The Department of Biomedical Engineering confers a doctoral degree in biomedical engineering (Ph.D. in Biomedical Engineering). Currently, eight faculty members hold tenured positions, and one faculty member holds a tenure track position in the department. Several departments at IIT contribute courses and faculty to the graduate program: Biological and Chemical Sciences; Physics; Chemical and Biological Engineering; Computer Science; Electrical and Computer Engineering; Mechanical, Materials, and Aerospace Engineering; the College of Psychology; and the Center for Ethics in the Professions.

An M.D./Ph.D. program is in place whereby students with engineering backgrounds can receive a Ph.D. in Biomedical Engineering at IIT and an M.D. from the University of Chicago. Qualified students are admitted to the MSTP (Medical Scientist Training Program) at the University of Chicago and subsequently apply to the Department of Biomedical Engineering for their Ph.D. studies.

**Degrees Offered**

- Master of Engineering in Biomedical Engineering
- Master of Science in Biomedical Engineering
- Doctor of Philosophy in Biomedical Engineering

**Research Areas**

- Cell and Tissue Engineering
- Medical Imaging
- Neural Engineering

**Faculty**

- Arfanakis, Konstantinos, Professor and Director of the MRI Program in the Pritzker Institute. B.S., University of Athens (Greece); M.S., Ph.D., University of Wisconsin-Madison. Magnetic resonance imaging (MRI), MRI acquisition and post-processing, diffusion tensor MRI (DTI), functional MRI (fMRI).

- Arzbaecher, Robert, Emeritus Professor. Ph.D., University of Illinois, Urbana-Champaign. Instrumentation, signal processing and control.

- Brey, Eric M., Professor. B.S., M.Eng., University of Louisville; Ph.D., Rice University. Angiogenesis, biomaterials, tissue engineering.

- Cinar, Ali, Professor of Chemical Engineering and Biomedical Engineering and Director of the Engineering Center for Diabetes Research and Education. B.S., Robert College (Turkey); M.S., Ph.D., Texas A & M University. Diabetes and control of artificial pancreas systems; modeling, supervision, and control of biological, biomedical, and chemical processes with agent-based systems, multivariate statistics and artificial intelligence applications; modeling of angiogenesis and tissue growth.

- DePaola, Natacha, Professor and the Carol and Ed Kaplan Armour Dean of Engineering. B.S., Simon Bolivar University (Venezuela); M.S., Massachusetts Institute of Technology; Ph.D., Harvard Medical School - Massachusetts Institute of Technology.

- Dhar, Promila, Senior Lecturer.

- Haferkamp, Bonnie, Senior Lecturer. B.S., Iowa State University; M.S., Ph.D., Illinois Institute of Technology.

- Irving, Thomas C., Professor of Biology, Physics, and Biomedical Engineering and Executive Associate Chair for Biology, Biological and Chemical Sciences. B.Sc., M.Sc., Ph.D., University of Guelph (Canada). Structure and biophysics of macromolecular systems, muscle structure and physiology, synchrotron radiation instrumentation. Biochemistry, Molecular Biochemistry, and Biophysics.

- Kamper, Derek, Associate Professor. B.S., Dartmouth College; M.S., Ph.D., Ohio State University. Neural control, biomechanics and rehabilitative medicine.

- Kang-Mieler, Jennifer J., Associate Professor. B.S., M.S., Ph.D., Northwestern University. Models of thrombotic retinal vessel occlusion, blood flow, electroretinography.

- Mogul, David, Associate Professor and Chair. B.S., Cornell University; M.S., M.B.A., Ph.D., Northwestern University. Control of epilepsy, brain electrophysiology, brain stimulation, traumatic brain injury.
Papavasiliou, Georgia, Associate Professor. B.S., Ph.D., Illinois Institute of Technology. Computational modeling of polymerization systems, design of polymeric biomaterials for tissue engineering and drug delivery applications.

Tichauer, Kenneth, Assistant Professor.

Trommer, Barbara L., Research Professor. B.A., Queens College; M.D., Columbia College, College of Physicians and Surgeons. Epilepsy, autism, and treatment for neurological disorders.

Troyk, Philip R., Professor and Associate Dean, Armour College of Engineering. B.S., University of Illinois, Urbana-Champaign; M.S., Ph.D., University of Illinois-Chicago. Neural prostheses, medical device implants, neuroscience.

Turitto, Vincent, Pritzker Professor and Director of the Pritzker Institute of Biomedical Science and Engineering. B.ChE., Manhattan College; D.Engr.Sci., Columbia University. Blood flow and thrombosis, atherosclerosis, cellular biodynamics, biomaterials.

Admission Requirements

Minimum cumulative undergraduate GPA: 3.2/4.0
GRE minimum scores:
1800 (combined)
1200 (quantitative + verbal) 3.0 (analytical writing)

Meeting the minimum admission standards for GPA and GRE scores does not guarantee admission. Test scores and GPA are just two of several important factors considered. The admissions committee will also consider recommendations from three college faculty members acquainted with the character, research ability, potential, qualifications, and motivation of the applicant, and the needs of the departmental faculty. Entering graduate students are assigned a temporary academic advisor who will provide initial guidance. As their research and other academic interests become defined, students select a permanent research advisor, who will also guide them through their academic studies.
Master of Engineering in Biomedical Engineering

30 credit hours

The overall objective of the Master of Engineering in Biomedical Engineering degree is to provide training relevant to professional employment in a BME-related field. The student must have a minimum 3.0/4.0 GPA in an engineering or science Bachelor’s program to be admitted. Candidates should have prior technical coursework that will provide proficiency in areas that are relevant to the field of biomedical engineering.

Required Courses

BME 500  Introduction to Biomedical Engineering
BME 533  Biostatistics
BME 553  Quantitative Physiology

AND two Life Science and/or Advanced Mathematics courses.

AND five Engineering and/or Computer Science courses, of which at least two are BME courses.

Master of Science in Biomedical Engineering

32 credit hours

Thesis

The overall objective of the Master of Biomedical Engineering degree is to provide training relevant to professional employment in a BME-related field. A minimum total of 32 credit hours is required for this degree, of which at least 24 credit hours must come from coursework; 6-8 credits of research are required. This degree requires completion of a written dissertation and a subsequent oral defense of it before an approved Master thesis examination committee.

Admission Criteria: Because the M.S. degree requires the time and frequently the resources of a faculty mentor to be available, in order to adequately execute the research component of the degree, the BME Department will admit candidates who not only have the credentials suitable for this degree but for which a department faculty member consents to serve as the candidate’s research mentor.

Required Courses

BME 500  Introduction to Biomedical Engineering
BME 533  Biostatistics
BME 553  Quantitative Physiology

AND two Life Science and/or Advanced Mathematics courses

AND three Engineering and/or Computer Science courses, of which at least two are BME courses.
# Doctor of Philosophy in Biomedical Engineering

**Total credit hours 72**  
Qualifying examination (written and oral)  
Thesis research proposal/comprehensive examination  
Dissertation and oral defense  

This degree is awarded in recognition of a high level of mastery in subject matter and a significant original research contribution in biomedical engineering. The Ph.D. recipient will be capable of a continuing effort toward the advancement of knowledge and achievement in research and other scholarly activities and may pursue a career in a medical, an industrial, or an academic environment.

A minimum of 72 credit hours is required for the Ph.D. in Biomedical Engineering. Students who have received an M.S. degree from another university may petition for transfer of up to 32 credit hours applicable toward the Ph.D. degree. Students must pass the Ph.D. qualifying examination within the first year of full-time Ph.D. studies. This is a written and oral examination intended to explore both the depth and breadth of the student’s academic abilities. Within two and one-half years of matriculation, students will be required to defend their thesis research proposal (comprehensive examination). A written dissertation and oral defense are also required for receiving the doctoral degree. Dissertation format and deadlines are established by the Graduate College.

There are no specific courses that are required for the doctoral degree in biomedical engineering. However, a minimum of three courses in life science, three courses in mathematics, and six courses in biomedical engineering or other engineering-related courses are required. The specific courses selected to meet these requirements will depend on the entering qualifications of the student and the nature of the thesis research proposal. In general, the student’s thesis committee will determine the specific course requirements necessary for graduation.

The following blocks of courses list applicable graduate level courses for graduate students in BME. They do not represent a complete and comprehensive list of all relevant courses since course offerings across departments may change with time. Graduate students should consult with their advisors to plan their curriculum.

## Biomedical Engineering Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 500</td>
<td>Introduction to Biomedical Engineering</td>
</tr>
<tr>
<td>BME 501</td>
<td>Communication Skills in Biomedical Engineering</td>
</tr>
<tr>
<td>BME 503</td>
<td>Mathematics and Statistical Methods for Neuroscience I</td>
</tr>
<tr>
<td>BME 504</td>
<td>Neurobiology</td>
</tr>
<tr>
<td>BME 505</td>
<td>Mathematics and Statistical Methods for Neuroscience II</td>
</tr>
<tr>
<td>BME 506</td>
<td>Computational Neuroscience II: Vision</td>
</tr>
<tr>
<td>BME 507</td>
<td>Cognitive Neuroscience</td>
</tr>
<tr>
<td>BME 508</td>
<td>Mathematics and Statistics for Neuroscience III</td>
</tr>
<tr>
<td>BME 509</td>
<td>Vertebrate Neural Systems</td>
</tr>
<tr>
<td>BME 518</td>
<td>Reaction Kinetics for Biomedical Engineering</td>
</tr>
<tr>
<td>BME 521</td>
<td>Medical Imaging</td>
</tr>
<tr>
<td>BME 522</td>
<td>Mathematical Methods in Biomedical Engineering</td>
</tr>
<tr>
<td>BME 523</td>
<td>Cell Biomechanics: Principles and Biological Processes</td>
</tr>
<tr>
<td>BME 524</td>
<td>Quantitative Aspects of Cell and Tissue Engineering</td>
</tr>
<tr>
<td>BME 530</td>
<td>Inverse Problems in Biomedical Imaging</td>
</tr>
<tr>
<td>BME 532</td>
<td>Medical Imaging Science</td>
</tr>
<tr>
<td>BME 533</td>
<td>Biostatistics</td>
</tr>
<tr>
<td>BME 535</td>
<td>Magnetic Resonance Imaging</td>
</tr>
<tr>
<td>BME 537</td>
<td>Introduction to Molecular Imaging</td>
</tr>
<tr>
<td>BME 538</td>
<td>Neuroimaging</td>
</tr>
<tr>
<td>BME 540</td>
<td>Wave Physics &amp; Applied Optics for Imaging Scientists</td>
</tr>
<tr>
<td>BME 542</td>
<td>Advanced Concepts in Image Science</td>
</tr>
<tr>
<td>BME 543</td>
<td>Bioinstrumentation &amp; Electronics</td>
</tr>
<tr>
<td>BME 551</td>
<td>Physiological Signal Processing &amp; Control Theory</td>
</tr>
<tr>
<td>BME 552</td>
<td>Control Systems for Biomedical Engineers</td>
</tr>
<tr>
<td>BME 553</td>
<td>Quantitative Physiology</td>
</tr>
<tr>
<td>BME 557</td>
<td>Neuromechanics of Human Movement</td>
</tr>
<tr>
<td>BME 581</td>
<td>Fluid Mechanics for Biomedical Engineers</td>
</tr>
<tr>
<td>BME 582</td>
<td>Advanced Mass Transport for Biomedical Engineers</td>
</tr>
<tr>
<td>BME 585</td>
<td>Computational Models of the Human Cardiovascular System</td>
</tr>
<tr>
<td>BME 595</td>
<td>Seminar in Biomedical Engineering</td>
</tr>
<tr>
<td>BME 597</td>
<td>Special Problems</td>
</tr>
<tr>
<td>BME 691</td>
<td>Research and Thesis for Ph.D. degree</td>
</tr>
</tbody>
</table>
Doctor of Philosophy in Biomedical Engineering - continued

**Life Science Courses (representative)**

- BIOL 403 Biochemistry Lecture
- BIOL 414 Genetics for Engineering Scientists
- BIOL 426 Concepts of Cancer Biology
- BIOL 430 Animal Physiology
- BIOL 445 Cell Biology
- BIOL 512 Advanced Biochemistry
- BIOL 515 Molecular Biology
- BIOL 527 Immunology and Immunochemistry
- BIOL 550 Bioinfomatics

**Approved Math/Applied Math Courses**

- MATH 461 Fourier Series and Boundary-Value Problems
- MATH 476 Statistics
- MATH 489 Partial Differential Equations
- MATH 512 Partial Differential Equations
- MATH 519 Complex Analysis
- MATH 532 Linear Algebra
- MATH 542 Stochastic Processes
- MATH 546 Introduction to Time Series
- MATH 555 Tensor Analysis
- MATH 577 Computational Mathematics I
- MATH 578 Computational Mathematics II
- MATH 581 Finite Element Method

**Engineering or Physics Courses (representative)**

*(may count toward math requirement)*

- CHE 535 Applications of Mathematics to Chemical Engineering
- CHE 536 Computational Techniques in Engineering
- MMAE 501 Engineering Analysis I
- MMAE 502 Engineering Analysis II
- MMAE 503 Advanced Engineering Analysis
- MMAE 517 Computational Fluid Mechanics
- PHYS 501 Methods of Theoretical Physics I
- PHYS 502 Methods of Theoretical Physics II

**Selected Engineering Electives**

- CHE 555 Polymer Processing
- CHE 575 Polymer Rheology
- CHE 577 Bioprocess Engineering
- CHE 582 Interfacial and Colloidal Phenomena with Applications
- CHE 583 Pharmaceutical Engineering
- CHE 585 Drug Delivery
- CS 480 Artificial Intelligence Planning & Control
- CS 525 Advanced Database Organization
- CS 580 Topics in Machine Learning
- CS 583 Probabalistic Graphical Models
- ECE 511 Analysis of Random Signals
- ECE 565 Computer Vision and Image Processing
- ECE 566 Statistical Pattern Recognition
- ECE 567 Statistical Signal Processing
- MMAE 510 Fundamentals of Fluid Mechanics
- MMAE 512 Dynamics of Viscous Fluids
- MMAE 517 Computational Fluid Dynamics
- MMAE 579 Advanced Materials Processing
Biomedical Engineering

Course Descriptions

**BME 500 Introduction to Biomedical Engineering**
Introduction to the concepts and research in biomedical engineering. Provides an overview of current biomedical engineering research areas, emphasis on application of an engineering approach to medicine and physiology signals. (3-0-3)

**BME 501 Communication Skills in Biomedical Engineering**
Students will be taught to critically analyze manuscripts in the biomedical engineering literature. They will write a critique of the manuscripts, discuss the manuscripts in class, and prepare power point presentations that will be presented and evaluated by the entire class. (3-0-3)

**BME 503 Mathematical & Statistical Methods for Neuroscience I**
This quarter introduces mathematical ideas and techniques in a neuroscience context. Topics will include some coverage of matrices and complex variables; eigen value problems, spectral methods and Greens functions for differential equations; and some discussion of both deterministic and probabilistic modeling in the neurosciences. Instructor permission required. (2-0-2)

**BME 504 Neurobiology**
This course is concerned with the structure and function of systems of neurons, and how these are related to behavior. Common patterns of organization are described from the anatomical, physiological, and behavioral perspectives of analysis. The comparative approach is emphasized throughout. Laboratories include exposure to instrumentation and electronics, and involve work with live animals. A central goal of the laboratory is to expose students to in vivo extracellular electrophysiology in vertebrate preparations. Laboratories will be attended only on one day a week but may run well beyond the canonical period. Instructor permission required. (2-0-2)

**BME 505 Mathematical & Statistical Methods for Neuroscience II**
This quarter treats statistical methods important in understanding nervous system function. It includes basic concepts of mathematical probability; information theory, discrete Markov processes, and time series. Instructor permission required. Prerequisite(s): [(BME 503)] (2-0-2)

**BME 506 Computational Neuroscience II: Vision**
This course considers computational approaches to vision. It discusses the basic anatomy and physiology of the retina and central visual pathways, and then examines computational approaches to vision based on linear and non-linear systems theory, and algorithms derived from computer vision. (3-0-3)

**BME 507 Cognitive Neuroscience**
This course is concerned with the relationship of the nervous system to higher order behaviors such as perception and encoding, action, attention and learning and memory. Modern methods of imaging neural activity are introduced, and information theoretic methods for studying neural coding in individual neurons and populations of neurons are discussed. Instructor permission required. (2-0-2)

**BME 508 Mathematics & Statistics for Neuroscience III**
This course covers more advanced topics including perturbation and bifurcation methods for the study of dynamical systems, symmetry methods, and some group theory. A variety of applications to neuroscience with be described. Instructor permission required. Prerequisite(s): [(BME 503 and BME 505)] (2-0-2)

**BME 509 Vertebrate Neural Systems**
This lab-centered course teaches students the fundamental principles of mammalian neuroanatomy. Students learn the major structures and the basic circuitry of the CNS and PNS. Students become practiced at recognizing the nuclear organization and cellular architecture of many regions in animal brain models. This course is taught at the University of Chicago. Instructor permission required. (3-0-3)

**BME 510 Neurobiology of Disease I**
This seminar course is devoted to basic clinical and pathological features and pathogenic mechanisms of neurological diseases. The first semester is devoted to a broad set of disorders ranging from developmental to acquired disorders of the central and peripheral nervous system. Weekly seminars are given by experts in the clinical and scientific aspects of the disease under discussion. For each lecture, students are given a brief description of clinical and pathological features of a given set of neurological diseases followed by a more detailed description of the current state of knowledge of several of the prototypic pathogenic mechanisms. (2-0-2)

**BME 511 Extracellular Matrices: Chemistry & Biology**
Advanced topics dealing with the biology and chemistry of the extracellular matrix, cell-matrix interactions, and current methodologies for engineering these interfaces. (2-0-2)

**BME 512 Behavioral Neurosciences**
This course is concerned with the structure and function of systems of neurons and how these are related to behavior. Common patterns of organization are described from the anatomical, physiological, and behavioral perspectives of analysis. The comparative approach is emphasized throughout. Laboratories include exposure to instrumentation and electronics and work involvement with live animals. (2-0-2)

**BME 513 Methods of Computational Neuroscience: Single Neurons**
Topics include, but are not limited to, Hodgkin-Huxley equations, cable theory, single neuron models, information theory; signal detection theory, reverse correlation, relating neural responses to behavior, and rate versus temporal codes. Instructor permission required. (3-0-3)
BME 516
Biotechnology for Engineers
This course will provide students opportunity to learn about the field of biotechnology and how to apply engineering principles to biological systems and living organisms for betterment of medicines as well as agricultural products. The course covers the introduction to biotechnology with information about cell and molecular biology, the role of enzyme and growth kinetics, media preparations for cell culture and various chromatographic techniques, and antibiotics and its role in secondary metabolic production. Biological effluent treatment and regulatory issues to obtain FDA will be taught. Instructor permission is required.
(3-0-3)

BME 518
Reaction Kinetics for Biomedical Engineering
This course is an introduction to the fundamentals of chemical kinetics. Analysis of rate data; single and multiple reaction schemes. Biomedical topics include biological systems, enzymatic pathways, enzyme and receptor-ligand kinetics, pharmacokinetics, heterogeneous reactions, microbial cell growth and product formation, and the design and analysis of biological reactors.
Corequisite(s): (BME 482)
Prerequisite(s): [(BME 301, BME 335, and MATH 252)]
(3-0-3)

BME 519
Cardiovascular Fluid Mechanics
Anatomy of the cardiovascular system. Scaling principles. Lumped parameter, one-dimensional linear and nonlinear wave propagation, and three-dimensional modeling techniques applied to simulate blood flow in the cardiovascular system. Steady and pulsatile flow in rigid and elastic tubes. Form and function of blood, blood vessels, and the heart from an engineering perspective. Sensing, feedback, and control of the circulation. Includes a student project.
(3-0-3)

BME 521
Medical Imaging
Study of modern technology for medical imaging. Theory and operation of CAT, SPECT, PET, MRI, X-ray and echo imaging modalities.
(3-0-3)

BME 522
Mathematical Methods in Biomedical Engineering
Graduate standing in BME or consent of instructor. This course is an introductory graduate level course that integrates mathematical and computational tools that address directly the needs of biomedical engineers. The topics covered include the mathematics of diffusion, pharmacokinetic models, biological fluid mechanics, and biosignal representations and analysis. The use of MATLAB will be emphasized for numerically solving problems of practical relevance. Open only to Biomedical Engineering majors.
(3-0-3)

BME 523
Cell Biomechanics: Principles & Biological Processes
This course will provide students an opportunity to learn about mechanical forces that develop in the human body and how they can influence cell functions in a range of biological processes from embryogenesis, wound healing, and regenerative medicine to pathological conditions such as cancer invasion. Examples of research methods for investigating cell biomechanics in various biological systems will be discussed. Permission of instructor is required.
(3-0-3)

BME 524
Quantitative Aspects of Cell and Tissue Engineering
This course is designed to cover fundamentals of cell and tissue engineering from a quantitative perspective. Topics addressed include elements of tissue development, cell growth and differentiation, cell adhesion, migration, molecular and cellular transport in tissues and polymeric hydrogels for tissue engineering and drug delivery applications.
(3-0-3)

BME 530
Inverse Problems in Biomedical Imaging
This course will introduce graduate students to the mathematical theory of inverse problems. Concept from functional analysis will be applied for understanding and characterizing mathematical properties of inverse problems. This will permit for the analysis of the stability and resolution of image reconstruction algorithms for various existing and novel biomedical imaging systems. The singular value decomposition (SVD) is introduced and applied for understanding fundamental properties of imaging systems and reconstruction algorithms. Instructor permission required. Open only to Biological Engineering majors.
(3-0-3)

BME 532
Medical Imaging Science
This course is an introduction to basic concepts in medical imaging, such as: receiver operating characteristics, the rose model, point spread function and transfer function, covariance and auto covariance, noise, filters, sampling, aliasing, interpolation, and image registration. Instructor permission required.
(3-0-3)

BME 533
Biostatistics
This course is designed to cover the tools and techniques of modern statistics with specific applications to biomedical and clinical research. Both parametric and nonparametric analysis will be presented. Descriptive statistics will be discussed although emphasis is on inferential statistics and experimental design.
(3-0-3)

BME 535
Magnetic Resonance Imaging
This is an introduction to the Physics and technology of magnetic resonance imaging (MRI). The topics that are covered include: basic MR physics, source of signal, signal acquisition, pulse sequences, hardware, artifacts, spectroscopy, and advanced imaging techniques. Instructor permission required.
(3-0-3)

BME 537
Introduction to Molecular Imaging
This course provides an overview of molecular imaging, a subcategory of medical imaging that focuses on noninvasively imaging molecular pathways in living organisms. Topics include imaging systems, contrast agents, reporter genes and proteins, tracer kinetic modeling. Preclinical and clinical applications will also be discussed with an emphasis on cancer and the central nervous system.
(3-0-3)
BME 538
**Neuroimaging**
This course describes the use of different imaging modalities to study brain function and connectivity. The first part of the course deals with brain function. It includes an introduction to energy metabolism in the brain, cerebral blood flow, and brain activation. It continues with an introduction to magnetic resonance imaging (MRI), perfusion-based fMRI, Bold fMRI, fMRI paradigm design and statistical analysis, introduction to positron emission tomography, (PET) and studying brain function with PET, introduction to magneto encephalography (MEG) and studying brain function with MEG. The second part of the course deals with brain connectivity. It includes an introduction to diffusion tensor MRI, explanation of the relationship between the diffusion properties of tissue its structural characteristics, and white matter fiber tractography techniques. Instructor permission required.
(3-0-3)

BME 539
**Advanced Medical Imaging**
This course introduces advanced clinical imaging modalities, research imaging techniques, and concepts from image science and image perception. The first part of the course introduces the perception of image data by human observers and the visualization of brain structure and function. It includes an introduction to magnetic resonance imaging (MRI) and a survey of neurological imaging via functional MRI (fMRI). The second part of this course covers image science, clinical imaging applications, and novel research imaging techniques. It includes an introduction to radiation detection and image quality evaluation, a survey of clinical cases, and an overview of new imaging methods.
(3-0-3)

BME 540
**Wave Physics & Applied Optics for Imaging Scientists**
This course will introduce students to fundamental concepts in wave physics and the analysis of optical wave fields. These principles will be utilized for understanding existing and novel imaging methods that employ coherent radiation. Solutions to inverse scattering and inverse source problems will be derived and algorithmic realizations of the solutions will be developed. Phase contrast imaging techniques and X-ray imaging systems that employ coherent radiation will be studied. Instructor permission required.
(3-0-3)

BME 542
**Advanced Concepts in Image Science**
This graduate level course introduces students to fundamental concepts in image science that are related to the optimization and evaluation of biomedical imaging systems. Topics covered include: deterministic descriptions of imaging systems, stochastic descriptions of imaging systems, statistical decision theory, and objective assessment of image quality. Prerequisite(s): [(BME 530 and BME 532)]
(3-0-3)

BME 543
**Bioinstrumentation & Electronics**
Principles of circuit analysis are applied to typical transducer and signal recording situations found in biomedical engineering. Basic electrical and electronic circuit theory is reviewed with an emphasis on biomedical measurement applications. A special topic is individually studied by the student and presented to the class electrical physics class or basic circuits.
(3-0-3)

BME 551
**Physiological Signal Processing & Control Theory**
This is the first of a 2 part course co-taught at IIT and the University of Chicago. Essential elements of signal processing and control theory as it is applied to physiological systems will be covered. Part 1 will cover data acquisition and sampling, Laplace and Fourier transforms, filtering, time and frequency domains, system descriptions and lumped vs. distributed parameters. Students will use Matlab to test concepts presented in class.
(2-0-2)

BME 552
**Control Systems for Biomedical Engineers**
Control systems design and analysis in biomedical engineering. Time and frequency domain analysis, impulse vs. step response, open vs. closed loop response, stability, adaptive control, system modeling. Emphasis is on understanding physiological control systems and the engineering of external control of biological systems.
(3-0-3)

BME 553
**Quantitative Physiology**
The primary objective of this course is to introduce students to basic physiological concepts using a quantitative approach. The main systems that control the human body functions will be reviewed to enable the students to understand the individual role of each major functional system as well as the need for the integration or coordination of the activities of the various systems. Attempts will be made to highlight the patho-physiological consequences of defects or failures in the organ systems and the relevant corrective approaches. This course will include lectures from individuals who have relevant expertise in the different organ systems because of the complexity of the human body.
(3-0-3)

BME 575
**Neuromechanics of Human Movement**
This course will explore how we control movement of our extremities, with concepts drawn from mechanics and neurophysiology. The progression from neurological signals to muscle activation and resulting movement of the hand or foot will be modeled, starting at the periphery and moving back toward the central nervous system. Biomechanics of the limbs will be modeled using dynamic simulation software (Working Model) which will be driven by a neural controller, implemented in MATLAB. Issues related to sensory feedback and redundancy will be addressed.
(3-0-3)

BME 581
**Fluid Mechanics for Biomedical Engineers**
This course is primarily focused on the development of theoretical and experimental principles necessary for the delineation of fluid flow in various in vitro chambers and the cardiovascular system. Its content will primarily deal with the basic concepts of flow in various geometries, the heterogeneous nature of blood and the application of such principles in flow chambers designed to expose blood elements to defined flow conditions. The relationship to flow in the normal and diseased vascular system will also be considered. A basic Fluid Dynamics Course is recommended. Instructor permission required.
(3-0-3)
BME 582
Advanced Mass Transport for Biomedical Engineers
This course is primarily focused on the development of theoretical and mathematical principles necessary for the delineation of mass transport processes in biological & medical systems. The content includes heterogeneous reactions that occur at or in the vicinity of cells or vascular structures under applied laminar flow and transport across cell membranes and within tissues.
(3-0-3)

BME 585
Computational Models of the Human Cardiovascular System
This course will focus on the use of computational fluid dynamics for the modeling and analysis of the human cardiovascular system. The course will cover both computational methods for fluid dynamics and biomedical aspects of the human cardiovascular system. Computer models for the simulation and analysis of hemodynamic phenomena will be developed. Requires an Introductory fluid dynamics
(3-0-3)

BME 591
Research & Thesis for Master of Science Degree
Research and thesis for master of science degree students. Instructor permission required.
(Credit: Variable)

BME 594
Special Projects
Special projects.
(Credit: Variable)

BME 595
Seminar in Biomedical Engineering
Current research and development topics in biomedical engineering as presented by outside speakers, faculty and advanced students.
(3-0-3)

BME 597
Special Problems
Special problems.
(Credit: Variable)

BME 601
Research & Thesis PHD
Research and Thesis for PhD degree. (variable credit)
(Credit: Variable)