RUTGERS

School of Engineering

BioMedical Engineering UnderGraduate ProGram HandBook

Rutgers, The State University of New Jersey
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Updates available on-line at: http://biomedical.rutgers.edu

Last Update
11/01/2022

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UnderGraduate Program Administration

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CLASS ADVISING

All Classes	Your Assigned Faculty Advisor	Email List see page 6	Email for Appointment

Special Permission Number/Pre-req Override

Please email **Undergraduate Administrator or Director** with your:

~FULL NAME, RUID#, Class of 20XX and COURSE NAME (not Index #) ~

Please inform me of any messages during registration such as *course is closed, do not have pre-reqs, etc.*
Please wait patiently for a response.

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 options: 1) biomedical computing, imaging, and instrumentation, 2) biomechanics and rehabilitation engineering, and 3) tissue engineering and molecular bioengineering. The biomedical computing, imaging, and instrumentation 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, 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 areas 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, Goals, Educational Objectives and Educational Outcomes

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 integral part of the society to improve the understanding and control of biological processes towards improving human health. Our curriculum guides our students toward skill in creating new knowledge and technologies as well as applying current knowledge.

Rutgers Mission & Vision Statements are published at http://studentaffairs.rutgers.edu/about-us/mission-statement

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: http://www.soe.rutgers.edu/administration

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, http://www.bme.rutgers.edu/content/educationABET.php Also, note that one change has been made to the educational objectives since the last ABET visit. The change was a rewording of the objectives to make them consistent with the most recent ABET definition of Program Educational Objectives, although the sense of the objectives is unchanged.

Student Outcomes (SOs)

The student outcomes were adapted in the 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
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, **http://www.bme.rutgers.edu/content/educationABET.php**.

BME Faculty/Staff Locator

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Basic Curriculum

Department of Biomedical Engineering

Freshman Year

Fall

160:159	Gen Chem for Engrs	3
160:171	Intro to Experiment.	1
355:101	Expository Writing, I	3
640:151	Calculus I: Math/Phys	4
750:123	Analytical Physics Ia	2
440:100	Eng'g Orient Lecture	1
___:___	Hum/Soc Elective	3
	Total	**17**

Spring

160:160	Gen Chem for Engrs	3
440:127	Intro Comp for Engrs	3
640:152	Calculus II: Math/Phys	4
750:124	Analytical Physics Ib	2
440:221	Eng'g Mech: Statics	3
___:___	Hum/Soc Elective	3
	Total	**18**

Sophomore Year

Note:
If Intro to BME is full
Register for System Phys

Fall

125:201	Intro to Biomed Eng	3
640:251	Multivariable Calculus	4
750:227	Analytical Physics IIa	3
750:229	Analytical Phys IIa Lab	1
119:115	Biology I	4
___:___	Hum/Soc Elective	3
	Total	**18**

Spring

125:255	System Physiology	3
640:244	Diff Eqs Eng'g & Phys	4
750:228	Analytical Physics IIb	3
750:230	Analytical Phys IIb Lab	1
119:117	Biology Lab	2
540:343	Engineering Economics	3
	Total	**16**

Junior Year

Note:
If Transport/Numerical are full; register for Biomaterials/Kinetics

Fall

125:303	BME Transport Phenom	3
125:305	BME Numerical Modeling	3
125:308	Biomechanics	3
125:309	BME Devices Systems Lec	3
125:310	BME Devices Systems Lab	1
___:___	Technical Elective •	3
	Total	**16**

Spring

125:304	Biomaterials	3
125:306	Kinetics & Thermo	3
125:315	BME Measurements Lab	2
___:___	Technical Elective	3
___:___	Life Science Elective	3
	Total	**14**

Senior Year

Fall

125:401	Senior Design I	1
125:421	Senior Design Projects I	2
___:___	Departmental Elective	3
___:___	Departmental Elective	3
___:___	Technical Elective	3
___:___	Hum/Soc Elective	3
	Total	**15**

Spring

125:402	Senior Design II	1
125:422	Senior Design Projects II	2
___:___	Departmental Elective	3
___:___	Departmental Elective	3
___:___	Technical Elective	3
___:___	General Elective	3
	Total	**15**

Minimum number of credits required ..... BME Degree Credits: **129**

∞ Organic Chemistry is required for the **Pre-medical School** option. (***Organic Chemistry I + Organic Chemistry II + Lab***)
∞ **ONLY Pre-med students** are required to take all three of the following courses: 119:115 (Biology I) **and** 119:116 (Biology II) **and** 119:117 (Biology Lab).
∞ **Rule I**: without **both** intro courses (Intro to BME + Sys. Phys.) **NO** 300-level courses – You **MUST** see **UGD** for **Approval**.
∞ **Rule II:** for anyone to register in Senior Design they need to have passed 6 out the 8 core BME courses (**Passed courses MUST include 309, 310, & 315**)
∞ Total of **12 credits** of **Technical Electives** is **Required**.
∞ 14:650:388 Computer-Aided Design in Mechanical Engineering (3 cr. TE) is strongly recommended for the Biomechanics and Rehab.
∞ **125:309/310** Devices Lec/Lab and **125:401/421** Senior Design I Lec/Proj are only offered in the **Fall**.
∞ **125:315 Measurements Lab and 125:402/422 Senior Design II Lec/Proj** are only offered in the **Spring**.
∞ Allowed to use an additional Technical Elective 3 cr. (TE) to *replace* Life Science Elective 3 cr. (LSE).
∞ BME permanent Summer Courses are 201 and 255.
∞ BME **CORE** Courses offered both, Fall and Spring, semesters.
∞ Sophomore courses **2XX**; Junior courses **3XX (except RSA course)**, and Senior courses **4XX**

You must successfully pass **ALL** the courses on the curriculum to obtain your ..... Biomedical Engineering Degree!

Departmental Guidelines

∞ **Organic Chemistry is required for the Pre-Medical School option**.

Organic Chemistry I + Organic Chemistry II + Lab

∞ **ONLY Pre-med students are required** to take all three of the following courses:
119:115 (Biology I) and 119:116 (Biology II) and 119:117 (Lab).

∞ Total of **12 credits** of Technical Electives is **Required!**

∞ 14:650:388 Computer-Aided Design in Mechanical Engineering (3 cr TE) is strongly recommended for the Biomechanics and Rehab.

∞ **Rule I:** Without **200**-level courses (Intro to BME [125:201] **+** Sys. Phys. [125:255])
NO BME 300-level courses – You MUST see UGD for Approval.

∞ **Rule II:** For anyone registering for Senior Design they need to have passed 6 out the 8 core BME courses (**Must complete 309, 310, and 315** PLUS at least THREE out of 303, 304, 305, 306, and 308). So basically, we will allow you to take Senior Design if you fail AT MOST TWO COURSES (without counting for the labs).
While we allow students to register for SD with only 6/8 core, we do not encourage this as it may impact senior year electives. Also, the grad program is going to make a new rule that students who do not complete all of the junior core cannot apply to the CDP.

∞ **Rule III**: The rule for CO-OP is (assuming you are on track)
--> Depending on when you do your co-op (fall or spring) you will be allowed to take either 315, or 309/310 as co-reqs in the senior year.
--> You must have successfully completed everything else.

So, basically CO-OP students are allowed one extra course (315) in the senior year.

This is a fair resolution. It requires that you move to Senior Design after having successfully completed a significant fraction of the course work (6/8) and still we give you the benefit to recover from mishaps without penalizing you with an extra year. If you are 3 or more courses behind, including the labs, YOU should not be in Senior Design.

TRANSFER STUDENTS:

∞ Your curriculum will be determined by the number of credits that are transferred to Rutgers and the remaining courses needed to complete program. The rules above may or may not apply to you. You will find out after your evaluation by the Office of Academic Affairs (OAA).

The OAA handles Transfer Orientation Sessions, please contact that office for more information (848-445-2212).

SCHOOL OF ENGINEERING / ACADEMIC AFFAIRS OFFICE:

∞ You may review the School of Engineering website addressing several concerns: **soe.rutgers.edu**
There are links to other websites to assist you with most issues you are trying to resolve.

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 with Schedule of Courses online to see which courses will be offered. Although they may appear on list, does not mean they are offered.

14:125:201 Introduction to Biomedical Engineering (3)
Prerequisites: 01:640:152 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.

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 with Schedule of Courses online to see which courses will be offered. Although they may appear on list, does not mean they are offered.

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.

14:125:411 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 14:125:309

Introductory 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.

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.

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 credits

Prerequisites: 14:125:309, 310, and 315

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.

14:125:475 Design and Advanced Fabrication of Biomedical Devices- 3 credits

Prerequisites: 14:125:304

The purpose of this course is to provide an overview of fabrication techniques and bioconjugate chemistry, as applied in the biomedical field. The course will cover topics covering to macro- to molecular-scale considerations for medical devices and implants. Students that complete the course will gain an understanding of the factors that go into the design and fabrication of medical devices as well as the tradeoffs between biomaterials theory and device implementation. They will also have hands-on exposure to digital design tools used in fabrication and observe traditional and cutting-edge fabrication instruments in use.

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 3-credit Graduate courses, except 587/588, will count as a Departmental Elective.

Criteria for eligibility/Rules to take Graduate Courses **APPLIES**:
P/NC options, grading policy, participation expectations, etc.
See Graduate Handbook/Administrator/Director for assistance via **bme.rutgers.edu**

Technical & Life Science 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.)

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

Code	Title
01:070:349	Advanced Physical Anthropology (NB)
01:070:354	Functional and Developmental Anatomy of the Primate Skeleton (NB)
01:070:358	Human Osteology (NB)
01:119:116	General Biology II (NB)
01:146:245	Fundamentals of Neurobiology (NB)
01:146:270	Fundamentals of Cell and Developmental Biology (NB)
01:146:295	Essentials of Cell Biology and Neuroscience (NB)
01:146:445	Advanced Neurobiology I (NB)
01:146:446	Advanced Neurobiology Laboratory I (NB)
01:146:450	Endocrinology (NB)
01:146:470	Advanced Cell Biology I (NB)
01:146:471	Advanced Cell Biology Laboratory (NB)
01:146:474	Immunology (NB)
01:146:478	Molecular Biology (NB)
01:160:307	Organic Chemistry (NB)
01:160:308	Organic Chemistry (NB)
01:160:311	Organic Chemistry Laboratory (NB)
01:160:315	Honors Organic Chemistry (NB)
01:160:316	Honors Organic Chemistry (NB)
01:160:323	Physical Chemistry (NB)
01:160:327	Physical Chemistry (NB)
01:160:341	Physical Chemistry: Biochemical Systems (NB)
01:160:344	Introduction to Molecular Biophysics Research (NB)
01:160:409	Organic Chemistry of High Polymers (NB)
01:160:437	Physical Chemistry of Biological Systems (NB)
01:198:112	Data Structures (NB)
01:198:205	Introduction to Discrete Structures (NB)
01:198:206	Introduction to Discrete Structures II (NB)

Code	Title
01:198:211	Computer Architecture (NB)
01:198:323	Numerical Analysis and Computing (NB)
01:198:336	Principles of Information and Data Management (NB)
01:355:302	Scientific and Technical Writing (NB)
01:447:245	Introduction to Cancer (NB)
01:447:380	Genetics (NB)
01:447:390	General Microbiology (NB)
01:447:489	Advanced Independent Study in Genetics (NB)
01:447:495	Cancer (NB)
01:640:250	Introductory Linear Algebra (NB)
01:640:300	Introduction to Mathematical Reasoning (NB)
01:640:311	Introduction to Real Analysis I (NB)
01:640:312	Introduction to Real Analysis II (NB)
01:640:321	Introduction to Applied Mathematics (NB)
01:640:325	Foundations of Quantum Mechanics (NB)
01:640:336	Dynamical Models in Biology (NB)
01:640:338	Discrete and Probabilistic Models in Biology (NB)
01:640:339	Mathematical Models in the Social Sciences (NB)
01:640:348	Cryptography (NB)
01:640:350	Linear Algebra (NB)
01:640:354	Linear Optimization (NB)
01:640:403	Introductory Theory of Functions of a Complex Variable (NB)
01:640:411	Mathematical Analysis I (NB)
01:640:412	Mathematical Analysis II (NB)
01:640:421	Advanced Calculus for Engineering (NB)
01:640:423	Elementary Partial Differential Equations (NB)
01:640:424	Stochastic Models in Operations Research (NB)
01:640:426	Topics in Applied Mathematics (NB)
01:640:428	Graph Theory (NB)
01:640:429	Industry-Oriented Mathematics: Case Studies (NB)
01:640:432	Introduction to Differential Geometry (NB)
01:640:477	Mathematical Theory of Probability (NB)
01:694:301	Introductory Biochemistry and Molecular Biology (NB)
01:694:407	Biochemistry (NB)
01:694:408	Molecular Biology and Biochemistry (NB)
01:694:411	Molecular Pathways and Signal Transduction (NB)
01:750:301	Physics of Sound (NB)
01:750:305	Modern Optics (NB)

Code	Title
01:750:313	Modern Physics (NB)
01:750:323	Advanced General Physics I (NB)
01:750:324	Advanced General Physics II (NB)
01:750:326	Computer-Based Experimentation and Physics Computing (NB)
01:750:327	Modern Instrumentation (NB)
01:750:341	Principles of Astrophysics (NB)
01:750:342	Principles of Astrophysics (NB)
01:750:351	Thermal Physics (NB)
01:750:361	Quantum Mechanics and Atomic Physics (NB)
01:750:381	Mechanics (NB)
01:750:382	Mechanics (NB)
01:750:385	Electromagnetism (NB)
01:750:386	Electromagnetism (NB)
01:960:212	Statistics II (NB)
01:960:379	Basic Probability and Statistics (NB)
01:960:381	Theory of Probability (NB)
01:960:382	Theory of Statistics (NB)
01:960:401	Basic Statistics for Research (NB)
01:960:463	Regression Methods (NB)
01:960:467	Applied Multivariate Analysis (NB)
01:960:476	Introduction to Sampling (NB)
01:960:483	Statistical Quality Control (NB)
01:960:484	Basic Applied Statistics (NB)
11:115:301	Introductory Biochemistry (NB)
11:115:403	General Biochemistry (NB)
11:115:404	General Biochemistry (NB)
11:117:413	UNIT PROCESSES IN ENVIRONMENTAL ENGINEERING I (NB)
11:117:414	Unit Processes in Bioenvironmental Engineering II (NB)
11:117:462	Design of Solid Waste Treatment Systems (NB)
11:117:474	Air Pollution Engineering (NB)
14:125:490	BME HA RESEARCH II (NB)
14:155:201	CHEMICAL ENGINEERING MATERIAL AND ENERGY BALANCES (NB)
14:155:208	CHEMICAL ENGINEERING THERMODYNAMICS I (NB)
14:180:216	Introductory Computer-Aided Design and Drafting (NB)
14:180:243	Mechanics of Solids (NB)
14:332:221	Principles of Electrical Engineering I (NB)
14:332:222	Principles of Electrical Engineering II (NB)
14:332:231	Digital Logic Design (NB)

Code	Title
14:332:252	PROGRAMMING METHODOLOGY 1 (NB)
14:332:373	Elements of Electrical Engineering (NB)
14:332:402	Sustainable Energy (NB)
14:440:222	Engineering Mechanics: Dynamics (NB)
14:440:301	Introduction to Packaging Engineering (NB)
14:440:302	CAD For Packaging Engineering (NB)
14:440:371	Packaging Evaluation Methods (NB)
14:440:373	Packaging Manufacturing (NB)
14:440:378	Sustainable Packaging (NB)
14:440:392	Undergraduate Research in Engineering
14:440:403	Safety Engineering in Packaging (NB)
14:440:406	Packaging Printing and Decoration (NB)
14:440:468	Packaging Machinery (NB)
14:440:471	Distribution Packaging (NB)
14:540:201	Work Design and Ergonomics (NB)
14:540:210	Engineering Probability (NB)
14:540:461	Engineering Law (NB)
14:635:203	Introduction to Materials Science & Engineering (NB)
14:635:204	Materials Processing (NB)
14:635:205	Crystal Chemistry and Structure of Materials (NB)
14:635:206	Thermodynamics of Materials (NB)
14:635:303	Phase Diagrams (NB)
14:635:304	Ceramic Compositions (NB)
14:635:305	Materials Microprocessing (NB)
14:635:306	Processing III (NB)
14:635:307	Kinetics of Materials Processes (NB)
14:635:309	Characterization of Materials (NB)
14:635:312	Glass Engineering (NB)
14:635:314	Strength of Materials (NB)
14:635:316	Electronic, Optical And Magnetic Properties Of Materials (NB)
14:635:320	Introduction to Nanomaterials (NB)
14:635:321	Structural, Mechanical and Chemical Application of Nanostructures and Nanomaterials (NB)
14:635:322	Photonic, Electronic and Magnetic Applications of Nanostructures and Nanomterials (NB)
14:635:330	Introduction to Nanomaterials (NB)
14:635:340	Electrochemical Materials And Devices (NB)
14:635:360	Materials Science & Engineering Of Ceramics & Glasses (NB)
14:635:405	Solar Cell Design And Processing (NB)
14:635:407	Mechanical Properties of Materials (NB)

Code	Title
14:635:410	Biological Applications Of Nanostructures And Nanomaterials (NB)
14:650:210	Introduction to Aerospace Engineering (NB)
14:650:231	Mechanical Engineering Computational Analysis and Design (NB)
14:650:291	Mechanics of Materials (NB)
14:650:342	Design of Mechanical Components (NB)
14:650:388	Computer-Aided Design in Mechanical Engineering (NB)
16:137:655	Externship Experience I (NB)
30:718:304	Pathophysiology (NB)
30:721:301	Introduction to Pharmaceutics (NB)
30:721:320	Drug Delivery I and Laboratory (NB)
30:721:430	Introduction to Biopharmaceutics and Pharmacokinetics (NB)
TR:125:TE1	Biomedical Engineering Technical Elective Transfer Equivalent (NB)
TR:125:TE2	Biomedical Engineering Technical Elective Transfer Equivalent (NB)
TR:125:TE3	Biomedical Engineering Technical Elective Transfer Equivalent (NB)
TR:125:TE4	Biomedical Engineering Technical Elective Transfer Equivalent (NB)
TR:125:TEC	Biomedical Engineering Technical Elective Transfer Equivalent (NB)

**** If a class you wish to take is not listed and you believe it meets the qualifications of a technical elective, please contact the undergraduate director.****

Acceptable 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 ****

Areas of Interest in BME

Modern applications of Biomedical Engineering encompass a wide range of technical areas. The goal of the Rutgers Biomedical Engineering Department is to educate its students with a broad base in core biomedical engineering and provide depth in the frontier areas of biomedical engineering profession through exposure to key areas of specialization. Based on area of interest, the student can then design the appropriate technical elective, life-science elective, and departmental elective. In the event there are specific questions related to each area, general faculty advisors should be contacted.

Your degree will say: "Biomedical Engineering"

*** Please check with the Track Advisors for updates to recommended electives.**

Track Advisors

Your Interests In:	Advisors	Advising
Biomedical Computing, Imaging, and Instrumentation (BCII)	M. Pierce mark.pierce@rutgers.edu	Email for Appointment
Biomechanics and Rehabilitation Engineering (BRE)	J. Zahn jdzahn@soe.rutgers.edu	Email for Appointment
Tissue Engineering and Molecular Bioengineering (TEMB)	Li Cai lcai@soe.rutgers.edu T. Shinbrot shinbrot@soe.rutgers.edu	Email for Appointment

Biomedical Computing, Imaging & Instrumentation (BCII)

Target Audience:

These course recommendations are designed to train students who are interested in academic or industrial careers that involve the measuring and modeling of physiological systems, medical imaging, medical image processing and analysis and the graphics and visualization industries. Emphasis is placed both on understanding the physiological system as well as the engineering and development of new sensors and measurement devices. Specialists in Medical Imaging and Medical Image Analysis find careers in small and large industries as well as research centers and universities. They will also prepare students with a solid background for graduate study.

BME Department Electives for BCII

14:125:403	Cardiovascular Engineering
14:125:411	Bioelectric Systems
14:125:424	Biomedical Instrumentation Lab
14:125:431	Introduction to Optical Imaging
14:125:437	Computational Systems Biology
14:125:455	BME Global Health
14:125:465	BME Microfluidics

Recommended Life Science Electives for BCII *(see complete list of Life Sciences in Handbook)*

01:146:245	Fundamentals of Neurobiology
01:146:270	Fundamentals of Cell and Developmental Biology
01:146:295	Essentials of Cell Biology & Neuroscience

Recommended Technical Science Electives for BCII *(see complete list of TE in Handbook)*

01:198:424	Modeling and Simulation of Continuous Systems
14:332:346	Digital Signal Processing
14:332:361	Electronic Devices
14:332:376	Virtual Reality
14:332:417	Control Systems Design
14:332:448	Image Processing-Design
14:332:466	Opto-Electronic Devices
14:332:471	Robotics and Computer Vision
01:640:350	Linear Algebra
01:640:421	Advanced Calculus for Engineering
01:750:305	Modern Optics

Biomechanics and Rehabilitation Engineering (BRE)

Target Audience:

The biomechanics "option" has added emphasis on tissue and fluid mechanics, whereas the rehabilitation engineering option has an emphasis on prosthetics and assisted devices. These recommendations electives have been identified as more appropriate for an emphasis on rehabilitation engineering (R) and/or biomechanics (B). Students undertaking this curriculum will be well prepared for employment in the medical device industry (orthopedic, imaging, cardiovascular), and positions involving direct contact with health care, rehabilitation, and human performance. Also, an excellent background for students seeking advanced degrees in engineering, medicine, and physical/occupational therapy.

BME Department Electives for BRE

14:125:417	Musculoskeletal Mechanics
14:125:433	Tissue Engineering I: Fundamentals and Tools (B)
14:125:434	Tissue Engineering II: Biomedical and Biotechnological Applications (B)
14:125:455	BME Global Health
14:125:460	Motor Control & Motion Analysis
14:125:465	BME Microfluidics

Recommended Life Science Electives for BRE *(see complete list of Life Sciences in Handbook)*

01:146:270	Fundamentals of Cell and Developmental Biology (B)

Recommended Technical Science Electives for BRE *(see complete list of TE in Handbook)*

14:155:551	Polymer Science and Engineering I
14:155:552	Polymer Science and Engineering II
14:332:376	Virtual Reality
14:332:471	Robotics and Computer Vision
14:440:222	Dynamics
14:540:461	Engineering Law
14:635:320	Introduction to Nanomaterials
14:635:407	Mechanical Properties of Materials
01:640:421	Advanced Calculus for Engineering
14:650:342	Design of Mechanical Components
14:650:388	Computer-Aided Design
14:650:401	Control Systems
14:650:455	Design of Mechanisms
14:650:472	Biofluid Mechanics (B)
01:960:384	Intermediate Statistical Analysis

Tissue Engineering and Molecular Bioengineering (TEMB)

Target Audience:

These course recommendations are designed for students who desire to apply engineering principles to the development of biomedical technologies underlying tissue engineering, biomaterials design and applications, and molecular medicine. An emphasis is placed on biochemistry and on molecular and cell biology in the life sciences arena and on thermodynamics, kinetics, and transport and materials sciences within the engineering sciences. Students undertaking this curriculum will be well prepared for employment in the tissue engineering, pharmaceutical and biotechnology industries, for medical school, or for graduate study in Biomedical Engineering.

BME Department electives appropriate for TEMB

14:125:433	Tissue Engineering I: Fundamentals and Tools
14:125:434	Tissue Engineering II: Biomedical and Biotechnological Applications[1]
14:125:437	Computational Systems Biology
14:125:445	Principles of Drug Delivery
14:125:455	BME Global Health
14:125:465	BME Microfluidics

Recommended Life Science Electives *(see complete list of Life Sciences in Handbook)*

01:694:301	Intro. to Biochemistry & Molecular Biology
01:694:407	Molecular Biology & Biochemistry I
01:694:408	Molecular Biology & Biochemistry II
01:146:270	Fundamentals of Cell and Developmental Biology

Recommended Technical Science Electives *(see complete list of TE in Handbook)*

01:146:474	Immunology
01:146:470	Advanced Cell Biology I
14:155:411	Introduction to Biochemical Engineering
14:155:551	Polymer Science and Engineering I
14:155:552	Polymer Science and Engineering II
01:160:409	Organic Chemistry of High Polymers
01:447:380	Genetics
14:635:320	Introduction to Nanomaterials
14:635:323	Bio. Applications of Nanomaterials
01:640:250	Introduction to Linear Algebra
01:640:421	Advanced Calculus for Engineering
01:694:411	Molecular Pathways and Signaling
01:960:379	Basic Probability and Statistics
01:960:384	Intermediate Statistical Analysis

Special Programs

Declaring a Minor

There are no official minors in any engineering subject. It is possible for students to pursue 2 engineering BS degrees, simultaneously or sequentially. In this case only 1 set of humanities/social science electives need to be completed.

Declaring a Different Major within Engineering

Careful thought should precede any change of curriculum. Students should consult the executive officers or appropriate faculty advisors in the two majors.

Double Major vs. Dual Degree

A Double Major means that you must fulfill the 'major requirements' as described for that department (refer to the Undergraduate catalog for details). Generally, a second major is around 30 credits. You would remain a School 14 student, but you would have the second major denoted on your transcript.

A Dual Degree means that you apply to the other college and be accepted. After you are accepted, you must fulfill all requirements for the BA for that college (like Rutgers College or Cook College). This is a more involved process and includes additional work on top of the ~30 credits for the major. For example, if you declare a technical major like Mathematics or Physics, Rutgers College requires that you take additional non-western humanity courses as well as completing a minor in a H/SS area. Consult the specific college for more details.

You would receive two separate degrees, one from each school. If you do not complete both degrees concurrently (example, you have a few classes left for you BA, and you decide to graduate with just your BS from Engineering), you may not come back to finish your remaining classes and obtain the second degree.

For either option, refer to the department in which you want to get the major/degree for **advice on course selection**, and check the RU catalog and departmental websites. Fill out the form and bring it to EN B100 (Academic Affairs).

B.S./M.B.A. Program

Qualified candidates for the Bachelor of Science (BS) degree in the School of Engineering are given the opportunity to obtain the Master of Business Administration (MBA) degree from the Rutgers Graduate School of Management in one year of academic work following the completion of the requirements for the BS degree.

If accepted into the program, during the fourth year, BME students will take graduate courses towards the MBA degree which will be offered at Rutgers Business School: Graduate Program — Newark and New Brunswick's campuses. The fourth year is declared as the senior year of undergraduate school. The student, consequently, receives the benefit of undergraduate tuition rates. At the end of the fourth year, students should have successfully completed all undergraduate requirements for the BS Degree. During the fifth year, the students will complete graduate studies and receive the MBA degree.

A 3.0 grade point average is required. The GMAT should be taken during the junior year. The application to the MBA program should be pursued during the spring semester of the junior year. Please contact the Business School for more information.

B.S./M.D. Program

BME students either are not eligible to do the BS/MD program or that they will be expected to take the full 4 years to complete the program. Please contact the Health Professions Office for more information at **hpo.rutgers.edu**.

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 B.S and M.S. /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 Graduate Administrator with questions.

James J. Slade Scholars Program

Administered through Office of Academic Affairs

www.soe.rutgers.edu/oaa

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 does not count toward the Undergraduate BS Degree !

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

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.

Extra Special Problem courses (491-492) credits or other technical courses may be used to replace up to four required technical courses (including those in the major) with the approval of research advisor and executive officer.

Industrial Interactions

The Office of Career Exploration and Success will be assisting you with career development and employment opportunities. They have a variety of resources (CareerKnight, Online Career Self-Assessment and Planning, On-Campus Interviewing Program), various clinics (Mock Interview Clinic, Drop-in Resume Clinic, Networking Clinic, Internship Clinic) and the staff (Liaisons for Engineering: Joe Scott, Tamara Peters, and Mindy O'Mealia) to provide you with the guidance you will need and the career opportunities you are seeking.

Your next step should be to access the CareerKnight system at http://careers.rutgers.edu. All students automatically have a CareerKnight account. This system will allow you to begin your career development plan from scheduling an appointment with a career counselor to applying for internships. You can also contact The Office of Career Exploration and Success at 848-932- 7997, if you have any questions.

Once you have received an Internship offer, complete the Application for Internship in this handbook and submit to the Undergraduate Administrator who will provide you access to register.
Please ensure that you are aware of the following:

Regulations:

1. Internship credits counts as a **Technical Electives ONLY. No Exceptions!**
2. Graded on a **Pass/No Credit** scale.
3. Final report (1-2 pages) MUST be submitted to *UG Director* at end of Internship summarizing work.
   - Report should include what the job duties were, what skills were learned, and anything else about the industry experience that you wish to share, bad or good.
4. Supervisor(s) MUST submit evaluation to *UG Director* at the end of the Internship.
   - This can simply be an email but MUST be sent DIRECTY to the Undergraduate Director from the supervisor! Evaluation should confirm employment, list the duties performed, and contributions made to the project. If appropriate, supervisor can also include information about your performance. If an internal evaluation is performed and supervisor is comfortable/allowed to share that, that will also suffice.
5. Register during open registration period.
6. **Limit is TWO** Internship 3cr. Courses will count towards degree.

Co-op Program

The Co-op program is a formal mechanism where students earn course credits by working for a local company for six months (one semester plus a summer). This provides the students with a capstone experience to the undergraduate curriculum by integrating prior coursework into a working engineering environment. Previous Co-op students have worked at companies such as Johnson & Johnson Ethicon, Johnson & Johnson McNeil, Howmedica Osteonics, and Boston Scientific. **Please see the Undergraduate Director for approval**.

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

Faculty Research Expertise

Ioannis P. Androulakis	Ph.D., Purdue University *Novel computational algorithms, microarray experiment and molecular dynamics simulations, combustion phenomena*
Francois Berthiaume	Ph.D., Pennsylvania State University *Wound Healing, Tissue Engineering & Regenerative Medicine, Metabolic Engineering*
Nada Boustany	Ph.D., Massachusetts Institute of Technology *Biomedical Imaging, Cellular Biophysics, Optical Microscopy*
Helen Buettner	Ph.D., University of Pennsylvania *Nerve growth and regeneration, cellular engineering, modeling of biological processes, computer graphics and simulation, video microscopy*
Li Cai	Ph.D., Dana Farber Cancer Institute *Nerve growth and regeneration, cellular engineering, modeling of biological processes, computer graphics and simulation, video microscopy*
Gary Drzewiecki	Ph.D., University of Pennsylvania *The cardiovascular system, new methods of blood pressure determination, mathematical models of the normal and diseased heart, study of flow in circulation, application of chaos and fractals*
Joseph Freeman	Ph.D., Rutgers University *Tissue engineering, Biomechanics, Biomaterials, and Musculoskeletal regeneration*
Adam Gormley	Ph.D., University of Utah *Biomaterials, nanomedicine, self-assembly, biosensing and diagnostics*
Kristen Labazzo	Ph.D., Rutgers University *Biomaterials, mesenchymal stem cells, medical devices, assistive technologies*
Noshir Langrana	Ph.D., Cornell University *Orthopedic biomechanics, biomechanical design, finite element methods and tissue engineering*
John K-J. Li	Ph.D., University of Pennsylvania *Cardiovascular mechanics, biosensors and transducers, cardiac arrhythmias and assist devices, controlled drug delivery systems, ultrasound, and electro-optics*
Adrian Mann	D. Phil., Oxford University *Biomaterial fabrication and characterization, Nanomechanics and Nanoprobe Microscopy*

Prabhas Moghe	Ph.D., University of Minnesota *Cell and tissue engineering, Cell-interactive Biomaterials, Micro/Nanobiotechnology*
Biju Parekkadan	Ph.D., Harvard-MIT Division of Health Sciences and Technology *Cell & Genetic Engineering, Bioreactor engineering, Regenerative Medicine & Immunotherapy*
Mark Pierce	Ph.D., University of Manchester *Biomedical optics, Microscopy, Contrast agents, Cancer imaging*
Charles Roth	Ph.D., University of Delaware *Molecular bioengineering; nucleic acid biotechnology; liver systems engineering; cancer therapeutics*
Troy Shinbrot	Ph.D., University of Maryland *Nerve regeneration; structure from noise; pharmaceutical engineering*
George Shoane	Ph.D., University of California, Berkeley *Biological Control and Feedback; Biomedical Modeling*
David Shreiber	Ph.D., University of Pennsylvania *Tissue engineering, injury biomechanics, and nerve regeneration*
Jay Sy	PhD, Georgia Institute of Technology & Emory University *Drug delivery, Biomaterials, Medical Devices*
Valerie Tutwiler	Ph.D., Drexel University *Hemostasis/Thrombosis, Biomechanics, Biomaterials, Inflammation*
Maribel Vazquez	Sc.D., Massachusetts Institute of Technology *Microfluidics-based biosystems, neural cell migration and retinal regeneration*
Martin Yarmush	Ph.D. Rockefeller University M.D. Yale University School of Medicine *Tissue engineering, molecular bioengineering, bioseparations and biothermodynamics, and metabolic engineering*
Jeffrey Zahn	Ph.D., University of California, Berkeley *Microfabrications and microfluidics*

Forms: Research Guidelines

Internship in Biomedical Engineering:

Courses graded as Pass/No Credit can be counted as 3 credit technical electives.

The UAB has agreed to accept up to 6 credits in experiential-based learning toward the Engineering degree in addition to the capstone design. Exceptions can be made by the UGDs to accept up to 9 credits max. We had an implicit rule for making such an exception:
- We accept 9 credits max for students who have completed both the Internship (125:495; 3 credits) and a co-op (125:496/497; 6 credits)
- We accept 6 credits max for students who have not completed a co-op, which means two 3-credit Internship courses can be counted.

Some additional notes:
- For any given semester, students can only take up to 6 credits of experiential based learning, so students are not allowed to register co-op and internship together.
- By default, departmental Independent Study courses are also considered as experiential based learning, so they are part of the mix as well. UGDs can override this default if an independent study is offered in a classroom setting.
- The max number of research credits includes research done in other departments not managed by BME.

Time/Hours Expected Weekly-Minimum:

For Research, Co-op, or Internship; there is a **standard 5 hours per credit minimum required**.
(Example. 3 credits = 15 hours minimum; 2 credits = 10 hours minimum; 1 credit = 5 hours minimum)

*However, student and PI may reach alternate (more or less) arrangements based on research needs.

Due to COVID19:

The following forms must be sent directly to **Advisors/Faculty/PIs** and **UnderGraduate Director** to obtain their signature and ultimately sent to **UnderGraduate Administrator** for registration purposes.

Application for Directed Research14:125:291/292

DEPARTMENT OF BIOMEDICAL ENGINEERING

**** FRESHMAN AND SOPHOMORE STUDENTS ****

Instructions:

1) **MUST be a BME Student with GPA of 3.25 or higher.**
2) **Complete this form and obtain all required signatures.**
3) **Submit it to the Undergraduate Program Administrator in BME-110 for the Special Permission Number to register during registration period.**
4) **Use the Special Permission number given to register for 3 credits! to be a full-time student only**
5) **CREDITS Do Not count toward BS DEGREE. No Exceptions!**
6) **Advisor(s) must submit grade via email to Undergraduate Director promptly during grading period. (Grades of A, B, and C correspond to Pass)**

Student's Name (Print)_____,_____#_____
(Last) (First) (RUID)

E-Mail: _____ **Avg. GPA: _____**

Semester: _____ **Class of: _____**

Are you on academic probation? Yes _____ No _____

***Print PI's name(s) Lab: _____**

Project Title:

_____

_____

_____

Approval Signature(s) of PI's:

_____

Department Chair or Undergraduate Director's Signature:

_____Date: _____

Signature of Student:_____Date: _____

Index Number: _____ **Special Permission Number:_____**

Independent Study 14:125:491/492 (3cr.)

DEPARTMENT OF BIOMEDICAL ENGINEERING

**** JUNIOR AND SENIOR STUDENTS ****

Instructions:

1) **Complete this form and have it signed by the research advisor you will be working under.**
2) **Submit it to the Undergraduate Program Administrator in BME-110 for the Special Permission Number to register during registration period.**
3) **Use the Special Permission number given to register for 3 credits!**
4) **TECHNICAL ELECTIVE credit only. No Exceptions!**
5) **You must have completed or currently registered for Devices Lecture and Lab to be eligible.**
6) **Advisor(s) must submit grade via email to Undergraduate Director promptly during grading period.**

Student's Name (Print)_____**,**_____**#**_____
(Last) (First) (RUID)

E-Mail: _____ **Avg. GPA:** _____

Semester: _____ **Class of:** _____

Are you on academic probation? Yes _____ **No** _____
If yes, you cannot receive credit for Independent Study in Biomedical Engineering.

(Maximum number of credits students can earn for Independent Study in Biomedical Engineering is six, but no more than three in any semester.)

***Print PI's name(s):** _____

Project Title:

_____

_____

If you are not a BME student,
Please give your department name: _____

Approval Signature(s) of PI's and Email Address(es):

PI's Signature:_____**Email:** _____

[PI NOTE: Student must complete all assignments/reports you require, and you must send UG Director Grade.]

Signature of Student:_____**Date:** _____

Index Number: _____ **Special Permission Number:**_____

BME Research Scholars Academy

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

The 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 at Yannis@soe.rutgers.edu.**

Application for Internship14:125:495 (3 cr.)

DEPARTMENT OF BIOMEDICAL ENGINEERING

*This form **MUST** be completed **BEFORE** registering and starting Internship. UPD needs to approve the internship prior to its start to ensure that it meets the requirements of a technical elective. Then given to Undergraduate Administrator, who will assign a special permission number. *

I. PERSONAL INFORMATION **REGISTERING for:___ Summer (OR) ___ Fall/Spring**

Student's Name _____ _____
(Last) **(First)**

Phone: _____ Class of: _____

Email: _____ **RUID#**_____

First Day of Work:_____ Last Day of Work:_____

II. EMPLOYER INFORMATION

Employing Institution: _____

Supervisor/Contact Name(s):

1. _____ 2._____

Phone/Fax: _____ Phone/Fax: _____

Email: _____ Email: _____

Job Description: _____

_____

_____

_____

Regulations:

1. Internship credits counts as a **Technical Electives ONLY. No Exceptions!**
2. Graded on a **Pass/No Credit** scale.
3. Final report (1-2 pages) MUST be submitted to *UG Director* at end of Internship summarizing work.
   - Report should include what the job duties were, what skills were learned, and anything else about the industry experience that you wish to share, bad or good.
4. Supervisor(s) MUST submit evaluation to *UG Director* at the end of the Internship.
   - This can simply be an email but MUST be sent DIRECTY to the Undergraduate Director from the supervisor! Evaluation should confirm employment, list the duties performed, and contributions made to the project. If appropriate, supervisor can also include information about your performance. If an internal evaluation is performed and supervisor is comfortable/allowed to share that, that will also suffice.
5. Register during open registration period.
6. **Limit is TWO** Internship 3cr. Courses will count towards degree.

III. Signatures:

I have read the above regulations *and* understand the rules for my internship assignment

Student's Signature:_____Date: _____

UG Director Signature:_____Date: _____

Index Number: _____ Special Permission Number: _____

Application for Co-Op 14:125:496/497 (6 cr.)

DEPARTMENT OF BIOMEDICAL ENGINEERING

*This form **MUST** be completed **BEFORE** registering for Co-op. It must be approved by the Undergraduate Director. Then given to Undergraduate Administrator, who will assign a special permission number. *

I. **PERSONAL INFORMATION**

Student's Name (Print)_____,_____#_____
(Last) (First) (RUID)

Phone: _____ Class of: _____

Email: _____ Course: 125:496____or 125:497_____

First day of Work:_____ Last day of Work:_____

II. **EMPLOYER INFORMATION**

Employing Institution: _____

Supervisor/Contact Name(s):

1. _____ 2._____

Phone/Fax: _____ Phone/Fax: _____

Email: _____ Email: _____

Job Description:

_____

_____

_____

_____

III. **Regulations:**

a. Co-op credits counts as a **Technical Electives ONLY. No Exceptions!**
b. Graded on a **Pass/No Credit** scale.
c. Final report (1-2 pages) **MUST** be submitted to ***UG Director*** at end of Co-op summarizing work.
d. Supervisor(s) **MUST** submit evaluation to ***UG Director*** at the end of the Co-op.
e. **Up to 6 additional credits** may be taken while on Co-op. Only **ONE** course during the day.
f. work ****continuously**** for 6 months **(Semester + Summer [not negotiable]).**
g. ***Full-time*** job assignment required.
h. Register during open registration period.
i. Non-compliant with all above – NOT ELIGIBLE FOR CO-OP…see Internship in BME.
j. **Limited to ONE** Co-Op 6 cr.

Students Initial here

IV. **Signatures:**

I have read the above regulations *and* understand the rules for my co-op assignment

Student's Signature:_____Date: _____

UG Director Signature:_____Date: _____

Index Number: _____**Special Permission Number:** _____

Bachelor's/Master's Combined Degree Program

Department of Biomedical Engineering

Objectives

The goal of the BME Bachelor's/Master's Combined Degree Program (BME-CDP) is to allow academically qualified students to receive the B.S. and M.S. or M.Eng degrees in a compressed 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)

Eligibility/Application

To be considered for the BME-CDP, candidates must:

See Graduate Handbook for rules/regulations for eligibility and application

*There is no GRE requirement for the BME-CDP although the GRE's may be required to apply for any PhD program or for future funding or fellowships.

Curriculum

The BME-CDP requires the candidate to take the remaining undergraduate credits during the Senior Year and 33 Graduate level credits during Senior and Graduate Years (Years 5+). The general timeline for the BME-CDP is as follows:

Senior Year: Candidates will take 6-18 graduate (500+ level) credits along with the remaining BME undergraduate courses needed for the B.S. degree (Senior Design, DE, TE, etc.).
Fifth Year (1st graduate year): Remainder of master's courses and work on the M.S. thesis or M.Eng project. Candidates can take fewer graduate courses, but this could lengthen the duration of the master's degree.
Summer following the Fifth Year: If necessary, students will complete the M.S. thesis and defend it or present the M.Eng project.

Please Note:

1) Candidates need to graduate with the BME B.S. degree at the end of the spring semester of the 4th year to continue (officially) in the master's program, as a full-fledged graduate student, starting either in the summer or fall following the 4th year.

2) Graduate courses in the senior year will be billed at the lower undergraduate tuition rate.

3) The J.J. Slade Scholar Program can be, and is recommended to be, pursued along with the BME-CDP. *If applying to the J.J. Slade Scholar Program in conjunction with the BME-CDP, that program requires a separate application form: https://soe.rutgers.edu/slade. At least ONE of your recommendation letters should be from your intended J.J. Slade Research Advisor. Contact Lawrence Stromberg (les42@soe.rutgers.edu) for questions on this additional option.*

4) Continuation in the BME-CDP is contingent on receiving **no more than one "C" grade** in any of the BME graduate courses during the Senior Year.

Sample Curriculum for the BME Bachelor's/Master's Combined Degree Program (BME-CDP)

Fall of Senior Year

14:125:401/421 Senior Design I 3 Credits
xx:125:xxx Departmental Elective 3 Credits
xx:125:xxx Departmental Elective 3 Credits
xx:xxx:xxx Technical Elective 3 Credits
16:125:605 BME Seminar (zero credit) ***and/or***
16:125:xxx Graduate Core Course(s) ***and/or***
16:125:xxx Graduate Elective Course(s)
— 1-9 Credits (1-3 courses)

Spring of Senior Year

14:125:402/422 Senior Design II 3 Credits
xx:125:xxx Departmental Elective 3 Credits
xx:125:xxx Departmental Elective 3 Credits
xx:xxx:xxx Technical Elective 3 Credits
16:125:605 BME Seminar (zero credit) ***and/or***
16:125:xxx Graduate Core Course(s) ***and/or***
16:125:xxx Graduate Elective Course(s)
— 1-9 Credits (1-3 courses)

Fall of 1st Master's Year (Official Graduate Student in the School of Graduate Studies)

16:125:501 BME Math Modeling Course 3 Credits
16:125:601 Engineering Ethics and Seminar 1 Credit
16:125:xxx Graduate Core or Electives (as needed) 3-9 Credits (1-3 courses)
16:125:701 Research (MS Only) 3 Credits

Spring of 1st Master's Year

16:125:586 BME Cell Biology Course 3 Credits
16:125:602 Engineering Writing and Seminar 1 Credit
16:125:628 Clinical Practicum 1 Credit
16:125:xxx Graduate Core or Electives (as needed) 3-9 Credits (1-3 courses)
16:125:699 Non-Thesis Study (M.Eng Only) ***OR*** 3 Credits
16:125:702 Research (MS Only) 3 Credits

Late Spring-Summer of 1st Master's Year (or 6th year depending on progress)

Finish up writing M.S. Thesis to defend or finishing the M.Eng project for presentation

Summary:

Senior Year Bachelor's Curriculum

Senior Design I & II
Departmental Electives
Technical Electives
Other courses as needed for the B.S.

Master's Curriculum

3 Core Courses (out of 5)	9 credits
1 BME Math Methods Course	3 credits
1 BME Adult and Stem Cell Biology Course	3 credits
3 One-Credit Professional Developmental Courses	3 credits
3 Electives	9 credits
2 Seminar Courses (when not taking 601/602)	0 credit
If pursuing MS: 6 Research Credits	6 credits (MS Only)
If pursuing M.Eng: 3 Non-Thesis Study Credits	3 credits (M.Eng Only)
If pursuing M.Eng: 4th Elective Course	3 credits (M.Eng Only)

33 Total Master's Credits