4
BIOC 645	Advanced Biochemistry I	4
BIOC 668	Molecular Biology	4
BIOC 680	Biomolecular Interactions	2
CSE 535	Database Systems	3
CSE 545	Artificial Intelligence	3
CSE 619	Design and Analysis of Computer Algorithms	3
CSE 622	Simulation and Modeling of Discrete Systems	3
CSE 627	Digital Image Processing	3
CSE 628	Computer Graphics	3
CSE 632	Data Mining	3
CSE 633	Computer Vision	3
CSE 635	Data Mining with Linear Models	3

CSE 660	Introduction to Bioinformatics	3
ECE 520	Digital Signal Processing	3
ECE 521	Digital Signal Processing Laboratory	1
ECE 523	Introduction to Biometrics	3
ECE 543	Fundamentals of Microfabrication and MEMS	3
ECE 544	Microfabrications/MEMS Laboratory	1
ECE 564	Fundamentals of Autonomous Robots	3
ECE 565	Fundamentals of Autonomous Robots Lab	1
ECE 614	Deep Learning	3
ECE 661	Sampled-Data Control Systems	3
ECE 662	Introduction to Optimum Control	3
ECE 676	Foundations of Polymer MEMS	3
ENTR 600	Introduction to Entrepreneurship	3
IE 563	Experimental Design in Engineering	3
IMBA 652	Venture Accelerator I	3
IMBA 654	Venture Accelerator II	3
IMBA 664	Venture Accelerator III	3
MBIO 601	Molecular Microbiology	2
MBIO 602	Immunology	3
MBIO 610	Methods and Analysis in the Biomedical Sciences	2
MBIO 618	Topics in Advanced Microbiology	1-3
ME 566	Advanced Engineering Mathematics II	3
ME 638	Computational Methods in Fluid Flow and Heat Transfer	3
ME 640	Optimum Design Methods	3
ME 647	Advanced Design Methods	3
ME 650	Biofluid Mechanics	3
ME 651	Kinematics and Kinetics of Human Movement	3
ME 652	Advanced Human Biodynamics	3
ME 671	Advanced Fluid Mechanics	3
ME 675	Advanced Topics in Mechanical Engineering	1-6
OBIO 611	Craniofacial Osteology	1-3
OBIO 612	Cranioaxillofacial Diagnostic Imaging	2-4
OBIO 617	Advanced Oral Pathology	1
OIID 604	Oral Microbiology	3

## 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 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.