RUTGERS–NEW BRUNSWICK
School of Engineering
Department of Biomedical Engineering

Undergraduate Program Handbook

Rutgers, The State University of New Jersey
Department of Biomedical Engineering

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Updates available on-line at:
http://bme.rutgers.edu/

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Dr. Kristen Labazzo
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PROGRAM COORDINATOR
Ms. Elaine Connors (econnors@soe.rutgers.edu)

Class Advising

All students are assigned a Faculty Advisor at the beginning of Sophomore year. If you do not know your advisor, please contact Ms. Connors or Dr. Labazzo.

Special Permission Number Requests

Please email the **Program Coordinator or the Undergraduate Director**

Introduction to Biomedical Engineering

The Biomedical Engineering program at Rutgers University was initially established in 1965 as a track within Electrical Engineering, offering M.S. degrees with a Biomedical Engineering emphasis. In 1986, the State of New Jersey formally chartered the Rutgers Department of Biomedical Engineering as an independent entity within the School of Engineering with exclusive responsibility for granting M.S. and Ph.D. degrees in biomedical engineering. The Department developed its graduate programs in collaboration with the University of Medicine and Dentistry of New Jersey (UMDNJ) to provide a strong foundation in the basic biomedical and clinical sciences along with rigorous training in engineering fundamentals. The undergraduate program in Biomedical Engineering was inaugurated in 1991 under the "Applied Sciences' option within the School of Engineering; a formal undergraduate B.S. degree in BME was approved by the University in 1997 and by the State in 1999.

The achievements of biomedical engineering constantly touch our daily lives. Past and current breakthroughs that were pioneered at Rutgers include: techniques for online analysis and operating room lesioning of brain tissue for Parkinson's disease; an artificial hand with finger dexterity; the use of virtual reality in the rehabilitation of limbs; revolutionary techniques for making large numbers of new biopolymers for implants; and rapid NMR analysis of protein structure, balloon catheters, and pacemakers.

The BME program currently offers three main curriculum concentrations: 1) biomedical computing, imaging, and instrumentation, 2) biomechanics and rehabilitation engineering, and 3) tissue engineering and molecular bioengineering. The biomedical computing, imaging, and instrumentation track provides training in computational approaches, various imaging modalities, bioelectronic device design, and in theoretical modeling related to microscopic and macroscopic biomedical phenomena.

A focus in biomechanics and rehabilitation engineering offers instruction on development of devices for improved human performance. In the tissue engineering and molecular bioengineering track, students apply principles of materials science, biochemistry, cell and molecular biology and engineering to design engineered tissues, biomaterials, and molecular medicine, through the pursuit of problems on the cellular, molecular, and nano scale. The broad education provided by these tracks allows students to choose from a wide variety of careers. Many graduates work in large corporations and smaller companies as practicing biomedical engineers. Increasing numbers of graduates are finding rewarding jobs in state and federal institutions, including the Patent and Trademark Office and many of the National Laboratories of Advanced Research. The degree program also prepares qualified students for graduate study leading to the M.S. or Ph.D. degrees in biomedical engineering. In addition, students are prepared to meet the graduate entrance requirements for medical and law schools, business administration, and other professional disciplines.

There are several exciting opportunities for conducting research at the Undergraduate level. The Department has recently established a Research Scholars Academy in Biomedical Engineering. Additionally, the department participates in the School of Engineering's James J. Slade Scholars Research Program. Both selective programs can serve as springboards for highly qualified students to commence work toward the M.S. or Ph.D. degree in the senior year of the undergraduate curriculum.

Biomedical Engineering Mission Statement

The mission of the BME undergraduate program is to provide students with a broad and flexible education in engineering and biological science as well as medically related subjects. The students are prepared to analyze, synthesize, and link knowledge in the multi-disciplinary fields, with the emphasis on quantitative approaches and methods. The students will be an integral part of society to improve the understanding and control of biological processes towards improving human health. Our curriculum guides our students toward skills in creating new knowledge and technologies as well as applying current knowledge.

Rutgers Mission & Vision Statements are published at https://studentaffairs.rutgers.edu/about#visionmission

Mission of the School of Engineering:

The School of Engineering Mission Statement was revised and ratified by the faculty on October 7, 2011. The mission statement is as follows:

- To educate and train the future engineers of a complex, diverse, and global workplace
- Provide high quality, relevant education programs to undergraduate and graduate students using the latest technology and education techniques
- To conduct state-of-the-art research that embraces technology to address societal challenges of a multifaceted United States and a globally connected world
- Create an environment to encourage and assist faculty to become leaders in their fields, and to further gain national and international recognition
- Conduct cutting-edge research in strategically important engineering areas
- To serve as a resource to local, New Jersey, and regional stakeholders in advancing the public's interest
- Promote economic development through technology, entrepreneurship, and innovation

The mission statement is published at: https://soe.rutgers.edu/about/mission-and-values

Accreditation

The program in Biomedical Engineering is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org, under the commission's General Criteria and Program Criteria for Biomedical Engineering.

Program Educational Objectives (PEOs)

The BME program educational objectives (PEO) are consistent with the mission of Rutgers University and with the overall mission of the School of Engineering stated above. These objectives were modified and ratified by the faculty on April 12, 2012. The University mission and aims of the school are printed in the Undergraduate Catalog for the School of Engineering, read by prospective students, and entering freshmen. The educational objectives of the Biomedical Engineering Program are to educate students to attain the following:

1. To establish themselves as practicing professionals in biomedical or biotechnology industries or engage themselves in advance study in biomedical engineering or a related field.
2. To make positive contributions in biomedical industries and/or other sectors.
3. To demonstrate their ability to work successfully as a member of a professional team and function effectively as responsible professionals.

The BME mission statement and PEOs are available to the public at the departmental Web page, https://bme.rutgers.edu/abet-accreditation

Criterion 3. Student Outcomes (SOs)

The student outcomes were adapted according to ABET guidelines therefore, each Biomedical Engineering student will demonstrate the following attributes by the time they graduate:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. an ability to communicate effectively with a range of audiences.
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

The student outcomes were established with the goal that they must be compatible with the program educational objectives and the mission of the School and University. Furthermore, the outcomes should be measurable, in the sense that our success in achieving them can be quantified. The BME student outcomes are available to the public at the departmental Web page, https://bme.rutgers.edu/abet-accreditation

BME Faculty/Staff Locator

DEPARTMENT OF BIOMEDICAL ENGINEERING

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Basic Biomedical Engineering Curriculum

Freshman Year

Fall			Spring		
160:159	Gen Chem for Engrs	3	160:160	Gen Chem for Engrs	3
160:171	Intro to Experiment.	1	440:127	Intro Comp for Engrs	3
355:101	College Writing (Updated)	3	640:152	Calculus II: Math/Phys	4
640:151	Calculus I: Math/Phys	4	750:124	Analytical Physics Ib	2
750:123	Analytical Physics Ia	2			
440:100	Eng'g Orient Lecture	1	440:221	Eng'g Mech: Statics	3
___:___	Hum/Soc Elective	3	___:___	Hum/Soc Elective	3
	Total	**17**		**Total**	**18**

Sophomore Year

Fall			Spring		
125:201	Intro to Biomed Eng	3	**125:255**	System Physiology	3
640:251	Multivariable Calculus	4	640:244	Diff Eqs Eng'g & Phys	4
750:227	Analytical Physics IIa	3	750:228	Analytical Physics IIb	3
750:229	Analytical Phys IIa Lab	1	750:230	Analytical Phys IIb Lab	1
119:115	Biology I	4	119:117	Biology Lab	2
___:___	Hum/Soc Elective	3	540:343	Engineering Economics	3
	Total	**18**		**Total**	**16**

Junior Year

Fall			Spring		
125:303	BME Transport Phenom	3	**125:304**	Biomaterials	3
125:305	BME Numerical Modeling	3	**125:306**	Kinetics & Thermo	3
125:308	Biomechanics	3	**125:315**	BME Measurements Lab	2
125:309	BME Devices Systems Lec	3	___:___	Technical Elective	3
125:310	BME Devices Systems Lab	1	___:___	Life Science Elective	3
___:___	Technical Elective •	3		**Total**	**14**
	Total	**16**			

Senior Year

Fall			Spring		
125:401	Senior Design I	1	**125:402**	Senior Design II	1
125:421	Senior Design Projects I	2	**125:422**	Senior Design Projects II	2
___:___	Departmental Elective	3	___:___	Departmental Elective	3
___:___	Departmental Elective	3	___:___	Departmental Elective	3
___:___	Technical Elective	3	___:___	Technical Elective	3
___:___	Hum/Soc Elective	3	___:___	General Elective	3
	Total	**15**		**Total**	**15**

Minimum number of credits required …BME DegreeCredits:**129**

RULE 1: You must pass both level 200 courses (sophomore core) before moving to level 300 courses

- These classes are offered both semesters and usually every summer

RULE 2: You must pass 6/8 level 300 classes (junior core) to be eligible for senior design, including both labs

- This is NOT the recommended route as junior core may be offered concurrently with senior electives. Please use this guidance wisely in cases of failed classes or missing a semester due to co-op, study abroad, etc.
- Students who miss a lab class in junior year for a co-op or study abroad may be approved to take the class in senior year provided they meet the 6/8 rule
- All junior core except 309 & 310 (FALL ONLY), and 315 (SPRING ONLY) are offered both semesters
- Select junior core may be offered over the summer but are not guaranteed

Department Core Course Requirements

The following is a description of the required core courses that are currently offered by the Biomedical Engineering Department to the School of Engineering undergraduates. Please check the Schedule of Courses Online to see which will be offered.

14:125:201 Introduction to Biomedical Engineering (3)
Prerequisites: (640:152 or 640:192) and (750:124 or 750:203)
Overview of applications of engineering in medicine and healthcare. Introduction to biological and biomedical problems using fundamental concepts and tools from electrical, mechanical, and chemical engineering.

14:125:255 Biomedical Engineering System Physiology (3)
Prerequisites: (640:152 or 640:192) and (750:124 or 750:203)
Introduction to quantitative modeling of physiological systems geared towards the Biomedical Engineering student. It will cover fundamental topics in physiology ranging from cell membrane models and chemical messengers to neuronal signaling and control of body movement. In addition, specific physiological systems are discussed in detail, including the cardiovascular, pulmonary, and visual systems. Furthermore, pharmacokinetic models provide quantitative assessment of the dynamics of drug distribution and compartmental interactions.

14:125:303 Biomedical Transport Phenomena (3)
Prerequisites: 01:640:244 and 14:125:201 and (14:125:255 or 14:125:355)
Biomedical mass transport processes involving diffusion, diffusion-convection, and diffusion-reaction schemes; Introduction to biofluid dynamics; Transport processes in the cardiovascular system, hemorheology, extracorporeal mass transport devices and tissue engineering.

14:125:304 Biomaterials (3)
Prerequisites: 14:125:201 and (14:125:255 or 14:125:355) OR 14:635:203 and 14:635:204
This course is designed to introduce the subjects of material properties, testing, biomaterial requirements and device design. It is the intention of the instructor to convey the basic knowledge of this large volume of information and to give an elementary understanding of the terminology used in the academic and commercial settings. This will provide the student with rudimentary skills that will allow them to succeed in grasping the ideas and theories of biomaterial science for future work.

14:125:305 Numerical Modeling in Biomedical Systems (3)
Prerequisites: 01:640:244 and 14:125:201 and 14:125:255 and 14:440:127
Introduction to modeling and simulation techniques in the analysis of biomedical systems. Application of numerical methods for the solution of complex biomedical process problems. Development and use of PC computer software for the analysis and solution of engineering problems.

Department Core Course Requirements

14:125:306 Kinetics and Thermodynamics of Biological Systems (3)

Prerequisites: 01:119:115 and 01:640:244 and 14:125:201 and 14:125:255

Fundamentals of thermodynamics and kinetic analysis as applied to biomedical systems and technologies. Essential principles in thermodynamics will be introduced, including First Law, Second Law, and interrelationships among thermodynamic variables. Fundamental tools in kinetic analysis are also covered, including interpretation of rate data, enzyme kinetics, and pharmacokinetics. Application to biological systems and biomedical technologies are provided.

14:125:308 Biomechanics (3)

Prerequisites: 01:640:251and 14:125:201 and 14:125:255 and 14:440:221

This course emphasizes the relationship between applied and resultant forces and stresses acting on the musculoskeletal system. Students are exposed to the basic concepts of vectors, internal and external forces, functional anatomy, trusses and equilibria of spatial force systems, moments and work and energy concepts. In addition, students learn about stress and strain tensors, principal forces, viscoelasticity, and failure analysis from classical mechanics.

14:125:309 Biomedical Devices and Systems (3)

Prerequisites: 01:640:251 and 01:750:227 and 14:125:201 and 14:125:255

Co-requisite: 14:125:310

Time and frequency domain analysis of electrical networks; hydrodynamic, mechanical, and thermal analogs; basic medical electronics, and energy conversion systems. Design of biological sensors.

14:125:310 Biomedical Devices & Systems Lab (1)

Prerequisites: 01:640:251 and 01:750:227 and 14:125:201 and 14:125:255

Co-requisite: 14:125:309

Experiments and demonstrations dealing with basic medical electronics and signal analysis. Provides an overview of current biomedical technology and its uses.

14:125:315 BME Measurement and Analysis Lab (2)

Prerequisites: 14:125:201 and 14:125:255 and 14:125:309 and 14:125:310

Experiments and demonstrations dealing with the measurement and analysis of various physiological quantities of cardiovascular and respiratory systems, and the measurement of cellular viability, metabolism, morphogenesis, and protein and nucleic acid composition.

14:125:401/402 and 421/422 Biomedical Senior Design I/II and Projects I/II (1, 2)

Prerequisites: Senior Standing (Passed 6 out of 8 junior level courses)

The purpose of this course is to give the student a comprehensive design experience in the biomedical engineering field. The student will complete a design project under the supervision of a faculty member. The project will typically involve the experimental or computational study of a design-oriented problem in biomedical engineering.

ELECTIVES

Departmental Electives

Please check the Schedule of Courses online for current offerings as offerings may change each semester.

14:125:403 Cardiovascular Engineering (3)
Prerequisites: 14:125:303 and (14:125:208 or 14:125:308) and 14:125:315
Introduction to modeling and measurement methods for the cardiovascular system, analysis of blood flow dynamics, the function of the heart, and noninvasive approaches. Applications to cardiovascular instrumentation, basic cardiovascular system research, assist devices, and disease processes.

14:125:409 Introduction to Prosthetic and Orthotic Devices (3)
Prerequisites: 14:125:303 and (14:125:208 or 14:125:308) and 4:125:315
The course introduces the application of mechanical engineering principles to the design of artificial limbs and braces. Teaching includes basic anatomy and physiology of limb defects, biomechanics, motion analysis, and current device designs. Design and visualization tools will include MatLab, and other application software.

14:125:411 Bioelectric Systems (3)
Prerequisites: 14:125:309 and 14:125:310
Introduction to the understanding of bioelectric phenomena that occur in physiological systems. This includes the origin of biopotentials, the use of biopotential electrodes in their measurements and subsequent amplification, signal processing and analysis of their physiological relevance. Applications of physical principles and basic electric engineering techniques are emphasized.

14:125:417 Introduction to Musculoskeletal Mechanics (3)
Prerequisite: 14:125:208 or 14:125:308
Introduction to motion-actuation, force-generation, and load- support mechanisms in musculoskeletal system, as explained from basic engineering principles. Experimental and analytical approaches to solve realistic orthopaedic and recreational activities problems.

14:125:424 Biomedical Instrumentation Laboratory (3)
Prerequisite: 14:125:315 or 14:332:221 or 14:332:373
Practical hands-on designs of biomedical instrumentation including biopotential and physiological signal processing amplifiers, electrodes, biosensor and transducers, electro-optical, acoustic, and ultrasonic devices.

14:125:431 Introduction to Optical Imaging (3)
Prerequisite: 14:125:303 and 14:125:309Introductory overview of optical phenomena and the optical properties of biological tissue. The course is specifically focused on optical imaging applications in biology and medicine. Topics will include reflection, refraction, interference, diffraction, polarization, light scattering, fluorescence and Raman techniques, and their application in biomedical imaging and microscopy.

ELECTIVES

14:125:433 Fundamentals and Tools of Tissue Engineering (3)

Prerequisite: 14:125:303

Fundamentals of polymer scaffolds and their use in artificial tissues. Regulation of cell responses in the rational design and development of engineered replacement tissue. Understanding the biological, chemical, and mechanical components of intra and intercellular communication. Preliminary discussions on real-life clinical experiences.

14:125:434 Tissue Eng II, Biomed and Biotechnological Applications (3)

Prerequisites: 14:125:433

This course will cover the applications of tissue engineering and builds upon the prior course fundamentals and tools. Emphasis is placed on applying the fundamental principles and concepts to problems in clinical medicine and large-scale industrial manufacturing. Topics: skin replacement, cartilage tissue repair, bone tissue engineering, nerve regeneration, corneal and retinal transplants, ligaments and tendons, blood substitutes, artificial pancreas, artificial liver, tissue integration with prosthetics, vascular grafts, cell encapsulation and angiogenesis.

14:125:437 Computational Systems Biology (3)

Prerequisites: 14:125:303 and 14:125:305 and 14:125:306

The course will provide an introductory overview of some of the key issues in computational systems biology. The course is designed in a way that will define the systems component and the biology component independently to give the students the opportunity to appreciate the special features of both elements. A novelty of the course is the introduction of medical informatics concepts.

14:125:445 Principles of Drug Delivery (3)

Prerequisites: 14:125:303

Fundamental concepts in drug delivery from an engineering perspective. Biological organisms are viewed as highly interconnected networks where the surfaces/interfaces can be activated or altered 'chemically' and 'physically/mechanically'. The importance of intermolecular and interfacial interactions on drug delivery carriers is the focal point of this course. Topics include: drug delivery mechanisms (passive, targeted); therapeutic modalities and mechanisms of action; engineering principles of controlled release and quantitative understanding of drug transport (diffusion, convection); effects of electrostatics, macromolecular conformation, and molecular dynamics on interfacial interactions; thermodynamic principles of self-assembly; chemical and physical characteristics of delivery molecules and assemblies (polymer based, lipid based); significance of biodistributions and pharmacokinetic models; toxicity issues and immune responses.

14:125:455 BME Global Health (3)

Prerequisites: 14:125:401 This course provides an overview of how biomedical technologies are developed and translated into clinical practice. The course identifies the major diseases facing industrialized and developing countries alongside the technological advances which can be used to tackle these problems. Throughout the course, particular attention will be paid to the economic, ethical, social, and regulatory constraints which often determine the true impact of new technologies.

ELECTIVES

14:125:465 BME Microfluidics (3)

Prerequisites: 14:125:303 or 14:650:312

Microfluidics is the study of flow phenomena at small length scales with characteristic channel dimensions typically less than the diameter of a human hair. Small length scale effects become important as surface forces such as viscous drag and surface tension govern flow behavior rather than body forces (inertia) as seen in macroscale fluid mechanics. Miniaturization of fluid handling systems also allows the development of cell handling and manipulation devices, or microTotal Analysis Systems (TAS) also called "lab on a chip", which combines biological sample preparation, separation, and analysis in a single device. Topics explored in this class include fundamental understanding and derivation of constitutive balances in fluid mechanics (i.e., Navier Stokes equation), exploration of electrokinetic flow phenomena for electrophoresis, fabrication techniques for microfluidics, overview of (TAS) systems especially capillary electrophoresis and miniaturized polymerase chain reaction for biochips, and exploration of integrated microfluidics for personalized medicine and drug delivery.

14:125:470 Advanced Biomedical Devices Lab (3)

Prerequisites: 14:125:309, 310

The course applies the background obtained from the Biomedical Systems and Devices Laboratory and Lecture courses (125:309 and 310) that are restricted to linear systems and devices. This proposed course introduces advanced nonlinear electronics and devices. The Advanced Biomedical Devices lab also covers device standards and precision laboratory test methods; introduction to medical device interface systems; biomedical device power sources; wireless data transmission, basic radio systems; the blue tooth standard. Lastly, students will learn how to apply nonlinear data reduction methods to process long duration wireless data records that they will obtain during lab exercises.

14:125:493/494 BME Research Scholars Academy (3, 3)

Prerequisite: Biomedical Engineering Research Scholars Academy Senior Students Only*

These courses provide advanced research immersion activity and the supporting educational tools for members of the BME Research Scholars Academy that participate within a formalized two-year research experience.
Students work independently with faculty members on a research project of relevance to biomedical engineering. In addition, students meet monthly for roundtable discussions of a wide range of scientific ethical and professional issues.

14:125:498/499 Topics in BME (3,3)

Prerequisite: Varies based on Topics

16:125:5XX

All BME Graduate courses, except 587/588, will count as a Departmental Elective.

Undergraduates who wish to take graduate courses need a minimum 3.0 GPA and permission from the instructor. Please obtain permission via email and forward to the program administrator for your SPN

Acceptable Technical Electives

Most of the courses listed below have multiple prerequisites. Please check with the Rutgers Schedule of Classes or contact the Department offering these courses regarding updated information about the prerequisites.

If there is a Technical Elective listed on Degree Navigator and not in handbook, please let

us know. **This is a PARTIAL list; please consult Degree Navigator for the most current list.**

Biomedical Engineering

14:125:4xx Any of the BME departmental elective courses can be counted toward technical electives.

14:125:490 BME Research Scholars Academy (*Prereq: RSA Juniors Only*) (*Contact RSA Advisor[s] for permission)* 14:125:491/2 Independent Study Research (6 credits max towards TE) (*Only by approval of the Faculty research advisor*) 14:125:493/4 BME Research Scholars Academy (*Prereq: RSA Seniors Only*) (*Contact RSA Advisor[s] for permission)* 14:125:495 BME Internship (*By Permission of Undergraduate Director Only) [Form at end of handbook]*

14:125:496/7 BME Co-op Internship (*By Permission of Undergraduate Director Only) [Form at end of handbook]*

General Engineering			**Electrical and Computer Engineering**	
14:440:292	Honors Eng Mech-Dyna		14:332:448	Digital Signal Processing Design
14:440:301	Intro Packaging Eng		14:332:452	Introduction to Software Engineering
14:440:302	Cad for Packaging Engineering		14:332:461	Pulse Circuits
14:440:371	Packaging Eval Mtds		14:332:465	Physical Electronics
14:440:373	Packaging Manufacturing		14:332:466	Opto-Electronic Devices
14:440:378	Sustainable Packaging		14:332:468	Microelectronic Processing – Design
14:440:403	Safety Engineering in Packaging		14:332:471	Concepts in Robotics and Computer Vision
14:440:404	Innovation & Entrepreneurship for Science and tech		14:332:481	Electromagnetic Waves
14:440:406	Packaging Printing and Decoration		**English Department**	
14:440:468	Packaging Machinery		01:355:302	Scientific and Technical Writing
14:440:471	Distribution Packaging		01:355:322	Writing for Engineers
Anthropology			**Genetics**	
01:070:349	Advanced Physical Anthropology		01:447:245	Intro to Cancer
01:070:354	Functional and Dev Anatomy of the Primate Skeleton		01:447:380	Genetics
01:070:358	Introduction to Human Osteology		01:447:390	General Microbiology

Biochemistry (Cook College)			01:447:489	Advanced Independent Study in Genetics
11:115:301	Intro to Biochemistry		01:447:495	Cancer
11:115:403	General Biochemistry I		**Industrial Engineering**	
11:115:404	General Biochemistry II		14:540:461	Engineering Law
Biology			**Mathematics**	
01:119:116	Biology II		01:640:250	Introductory Linear Algebra
Business			01:640:300	Introduction to Mathematical Reasoning
33:799:460	Six Sigma & Lean Manufacturing			
Cell Biology and Neuroscience			01:640:321	Applied Mathematics
01:146:245	Fundamentals of Neurobiology		01:640:325	Foundation of Quantum Mechanics
01:146:270	Fundamentals of Cell and Developmental Biology		01:640:350	Linear Algebra
01:146:295	Essentials of Cell Biology & Neuroscience		01:640:351	Intro to Abstract Algebra I
01:146:302	Computers in Biology		01:640:352	Intro to Abstract Algebra II
01:146:445	Advanced Neurobiology I		01:640:354	Linear Optimization
01:146:446	Advanced Neurobiology lab		01:640:357	Topics in Applied Algebra
01:146:450	Endocrinology		01:640:373	Numerical Analysis I
01:146:470	Advanced Cell Biology I		01:640:374	Numerical Analysis II
01:146:471	Advanced Cell Biology Laboratory		01:640:421	Advanced Calculus for Engineering
01:146:474	Immunology		01:640:423	Elementary Partial Differential Equations
01:146:478	Molecular Biology		01:640:424	Stochastic Models in Operation Research
Ceramics/Material Science Engineering			01:640:428	Graph Theory
14:635:323	Bio Applications of Nanomaterials		01:640:454	Combinatorics
14:635:330	Introduction of Nanomaterials		01:640:495	Selected Topics and Mathematics
14:635:340	Electrochemical Materials and Devices		**Mechanical and Aerospace Engineering**	
14:635:407	Mechanical Properties of Materials		14:650:342	Design of Mechanical Components
14:635:410	Biological Applications of Nanomaterials and Nanostructures		14:650:388	Computer-Aided Design in Mechanical Engineering
Chemical and Biochemical Engineering			14:650:401	Mechanical Control Systems

14:155:411	Introduction to Biochemical Engineering		14:650:449	Introduction to Mechanics of Composite Materials
14:155:551	Polymer Science and Engineering I		14:650:455	Design of Mechanisms
14:155:552	Polymer Science and Engineering II		14:650:472	Biofluid Mechanics
Chemistry			**Molecular Biology and Biochemistry**	
01:160:307	Organic Chemistry I		01:694:301	Introductory Biochemistry & Molecular Biology
01:160:308	Organic Chemistry II		01:694:407/8	Molecular Biology & Biochemistry
01:160:311	Organic Chemistry Lab		01:694:411	Molecular Pathways & Signal Transduction
01:160:323	Physical Chemistry		**Pharmacology and Toxicology**	
01:160:327	Physical Chemistry			
01:160:341	Physical Chemistry: Biochemical Systems		30:718:304	Pathophysiology
01:160:344	Introduction to Molecular Biophysics Research		**Pharmaceutics**	
01:160:409	Organic Chemistry of High Polymers		30:721:301	Introduction to Pharmaceutics
01:160:437	Physical Chemistry of Biological Systems		30:721:320	Drug Delivery I and Laboratory
Computer Science			30:721:430	Introduction to Biopharmaceutics and Pharmacokinetics
01:198:314	Principles of Programming Languages		**Physics**	
01:198:416	Operating Systems Design		01:750:305	Modern Optics
01:198:417	Distributed Systems: Concepts and Design		01:750:313	Modern Physics
01:198:424	Modeling and Simulation of Continuous Systems		01:750:406	Introductory Solid-State Physics
01:198:433	Integration of Brain + Computer Sciences		01:750:417	Intermediate Quantum Mechanics
01:198:440	Intro to Artificial Intelligence		01:750:464	Mathematical Physics
01:198:476	Advanced Web Applications: Design and Implementation		**Statistics**	
Electrical and Computer Engineering			01:960:379	Basic Probability and Statistics
14:332:373	Elements of Electrical Engineering		01:960:384	Intermediate Statistical Analysis
14:332:346	Digital Signal Processing		01:960:401	Basic Statistics for Research

14:332:361	Electronic Devices		01:960:463	Regression Methods
14:332:376	Virtual Reality		01:960:467	Applied Multivariable Analysis
14:332:417	Concepts in Control System Design		01:960:484	Basic Applied Statistics
14:332:437	Concepts in Digital System Design			
14:332:447	Concepts in Digital Signal Processing Design			

Acceptable Life Science Electives "or ANY course from the BME TE list"

Biochemistry (Cook College) 11:115:301
Intro to Biochemistry 11:115:403 General
Biochemistry I 11:115:404 General
Biochemistry II

Cellular Biology and Neuroscience
01:146:245 Fundamentals of Neurobiology
01:146:270 Fundamentals of Cell and Developmental Biology
01:146:295 Essentials of Cell Biology & Neuroscience
01:146:302 Computers in Biology
01:146:445 Advanced Neurobiology I 01:146:446
Advanced Neurobiology Lab 01:146:450
Endocrinology
01:146:470 Advanced Cell Biology I
01:146:471 Advanced Cell Biology Laboratory
01:146:474 Immunology
01:146:478 Molecular Biology

Exercise Science
01:337:370 Exercise Physiology

Genetics
01:447:245 Intro to Cancer
01:447:390 General Microbiology
01:447:495 Cancer
01:680:390 General Microbiology
Molecular Biology and Biochemistry
01:694:301 Intro to Biochem & Mol.Biology
01:694:407 Molecular Biology & Biochemistry I
01:694:408 Molecular Biology & Biochemistry II
01:694:411 Molecular Pathways & Signal Transduction

Pharmacology and Toxicology
30:718:304 Pathophysiology

Psychology
01:830:313 Physiological Psychology

Humanities/Social Science & General Electives

Please refer to:
http://www.soe.rutgers.edu/oas/electives

for list of Humanities/Social Science & General Electives

Office of Academic Affairs (B100) maintains & approves this list.

**** BME supports and approves these listings ****

Bachelor's/Master's Combined Degree Program

The goal of the BME Bachelor's/Master's Combined Degree Program (BME-CDP) is to allow academically qualified students to receive the BS and MS /M.Eng degrees in a shortened time frame. This highly intensive academic program gives students more research experience and better prepares them for research and development careers or further graduate study. Completing the BME-CDP is possible in as little as 5 years if the candidate takes graduate-level courses in the senior year **in addition to** completing all the undergraduate degree requirements. (Courses cannot double-count for both UG requirements and graduate credit)

Information can be found at https://bme.rutgers.edu/resources-and-forms
Including: Eligibility, Curriculum, and Application.
Email Ms. Elaine Connors, Program Coordinator at econnors@soe.rutgers.edu with questions.

James J. Slade Scholars Program

Administered through Office of Academic Affairs

https://soe.rutgers.edu/research/student-research/james-j-slade-scholars-program

Application & Completion forms for James J. Slade Scholar can be found on the above link

Please complete forms in its entirety.

NOTE:

James J. Slade Program credits do not count toward the Undergraduate BS Degree!

However, you can earn credit toward the Graduate Degree.
Register for courses 16:125:587/588.

Experiential Learning Guidelines

Experiential learning opportunities allow students to enhance their education with real-world exposure to research and industry. Students can earn up to six technical elective credits (2 courses) for participating in these activities.

Directed Research in Biomedical Engineering

These courses (291,292) provide opportunity to students (with 3.25 or higher GPA) to participate in research project earlier within biomedical engineering environment. The underclass students are provided with appropriate facilities and other professional development opportunities.

Note: The credits earned are extra and **does not count towards** the graduation requirements of BME Degree.
Prerequisite: Permission of department.

Independent Study in Biomedical Engineering

These courses (491/492) provide opportunities to JUNIORS and SENIORS to participate in research for technical elective credit. Students need to complete the Independent Study form, and register for 3 credits. Students earn a letter grade in these courses, and the workload is approximately 15 hours/week. Grade requirements are determined by the PI.

Internship in Biomedical Engineering

Students who obtain an internship during the academic year or over the summer can register their internship for technical elective credit with undergraduate director approval. Please complete the form (in the handbook/on the website). If working during the semester, the typical expectation is 15 hrs/ week, and during the summer it is full-time.
Students earn a Pass/No Credit grade.

Co-Op in Biomedical Engineering

A co-op is a 6-month, full-time work experience which encompasses one semester and the summer. Students can earn 6 technical elective credits (2 courses) for a co-op and earn a pass/no credit grade. Students cannot take more than 2 additional classes if registered for a co-op, however classes that conflict with work need to be discussed with your supervisor. BME has an approved co-op program tailored for sophomores, however most opportunities are open to all students and will be distributed regularly, students are also welcome to find their own co-op through resources like Handshake, and register it for credit.

Regulations for Internships and Co-Ops:

1. You must get permission PRIOR to starting the experience. Past internships, co-ops or research cannot retroactively get credit.
2. No more than 6 credits of experiential learning can be applied for technical elective credit.
3. Internship and co-op credits counts as **Technical Electives ONLY. No Exceptions!**
4. Final report (1-2 pages) **MUST** be submitted to ***UG Director*** summarizing internship/co-op work.
5. Supervisor(s) **MUST** submit evaluation to ***UG Director*** **directly** at the end of the internship/co-op.
6. Register during open registration period.

Students are not limited to internships and co-ops shared by the department. If you get an offer on your own, please submit the form for consideration for credit!

MBS Externship Experience 16:137:655

If you have any questions about the experiential learning opportunities, please send an email to Kristen Labazzo at sakala@soe.rutgers.edu or stop by her office in the Biomedical Engineering Building, Office 328C.

BME Research Scholars Academy

****MUST BE A RISING JUNIOR IN ORDER TO APPLY****

For APPLICATION PROCESS - Rising Juniors will be informed how to apply!

The BME Research Scholars Academy is designed for a highly selective group of biomedical engineering undergraduates, who, based on their demonstrated academic record and/or research potential, are given the opportunity to immerse themselves in an accelerated research program at Rutgers. It is anticipated that most Research Scholars Academy members will go on to further graduate and/or professional training after graduation.

- Applications are submitted online by Aug. 31st (junior year). We adhere to a minimum 3.5 GPA. Student must have planned with the prospective mentors prior to filling out the application.
- Selected candidates are provisionally admitted to the RSA and are assigned to mentors by the end of September (junior year).
- Students are evaluated by their mentors during the remaining of the fall semester and a final decision for accepting a student into the RSA is made by the mentor by the end of the semester and is communicated to the faculty responsible for the RSA program. We will establish general guidelines regarding what constitutes an evaluation. The process needs to be clear and transparent, and students need to be aware of what is required of them. Students who fail during the probation period cannot re-apply and /or be assigned to a different faculty member. The final decision is not negotiable. The fall semester of the junior year is a trial period for which students do not receive credit for.
- Students admitted to the RSA register for the upcoming 3 consecutive semesters (490 spring junior, 493 fall senior, 494 spring senior) and receive 9 credits and policies are the same. No co-op is allowed unless it is the result of prior coordination between the mentor and the industrial partner, and it involves work related to a student's HA project.
- Grading Policy:
  a. active participation of research in mentor's lab
  b. presentation on RSA student's research project (RSA project and Senior Design project should be different, if they are the same, significant amount of efforts should be put into the project)
  c. a short project report (includes Abstract, Intro, Methods, Results, and Discussions) to both the mentor and the RSA coordinator.
  d. participation of RSA activities (e.g., seminars on poster preparation, preparation for Graduate/ Medical school applications, Graduate/Medical student lives, etc.)
- The Academy members are nominated for the Rutgers University Research Fellowship (RURF) and other appropriate fellowship opportunities.
- In appropriate cases, the Academy members will be supported by faculty research grants through Research Experiences for Undergraduate Supplements or other federal and industrial grants.

REGISTRATION FOR CREDITS: The Research Scholars Academy members can count to six credits of Advanced BME Research (125:493 or 494) toward their BME technical electives or BME departmental electives. (**In addition**, Academy members can count a maximum of three credits of Independent Study in Biomedical Engineering (125:491, 492) electives toward their technical electives.

Note: Students that do not belong to the Research Scholars Academy and perform individual research with a BME faculty can count to six credits of Independent Study in Biomedical Engineering in Research (125:491, 492) toward their technical

electives, but they will not be allowed to register for 125:493 or 125:494, nor count any of their research toward departmental elective requirements.

For further information on the Research Scholars Academy, including application procedure, **please contact Dr. Ioannis (Yannis) Androulakis,** See Faculty Locator page for info.

BME Forms:

- Undergraduate Independent Study 14:125:491/492- https://bme.rutgers.edu/sites/default/files/2024-06/Independent%20Study%20491_492_Fillable.pdf
- Application for Co-Op 14:125:496/497- https://bme.rutgers.edu/sites/default/files/2024-06/Application%20for%20Co-Op%20496_497_fillable.pdf
- Application for Internship 14:125:495- https://bme.rutgers.edu/sites/default/files/2024-06/Application%20for%20Internship%20495_flillable.pdf
- Application for Directed Research 14:125:291/292- https://bme.rutgers.edu/sites/default/files/2024-06/Application%20for%20Directed%20Research%20291_292_fillable.pdf