



DREXEL UNIVERSITY  
School of  
Biomedical Engineering,  
Science and Health Systems

# CATALOG

2021-2022

**UNDERGRADUATE**



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# The School of Biomedical Engineering, Science and Health Systems

## Mission Statement

*The mission of the School of Biomedical Engineering, Science and Health Systems is to promote health and quality of life through education, research, and innovation that integrates engineering and life sciences in a global context.*

The School of Biomedical Engineering, Science and Health Systems (<http://drexel.edu/biomed/>) is a nationally recognized center for research in biomedical engineering and science offering multi-disciplinary instruction on a full- and part-time basis at the graduate and undergraduate levels.

The School of Biomedical Engineering, Science and Health Systems offers a bachelor of science program in biomedical engineering with a choice of five concentration areas: biomaterials and tissue engineering, biomechanics and human performance engineering, biomedical informatics, biomedical devices and imaging, and neuroengineering.

## Major

- Biomedical Engineering (BSBE) (p. 4)

## Accelerated Degree Programs

- Biomedical Engineering BSBE / Biomedical Engineering MSBE (p. 9)

## About the School

The School of Biomedical Engineering, Science and Health Systems (<http://drexel.edu/biomed/>) (formerly the Biomedical Engineering and Science Institute, founded in 1961) is a leader in biomedical engineering and biomedical science research and education. The undergraduate program was inaugurated in September 1998 and has steadily grown to attract the highest ability students at the University. The undergraduate biomedical engineering curriculum is accredited by the Engineering Accreditation Commission of ABET (<http://www.abet.org>).

The School's academic thrust areas, both in research and education, are at the forefront of biosensing, bioimaging, bioinformation engineering and integrated bioinformatics, drug delivery, biomedical ultrasound & optics, bionanotechnology, cellular tissue engineering, neuroengineering and human performance. Emerging initiatives include skin bioengineering and pediatric engineering. Various departments at Drexel University offer courses that are suited for students in biomedical engineering and biomedical science. The School's curriculum complements the strengths of the Colleges of Arts & Sciences, Business, Engineering, Computing & Informatics, Law, Medicine, and Nursing. As a whole, the curriculum offers the advanced knowledge needed for industrial careers, health professions, graduate research or careers in highly specialized fields such as pre-professional health (medical, dental, and veterinary) and pre-law.

The marriage of technology with biology and medicine drives the 21st Century industrial enterprise. Consistent with this mission, the School strives for clinical and industrial relevance in our academic pursuits, and also maintains a strong entrepreneurship program in biomedical technologies. The School's alliance with regional economic development agencies and corporations together with advisors from business

development, legal, and investment communities sustains the growth of this program. The students and faculty of the School are committed to move their discoveries from laboratories to clinical practice or home use. The success of the Translational Research in Biomedical Technologies program has been recognized and funded regionally as well as nationally.

The School has experienced remarkable growth in recent years thanks to our outstanding research portfolio, high quality and innovative graduate and undergraduate programs, and our multidisciplinary approach to education and research. Another competitive advantage is the unique free-standing university-level administrative structure with its own tenure-track faculty lines, budget and space. This helps transcend the traditional organizational boundaries of engineering, sciences and medicine. The School's independence allows the pursuit of growth and collaborations in various disciplines and its structure provides agility to reconfigure and reorganize in response to emerging opportunities. The University Strategic Plan recognizes our School of Biomedical Engineering, Science and Health Systems as "Drexel's prototype of academic integration."

Metropolitan Philadelphia has one of the nation's highest concentrations of medical institutions and pharmaceutical, biotechnology, medical device and systems industry. The School has forged strategic partnerships with select universities, research institutes, health care institutions and industries in the region. The School enjoys a close working relationship with our Drexel College of Medicine as well as alliances with prominent medical institutions in the region to develop joint research and educational programs. These include the University of Pennsylvania, Thomas Jefferson University, the Fox Chase Cancer Center and the Wistar Institute. These collaborative initiatives provide students with ample opportunities in basic and clinical research as well as innovative academic programs.

## Co-operative Education

Co-op and career opportunities available to students include employment in the medical device, equipment, and systems industry; the biomaterial and implant industry; the pharmaceutical industry; the biotechnology and agricultural industry; the telemedicine and tele-health industry; health care; medical and clinical information and management systems; and biomedical technology transfer. Preprofessional options available in the academic programs of the School prepare students for admission to schools of medicine, dentistry, and veterinary medicine. Students may also choose to continue their education at the graduate level to prepare for careers in research and development in biomedical engineering and science.

Visit the Drexel Steinbright Career Development Center (<http://www.drexel.edu/scdc/>) page for more detailed information on co-op and post-graduate opportunities.

## Special Programs

### Accelerated Bachelor's/Master's Dual Degree Program

The Accelerated BS/MS degree program provides opportunities for strongly motivated students with high ability to progress toward their educational goals at an accelerated pace. The program makes it possible for top engineering students to obtain both a bachelor's and master's degree in the same time period that it takes most Drexel students to obtain a bachelor's degree.

## **Preprofessional Programs**

Students who want to prepare for admission to schools of medicine, dentistry, or veterinary medicine have the option to pursue a pre-medical curriculum, including the BS/MD and early assurance programs at the Drexel College of Medicine. Students obtain professional counseling and assistance from the Office of Preprofessional Programs, 215-895-2437.

## **University Honors**

Students in the Biomedical Engineering program may apply for admission to the University Honors Program. Admission depends on superior academic performance at Drexel and may be approved after a personal interview with the Honors Committee.

## **BME Learning Community**

The mission of the Biomedical Engineering Learning Community (BLC) is to promote a dynamic and collaborative environment by forming a close-knit community living together on the same floor in Millennium Hall. Members of the BLC are not only housed together, but also attend classes together, participate in team building activities, and attend various academic and social events. These events and activities actively promote academic success and a sense of community among students. BLC students will build life-long friendships, networking connections, and make lasting college memories.

## **Study Abroad Programs**

The School enjoys a robust association and participation in the Drexel University Study Abroad Program. Multiple programs afford the BME student an opportunity to travel and experience new places and cultures in ways that fit their objectives.

Free standing programs are designed specifically for study abroad purposes. Courses are taken by students from Drexel and other American universities. Because the programs are catered specifically for study abroad students (rather than local students), courses usually include field trips and site visits to utilize the city as an integral part of the learning experience. Some programs only have a select list of courses while others have more extensive courses available.

Intensive Courses Abroad (ICAs) offer the opportunity to have an international academic experience in a short period of time (generally 7 - 10 days during break weeks). ICAs are normally led by a Drexel faculty director, in conjunction with an on campus course before and/or after the tour. They include activities such as guest lectures, industry visits, and other hands on events that transform the city into a living laboratory. The Drexel BME program regards the study abroad experience as a significant part of becoming a global leader in the field

# Biomedical Engineering

*Major: Biomedical Engineering*

*Degree Awarded: Bachelor of Science in Biomedical Engineering (BSBE)*

*Calendar Type: Quarter*

*Total Credit Hours: 187.5*

*Co-op Options: Three Co-op (Five years); One Co-op (Four years)*

*Classification of Instructional Programs (CIP) code: 14.0501*

*Standard Occupational Classification (SOC) code: 17-2031*

## About the Program

Biomedical Engineering is an innovative multidisciplinary Bachelor of Science degree program. It prepares students to conceive, design, and develop devices and systems that improve human health and quality of life. Biomedical engineering is the convergence of life sciences with engineering. From child car seats and football helmets to drug-delivery systems, minimally invasive surgery, and noninvasive imaging technology, the work of the biomedical engineer makes a difference in everyone's life.

This program is accredited by the Engineering Accreditation Commission of ABET: [www.abet.org](http://www.abet.org) (<http://www.abet.org>)

## Concentrations

The undergraduate Biomedical Engineering curriculum is designed to strike a balance between academic breadth in biomedical engineering and specialization in an area of concentration. Each concentration has its own degree requirements for graduation and its own plan of study:

- Biomaterials
- Tissue Engineering
- Biomechanics and Human Performance Engineering
- Biomedical Informatics
- Biomedical Imaging
- Neuroengineering

The degree program provides innovative experiences in hands-on experimentation and engineering design, as well as opportunities for personal growth and development of leadership and communication skills.

Working with a faculty advisor, students can select their core and elective courses from the curricula offered by the School of Biomedical Engineering, Science and Health Systems and the Departments of Biology, Chemistry, Physics, Mathematics, Chemical Engineering, Mechanical Engineering, Materials Science and Engineering, Electrical and Computer Engineering, and the College of Computing & Informatics.

## Additional Information

More information about the School's undergraduate program can be found at the School of Biomedical Engineering, Science and Health Systems' Academic Program (<http://drexel.edu/biomed/academics/undergraduate-programs/>) webpage.

Students are also encouraged to contact the School's director for student services:

Caryn Glaser  
 Director of Student Services  
 School of Biomedical Engineering, Science and Health Systems  
[glasercb@drexel.edu](mailto:glasercb@drexel.edu)  
 215.895.2237

Career and professional counseling is provided independently by the student's professional academic advisors and faculty advisors. Information regarding undergraduate professional academic advisors is available on the School's Undergraduate Advising (<http://drexel.edu/biomed/resources/current-undergraduate/advising/>) webpage.

## Program Educational Objectives

### PEO - Graduates Whose Careers Effectively Leverage Their Education in Biomedical Engineering

As a result, graduates will be able to recognize and/or create opportunities, adjust to new conditions, and take advantage of opportunities across multiple boundaries: disciplinary, geographic, social and cultural. Graduates may demonstrate success through professional/personal recognition and/or advancement.

### PEO - Graduates Competent to Obtain Additional Knowledge and/or Skills

As a result, graduates will continue to learn and enhance their skills through professional development and/or research activities. Graduates may use this new knowledge and/or additional skills to enhance current activities or move in a new direction. Graduates may also pursue further education in the form of graduate and professional degrees.

### PEO - Graduates Who Make Contributions in Research, Innovation, Design and/or Technological Development.

As a result, graduates will make significant or meaningful contributions in their chosen fields either through publications and/or presentations, the development of a product or process, obtaining patents for new products and/or processes, or other evidence of contributing to the advancement of knowledge, particularly in fields integrating engineering and the life sciences.

### PEO - Graduates Who Contribute to Their Communities

As a result, graduates will work independently and in diverse groups to effectively and efficiently achieve personal and organizational goals, manage projects, foster collaborative effort among co-workers, mentor individuals within the organization or in the community, engage in community or public service, create a product or process that fills a social need, and/or participate in educating individuals about an issue of societal concern.

### PEO - Graduates Who Practice Ethical Reasoning, Behavior, and Professionalism

As a result, graduates will work in the global environment respecting cultural and social differences, managing risk and accepting responsibility, and adhering to the professional codes of conduct appropriate to his or her field of study and/or practice.

## Student Learning Outcomes

By participating in the Biomedical Engineering undergraduate curriculum at the School of Biomedical Engineering, Science and Health Systems and graduating with the Bachelor of Science (BS) degree in Biomedical Engineering from Drexel University, students will be able to:

- Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- 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
- Communicate effectively with a range of audiences
- 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
- Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- Acquire and apply new knowledge, as needed, using appropriate learning strategies
- Apply knowledge and skills gained from a program of study to the achievement of goals in a work, clinical, or other professional setting

## Degree Requirements

### Math

BMES 310	Biomedical Statistics	4.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
MATH 201	Linear Algebra	4.0
MATH 210	Differential Equations	4.0

### Biology

BIO 122	Cells and Genetics	4.5
BIO 201	Human Physiology I	4.0
BIO 218	Principles of Molecular Biology	4.0
Bioscience Elective: Choose 200-level or higher BIO course		3.0
Bioscience Restricted Elective: Choose 1		3.0

BIO 203	Human Physiology II	
BIO 214	Principles of Cell Biology	
BIO 224	Form, Function & Evolution of Vertebrates	
BIO 244	Genetics I	
BIO 311	Biochemistry	

### General Studies

BMES 124	Biomedical Engineering Freshman Seminar I	2.0
BMES 338	Biomedical Ethics and Law	3.0
CIVC 101	Introduction to Civic Engagement	1.0
COOP 101	Career Management and Professional Development	1.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGL 102	Composition and Rhetoric II: Advanced Research and Evidence-Based Writing	3.0
ENGL 103	Composition and Rhetoric III: Themes and Genres	3.0
UNIV R101	The Drexel Experience	1.0
General Studies Electives (Choose 5) *		15.0

### Biomedical Engineering - Principles

#### Design

BMES 101	Introduction to BMES Design I: Defining Medical Problems	2.0
BMES 102	Introduction to BMES Design II: Evaluating Design Solutions	2.0
BMES 241	Modeling in Biomedical Design I	2.0
BMES 315	Experimental Design in Biomedical Research	4.0
BMES 341	Modeling in Biomedical Design II	2.0
BMES 381	Junior Design I	2.0
BMES 382	Junior Design II	2.0
BMES 491 [WI]	Senior Design Project I	3.0

BMES 492	Senior Design Project II	2.0
BMES 493	Senior Design Project III	3.0

### Biocomputation

BMES 201	Programming and Modeling for Biomedical Engineers I	3.0
BMES 202	Programming and Modeling for Biomedical Engineers II	3.0
BMES 337	Introduction to Physiological Control Systems	3.0
BMES 375	Computational Bioengineering	4.0

### Biomaterials

BMES 451	Transport Phenomena in Living Systems	4.0
CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
CHEM 253	Thermodynamics and Kinetics	3.0-4.0
or ENGR 210	Introduction to Thermodynamics	
ENGR 220	Fundamentals of Materials	4.0

### Biomechanics

BMES 345	Mechanics of Biological Systems	3.0
BMES 444	Biofluid Mechanics	3.0
MEM 202	Statics	3.0
MEM 238	Dynamics	4.0
PHYS 101	Fundamentals of Physics I	4.0

### Biosignals

BMES 302	Laboratory II: Biomeasurements	2.0
BMES 303	Laboratory III: Biomedical Electronics	2.0
BMES 432	Biomedical Systems and Signals	3.0
ECE 201	Foundations of Electric Circuits I	4.0
PHYS 102	Fundamentals of Physics II	4.0

### Biomedical Engineering - Electives

Laboratories (Choose 2)		4.0
BIO 202	Human Physiology Laboratory	
BIO 215	Techniques in Cell Biology	
BIO 219 [WI]	Techniques in Molecular Biology	
BIO 306	Biochemistry Laboratory	
BMES 301	Laboratory I: Experimental Biomechanics	
BMES 304	Laboratory IV: Ultrasound Images	
BMES 305	Laboratory V: Musculoskeletal Anatomy for Biomedical Engineers	
BMES 485	Brain Computer Interface Laboratory	
CHEM 244	Organic Chemistry Laboratory I	
CHEM 245	Organic Chemistry Laboratory II	
Concentration Requirements and STEM Electives		21.0
Concentration Requirements (3 required courses/concentration. See list below.)		
STEM Electives (See list below for possible courses that, combined with concentration courses, total 21.0 credits.) **		

### Total Credits

187.5-188.5

\* General studies electives include all liberal arts electives plus additional subjects, such as business, which do not fall under the subject areas of science, math or engineering. See the Biomedical Engineering General Studies List (<https://drexel.edu/biomed/resources/current-undergraduate/general-studies/>) for a detailed list of approved courses. An abbreviated list is shown here: DANC, MUSC, TVPR, VSST, GER, FREN, GST, PHIL, PPE, PSCI, BLAW, HRMT, INTB, MGMT, OPM, ORGB; CULA, ENTP, CRTV, EDLT, EHRD.

\*\* STEM electives include courses offered by the School of Biomedical Engineering, Science and Health Systems, as well as select science, technology, and math courses from other academic units. An abbreviated list of 200-level and higher courses is shown here: ENVS, PHYS, INFO (including INFO 101, INFO 110), CS (including CS 171, CS 172, CS 175, CS 176), HSCI (excluding HSCI 205). Please see Biomedical Engineering STEM Elective List (<https://drexel.edu/biomed/resources/current-undergraduate/>) for a detailed list of approved courses.

## Concentration Course Requirements

Students must select one concentration and complete the listed required courses. The student also needs to take additional STEM electives, as described above. The credit total of the concentration required courses and the STEM electives must be at least 21.0 credits.

### Biomaterials Concentration

CHEM 241	Organic Chemistry I *	4.0
BMES 460	Biomaterials I	4.0
BMES 461	Biomaterials II	4.0
<b>Total Credits</b>		<b>12.0</b>

\* CHEM 241 is a pre-requisite for BMES 460

### Biomechanics Concentration

BMES 441	Biomechanics I: Introduction to Biomechanics	4.0
BMES 442	Biomechanics II: Musculoskeletal Modeling and Human Performance	4.0
MEM 201	Foundations of Computer Aided Design	3.0
<b>Total Credits</b>		<b>11.0</b>

### Biomedical Imaging Concentration

BMES 421	Biomedical Imaging Systems I: Images	4.0
BMES 422	Biomedical Imaging Systems II: Ultrasound	4.0
PHYS 201	Fundamentals of Physics III *	4.0
<b>Total Credits</b>		<b>12.0</b>

\* PHYS 201 is a pre-requisite for BMES 421.

### Biomedical Informatics Concentration

BIO 219 [WI]	Techniques in Molecular Biology	3.0
BMES 483	Quantitative Systems Biology	4.0
BMES 484	Genome Information Engineering	4.0
<b>Total Credits</b>		<b>11.0</b>

### Neuroengineering Concentration

BIO 462	Biology of Neuron Function *	3.0
BMES 477	Neuroengineering I: Neural Signals	3.0
BMES 478	Neuroengineering II: Principles of Neuroengineering	3.0
<b>Total Credits</b>		<b>9.0</b>

\* BIO 462 is a pre-requisite for BMES 477.

### Tissue Engineering Concentration

BIO 219 [WI]	Techniques in Molecular Biology *	3.0
BMES 471	Cellular and Molecular Foundations of Tissue Engineering	4.0
BMES 472	Developmental and Evolutionary Foundations of Tissue Engineering	4.0
<b>Total Credits</b>		<b>11.0</b>

\* BIO 219 [WI] is a pre-requisite for BMES 471.

## Sample Plan of Study

### 4 year, 1 co-op

#### First Year

Fall	Credits Winter	Credits Spring	Credits Summer	Credits
BMES 101	2.0 BMES 102	2.0 BIO 122	4.5 VACATION	
BMES 124	2.0 CHEM 102	4.5 BMES 201	3.0	
CHEM 101	3.5 ENGL 102 or 112	3.0 COOP 101	1.0	
CIVC 101	1.0 MATH 122	4.0 ENGL 103 or 113	3.0	
ENGL 101 or 111	3.0 PHYS 101	4.0 MATH 200	4.0	
MATH 121	4.0	PHYS 102	4.0	
UNIV R101	1.0			
	<b>16.5</b>	<b>17.5</b>	<b>19.5</b>	<b>0</b>

#### Second Year

Fall	Credits Winter	Credits Spring	Credits Summer	Credits
BMES 202	3.0 BIO 218	4.0 BIO 201	4.0 BMES 303	2.0
ECE 201	4.0 BMES 241	2.0 BMES 345	3.0 BMES 310	4.0
ENGR 220	4.0 BMES 338	3.0 BMES 375	4.0 BMES 341	2.0
MATH 201	4.0 MATH 210	4.0 BMES 432	3.0 BMES 451	4.0
MEM 202	3.0 MEM 238	4.0 CHEM 253 or ENGR 210	3.0-4.0 Bioscience Restricted elective	3.0
	<b>18</b>	<b>17</b>	<b>17-18</b>	<b>15</b>

#### Third Year

Fall	Credits Winter	Credits Spring	Credits Summer	Credits
BMES 315	4.0 BMES 302	2.0 COOP EXPERIENCE	COOP EXPERIENCE	
BMES 381	2.0 BMES 337	3.0		
General Studies electives	6.0 BMES 382	2.0		
	BMES 444	3.0		
	Bioscience elective	3.0		
	Concentration required course	3.0		
	<b>12</b>	<b>16</b>	<b>0</b>	<b>0</b>

#### Fourth Year

Fall	Credits Winter	Credits Spring	Credits
BMES 491	3.0 BMES 492	2.0 BMES 493	3.0
Concentration required course	3.0 Concentration required course	3.0 General Studies elective	3.0
General Studies elective	3.0 General Studies elective	3.0 STEM electives	6.0
Lab elective	2.0 Lab elective	2.0	
STEM elective	3.0 STEM elective	3.0	
	<b>14</b>	<b>13</b>	<b>12</b>

**Total Credits 187.5-188.5**

\* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major. COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

## 5 year, 3 co-op

First Year				
Fall	Credits Winter	Credits Spring	Credits Summer	Credits
BMES 101	2.0 BMES 102	2.0 BIO 122	4.5 VACATION	
BMES 124	2.0 CHEM 102	4.5 BMES 201	3.0	
CHEM 101	3.5 ENGL 102 or 112	3.0 COOP 101*	1.0	
CIVC 101	1.0 MATH 122	4.0 ENGL 103 or 113	3.0	
ENGL 101 or 111	3.0 PHYS 101	4.0 MATH 200	4.0	
MATH 121	4.0	PHYS 102	4.0	
UNIV R101	1.0			
	<b>16.5</b>	<b>17.5</b>	<b>19.5</b>	<b>0</b>

Second Year				
Fall	Credits Winter	Credits Spring	Credits Summer	Credits
BMES 202	3.0 BIO 218	4.0 COOP EXPERIENCE	COOP EXPERIENCE	
ECE 201	4.0 BMES 241	2.0		
ENGR 220	4.0 BMES 338	3.0		
MATH 201	4.0 MATH 210	4.0		
MEM 202	3.0 MEM 238	4.0		
	<b>18</b>	<b>17</b>	<b>0</b>	<b>0</b>

Third Year				
Fall	Credits Winter	Credits Spring	Credits Summer	Credits
BIO 201	4.0 BMES 303	2.0 COOP EXPERIENCE	COOP EXPERIENCE	
BMES 345	3.0 BMES 310	4.0		
BMES 375	4.0 BMES 341	2.0		
BMES 432	3.0 BMES 451	4.0		
CHEM 253 or ENGR 210	3.0-4.0 Bioscience restricted elective	3.0		
	<b>17-18</b>	<b>15</b>	<b>0</b>	<b>0</b>

Fourth Year				
Fall	Credits Winter	Credits Spring	Credits Summer	Credits
BMES 315	4.0 BMES 302	2.0 COOP EXPERIENCE	COOP EXPERIENCE	
BMES 381	2.0 BMES 337	3.0		
General Studies electives	6.0 BMES 382	2.0		
	BMES 444	3.0		
	Bioscience elective	3.0		
	Concentration required course	3.0		
	<b>12</b>	<b>16</b>	<b>0</b>	<b>0</b>

Fifth Year				
Fall	Credits Winter	Credits Spring	Credits	
BMES 491	3.0 BMES 492	2.0 BMES 493	3.0	
Concentration required course	3.0 Concentration required course	3.0 General Studies elective	3.0	
General Studies elective	3.0 General Studies elective	3.0 STEM electives	6.0	
Lab elective	2.0 Lab elective	2.0		

STEM elective	3.0 STEM elective	3.0
	<b>14</b>	<b>13</b>
		<b>12</b>

Total Credits 187.5-188.5

\* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major. COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

## Co-op/Career Opportunities

Metropolitan Philadelphia has one of the highest concentrations of medical institutions and pharmaceutical and biotechnology industries in the nation. The Bachelor of Science degree in Biomedical Engineering gives students access to a broad spectrum of career opportunities in medical device and equipment industry, prosthetics and assist devices industry, biomaterials and implants industry, and the telemedicine, pharmaceutical, biotechnology, and agricultural sectors.

Biomedical Engineering graduates are also ideally prepared for professional education in medicine, dentistry, veterinary medicine, and law. Those who choose to pursue graduate education can aim for careers in research and development, biomedical technology innovation, and transfer, as well as healthcare technology management.

Visit the Drexel Steinbright Career Development Center (<http://www.drexel.edu/scdc/>) page for more detailed information on co-op and post-graduate opportunities.

## Biomedical Engineering, Science and Health Systems Faculty

Fred D. Allen, PhD (*University of Pennsylvania*) Associate Dean for Undergraduate Education. Teaching Professor. Tissue engineering, cell engineering, orthopedics, bone remodeling, wound healing, mechanotransduction, signal transduction, adhesion, migration.

Hasan Ayaz, PhD (*Drexel University*) School of Biomedical Engineering, Science and Health Systems. Associate Professor. Neuroergonomics for Brain Health and Performance, Functional Neuroimaging, Biomedical Signal Processing, Biomedical Optics, Cognitive Neuroengineering, Brain Computer Interfaces, Neurotechnology, Clinical Neuroergonomics, Systems and Applied Neuroscience, Functional Near Infrared spectroscopy (fNIRS), Electroencephalogram (EEG), Brain Computer Interfaces (BCI), Mobile Brain/Body Imaging (MoBI)

Sriram Balasubramanian, PhD (*Wayne State University*). Assistant Professor. Structural characteristics of the pediatric thoracic cage using CT scans and developing an age-equivalent animal model for pediatric long bones.

Kenneth A. Barbee, PhD (*University of Pennsylvania*) Senior Associate Dean, Associate Dean for Research. Professor. Cellular biomechanics of neural and vascular injury, mechanotransduction in the cardiovascular system, mechanical control of growth and development for wound healing and tissue engineering.

Paul Brandt-Rauf, MD, DrPH (*Columbia University*) Dean. Distinguished University Professor. Environmental health, particularly the molecular biology and molecular epidemiology of environmental carcinogenesis, and



protein engineering for the development of novel peptide therapies for the treatment and prevention of cancer.

Donald Buerk, PhD (*Northwestern University*). Research Professor. Biotechnology, physiology, systems biology, blood flow, microcirculation, nitric oxide, oxygen transport

Jaimie Dougherty, PhD (*Drexel University*). Associate Teaching Professor. Brain-computer interface, neural encoding, electrophysiological signal acquisition and processing.

Lin Han, PhD (*Massachusetts Institute of Technology*). Associate Professor. Nanoscale structure-property relationships of biological materials, genetic and molecular origins soft joint tissue diseases, biomaterials under extreme conditions, coupling between stimulus-responsiveness and geometry.

Kurtulus Izzetoglu, PhD (*Drexel University*). Associate Professor. Biomedical optics, biomedical signal processing, medical sensor design, functional brain imaging, cognitive neuro engineering, cognitive performance, anesthesia monitoring, brain injury models and assessment.

Andres Kriete, PhD (*University in Bremen Germany*) Associate Dean of Academic Affairs. Teaching Professor. Systems biology, bioimaging, control theory, biology of aging.

Steven Kurtz, PhD (*Cornell University*). Part-time Research Professor. Computational biomechanics of bone-implant systems and impact-related injuries, orthopaedic biomechanics, contact mechanics, orthopaedic biomaterials, large-deformation mechanical behavior and wear of polymers, and degradation and crosslinking of polyolefins in implant applications.

Peter A. Lewin, PhD (*University of Denmark, Copenhagen-Lyngby*) Richard B. Beard Professor. Distinguished University Professor. Biomedical ultrasonics, piezoelectric and polymer transducers and hydrophones; shock wave sensors., power ultrasonics, ultrasonic metrology, tissue characterization using nonlinear acoustics, biological effects of ultrasound (chronic wound healing and noninvasive drug delivery), applications of shock waves in medicine and image reconstruction and processing.

Hualou Liang, PhD (*Chinese Academy of Sciences*). Professor. Neuroengineering, neuroinformatics, cognitive and computational neuroscience, neural data analysis and computational modeling, biomedical signal processing.

Donald L. McEachron, PhD (*University of California at San Diego*) Coordinator, Academic Assessment and Improvement. Teaching Professor. Animal behavior, autoradiography, biological rhythms, cerebral metabolism, evolutionary theory, image processing, neuroendocrinology.

Banu Onaral, PhD (*University of Pennsylvania*) H.H. Sun Professor; Senior Advisor to the President, Global Partnerships. Professor. Biomedical signal processing; complexity and scaling in biomedical signals and systems.

Kambiz Pourrezaei, PhD (*Rensselaer Polytechnic University*). Professor. Thin film technology; nanotechnology; near infrared imaging; power electronics.

Christopher Rodell, PhD (*University of Pennsylvania*). Assistant Professor. Biomaterials, supramolecular chemistry, and drug delivery. Therapeutic applications including the etiology of disease, organ injury,

cardiovascular engineering, immune engineering, and biomedical imaging.

Ahmet Sacan, PhD (*Middle East Technical University*). Associate Teaching Professor. Indexing and data mining in biological databases; protein sequence and structure; similarity search; protein structure modeling; protein-protein interaction; automated cell tracking.

Joseph J. Sarver, PhD (*Drexel University*). Teaching Professor. Neuromuscular adaptation to changes in the myo-mechanical environment.

Mark E. Schafer, PhD (*Drexel University*). Research Professor. Diagnostic, therapeutic, and surgical ultrasound.

Patricia A. Shewokis, PhD (*University of Georgia*). Professor. Roles of cognition and motor function during motor skill learning; role of information feedback frequency on the memory of motor skills, noninvasive neural imaging techniques of functional near infrared spectroscopy (fNIRS) and electroencephalography (EEG) and methodology and research design.

Adrian C. Shieh, PhD (*Rice University*). Associate Teaching Professor. Mechanobiology, mechanotransduction, tumor microenvironment, cell and tissue biomechanics.

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Kara Spiller, PhD (*Drexel University*). Professor. Macrophage-biomaterial interactions, drug delivery systems, and chronic wound healing. Cell-biomaterial interactions, biomaterial design, and international engineering education.

Marek Swoboda, PhD (*Drexel University*). Assistant Teaching Professor. Cardiovascular engineering, cardiovascular system, diagnostic devices in cardiology, piezoelectric biosensors, and pathogen detection.

Amy Throckmorton, PhD (*University of Virginia*). Professor. Computational and experimental fluid dynamics; cardiovascular modeling, including steady, transient, fluid-structure interaction, lumped parameter, microelectromechanical systems, and patient-specific anatomical studies; artificial organs research; and engineering.

Bhandawat Vikas, PhD (*Johns Hopkins School of Medicine*). Associate Professor. Sensorimotor integration, whole-cell patch clamp and imaging in behaving animals, optogenetics, neuromechanics, locomotion.

Margaret Wheatley, PhD (*University of Toronto*) John M. Reid Professor. Ultrasound contrast agent development (tumor targeting and triggered drug delivery), controlled release technology (bioactive compounds), microencapsulated allografts (ex vivo gene therapy) for spinal cord repair.

Ming Xiao, PhD (*Baylor University*). Associate Professor. Nanotechnology, single molecule detection, single molecule fluorescent imaging, genomics, genetics, genome mapping, DNA sequencing, DNA biochemistry, and biophysics.

Yinghui Zhong, PhD (*Georgia Institute of Technology*). Assistant Professor. Spinal cord repair, and engineering neural prosthesis/brain interface using biomaterials, drug delivery, and stem cell therapy.

Leonid Zubkov, PhD, DSc (*St. Petersburg State University, Russia*). Research Professor. Physiology, wound healing, physiologic neovascularization, near-infrared spectroscopy, optical tomography,

histological techniques, computer-assisted diagnosis, infrared spectrophotometry, physiologic monitoring, experimental diabetes mellitus, penetrating wounds, diabetes complications, skin, animal models, radiation scattering, failure analysis

Catherin von Reyn, PhD (*University of Pennsylvania*). Assistant Professor. Cell type-specific genetic engineering, whole-cell patch clamp in behaving animals, modeling, and detailed behavioral analysis to identify and characterize sensorimotor circuits.

## Emeritus Faculty

Dov Jaron, PhD (*University of Pennsylvania*) *Calhoun Distinguished Professor of Engineering in Medicine*. Professor Emeritus. Mathematical, computer and electromechanical simulations of the cardiovascular system.

Rahamim Seliktar, PhD (*University of Strathclyde, Glasgow*). Professor Emeritus. Limb prostheses, biomechanics of human motion, orthopedic biomechanics.

Hun H. Sun, PhD (*Cornell University*). Professor Emeritus. Biological control systems, physiological modeling, systems analysis.

## Biomedical Engineering BS / Biomedical Engineering MS

*Major: Biomedical Engineering*

*Degree Awarded: Bachelor of Science in Biomedical Engineering (BSBE) and Master of Science in Biomedical Engineering (MSBE)*

*Calendar Type: Quarter*

*Total Credit Hours: 227.5*

*Co-op Options: Three Co-ops (Five years)*

*Classification of Instructional Programs (CIP) code: 14.0501*

*Standard Occupational Classification (SOC) code: 17-2031*

## Additional Information

More information about the School's accelerate dual degree program can be found at the School of Biomedical Engineering, Sciences and Health Systems' Academic Program (<https://drexel.edu/biomed/academics/undergraduate-programs/bs-ms-accelerated-degree/>) webpage.

Natalia Broz

Associate Director for Graduate Programs

School of Biomedical Engineering, Science and Health Systems

Email: [njb33@drexel.edu](mailto:njb33@drexel.edu)

Caryn Glaser

Director of Student Services

School of Biomedical Engineering, Science and Health Systems

[glasercb@drexel.edu](mailto:glasercb@drexel.edu)

## Admission Requirements

In addition to meeting the University requirements, students applying into the Biomedical BS/MS program must:

- Be an undergraduate in Biomedical Engineering in the 5 year, 3 co-op plan of study
- Have an approved plan to study that includes master's degree in Biomedical Engineering
- Have a minimum cumulative GPA of at least 3.4

For those interested in pursuing a MS thesis, there is an additional requirement:

- Students must submit a research petition no later than April 1 of junior year.\*

\*If the petition is not submitted or accepted, the student will not be able to pursue a thesis option.

## Degree Requirements

### Math

BMES 310	Biomedical Statistics	4.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
MATH 201	Linear Algebra	4.0
MATH 210	Differential Equations	4.0

### Biology

BIO 122	Cells and Genetics	4.5
BIO 201	Human Physiology I	4.0
BIO 218	Principles of Molecular Biology	4.0
Bioscience Elective: Choose 200-level or higher BIO course		3.0
Bioscience Restricted Elective (Choose 1)		3.0
BIO 203	Human Physiology II	
BIO 214	Principles of Cell Biology	
BIO 224	Form, Function & Evolution of Vertebrates	
BIO 244	Genetics I	
BIO 311	Biochemistry	

### General Studies

BMES 124	Biomedical Engineering Freshman Seminar I	2.0
BMES 338	Biomedical Ethics and Law	3.0
CIVC 101	Introduction to Civic Engagement	1.0
COOP 101	Career Management and Professional Development	1.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGL 102	Composition and Rhetoric II: Advanced Research and Evidence-Based Writing	3.0
ENGL 103	Composition and Rhetoric III: Themes and Genres	3.0
UNIV R101	The Drexel Experience	1.0

**General Studies Electives (Choose 5) \*\* 15.0**

### Biomedical Engineering - Principles

#### Design

BMES 101	Introduction to BMES Design I: Defining Medical Problems	2.0
BMES 102	Introduction to BMES Design II: Evaluating Design Solutions	2.0
BMES 241	Modeling in Biomedical Design I	2.0
BMES 315	Experimental Design in Biomedical Research	4.0
BMES 341	Modeling in Biomedical Design II	2.0
BMES 381	Junior Design I	2.0
BMES 382	Junior Design II	2.0
BMES 491 [WI]	Senior Design Project I	3.0
BMES 492	Senior Design Project II	2.0
BMES 493	Senior Design Project III	3.0

#### Biocomputation

BMES 201	Programming and Modeling for Biomedical Engineers I	3.0
BMES 202	Programming and Modeling for Biomedical Engineers II	3.0
BMES 337	Introduction to Physiological Control Systems	3.0
BMES 375	Computational Bioengineering	4.0

#### Biomaterials

BMES 451	Transport Phenomena in Living Systems	4.0
CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
CHEM 253	Thermodynamics and Kinetics	3.0-4.0
or ENGR 210	Introduction to Thermodynamics	

ENGR 220	Fundamentals of Materials	4.0	BMES 543	Quantitative Systems Biology	
<b>Biomechanics</b>			BMES 544	Genome Information Engineering	
BMES 345	Mechanics of Biological Systems	3.0	BMES 548	Structural Bioinformatics and Drug Design	
BMES 444	Biofluid Mechanics	3.0	BMES 549	Genomic and Sequencing Technologies	
MEM 202	Statics	3.0	BMES 551	Biomedical Signal Processing	
MEM 238	Dynamics	4.0	BMES 588	Medical Device Development	
PHYS 101	Fundamentals of Physics I	4.0	BMES 604	Pharmacogenomics	
<b>Biosignals</b>			BMES 611	Biological Control Systems	
BMES 302	Laboratory II: Biomeasurements	2.0	BMES 621	Medical Imaging Systems I	
BMES 303	Laboratory III: Biomedical Electronics	2.0	BMES 622	Medical Imaging Systems II	
BMES 432	Biomedical Systems and Signals	3.0	BMES 623	Medical Imaging Systems III	
ECE 201	Foundations of Electric Circuits I	4.0	BMES 631	Tissue Engineering I	
PHYS 102	Fundamentals of Physics II	4.0	BMES 632	Tissue Engineering II	
<b>Biomedical Engineering - Electives</b>			BMES 641	Biomedical Mechanics I	
Laboratories (Choose 2)			4.0	BMES 642	Biomedical Mechanics II
BIO 202	Human Physiology Laboratory		BMES 651	Transport Phenomena in Living Systems I	
BIO 215	Techniques in Cell Biology		BMES 660	Biomaterials I	
BIO 219 [W]	Techniques in Molecular Biology		BMES 661	Biomaterials II	
BIO 306	Biochemistry Laboratory		BMES 672	Biosimulation I	
BMES 301	Laboratory I: Experimental Biomechanics		BMES 673	Biosimulation II	
BMES 304	Laboratory IV: Ultrasound Images		BMES 675	Biomaterials and Tissue Engineering III	
BMES 305	Laboratory V: Musculoskeletal Anatomy for Biomedical Engineers		BMES 677	Mathematical Modeling of Cellular Behavior	
BMES 485	Brain Computer Interface Laboratory		BMES 678	Biocomputational Modeling and Simulation	
CHEM 244	Organic Chemistry Laboratory I		BMES 685	Experimental Methods in Neuroengineering	
CHEM 245	Organic Chemistry Laboratory II		BMES 710	Neural Signals	
<b>Concentration Requirements and STEM Electives (22 credits total; 6 of which are satisfied by GR SEM electives)</b>			16.0	BMES 711	Principles in Neuroengineering
Concentration Requirements (3 required courses/concentration. See list below.)				BMES 722	Neural Aspects of Posture and Locomotion I
STEM Electives (9.0-12.0 credits depending on concentration) (Graduate SEM electives satisfies 6.0 credits of UG STEM electives) ***				BMES 725	Neural Networks
<b>Graduate Core Courses</b>				BMES 821	Medical Instrumentation
BMES 501	Medical Sciences I	3.0	BMES 822	Medical Instrumentation II	
BMES 502	Medical Sciences II	3.0	BMES 825	Hospital Administration	
BMES 510	Biomedical Statistics	4.0	<b>Science, Engineering, and Medicine Electives (satisfies both UG and GR degree requirements) †</b>		
BMES 538	Biomedical Ethics and Law	3.0	<b>Thesis Option ††</b>		
BMES 864	Seminar (Must be taken 3 times)	0.0	BMES 897	Research	
BMES 550	Advanced Biocomputational Languages	4.0	BMES 898	Master's Thesis	
<b>Modeling Intensive Courses (choose 2)</b>			6.0	<b>Total Credits</b>	
BMES 611	Biological Control Systems		<b>227.5-228.5</b>		
BMES 651	Transport Phenomena in Living Systems I				
BMES 672	Biosimulation I				
BMES 673	Biosimulation II				
BMES 677	Mathematical Modeling of Cellular Behavior				
BMES 678	Biocomputational Modeling and Simulation				
BMES 710	Neural Signals				
<b>BMES Electives (can include up to 9.0 credits of Thesis)</b>			16.0		
BMES 503	Medical Sciences III				
BMES 508	Cardiovascular Engineering				
BMES 509	Entrepreneurship for Biomedical Engineering and Science				
BMES 515	Experimental Design in Biomedical Research				
BMES 517	Intermediate Biostatistics				
BMES 518	Interpretation of Biomedical Data				
BMES 524	Introduction to Biosensors				
BMES 528	Pediatric Engineering I				
BMES 529	Pediatric Engineering II				
BMES 531	Chronobioengineering I				
BMES 532	Chronobioengineering II				
BMES 534	Design Thinking for Biomedical Engineers				
BMES 535	Introduction to Product Design for Biomedical Engineers				
BMES 541	Nano and Molecular Mechanics of Biological Materials				

\* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

\*\* General studies electives include all liberal arts electives plus additional subjects, such as business, which do not fall under the subject areas of science, math or engineering. See the Biomedical Engineering General Studies List (<https://drexel.edu/biomed/resources/current-undergraduate/general-studies/>) for a detailed list of approved courses. An abbreviated list is shown here: DANC, MUSC, TVPR, VSST, GER, FREN, GST, PHIL, PPE, PSCI, BLAW, HRMT, INTB, MGMT, OPM, ORGB; CULA, ENTP, CRTV, EDLT, EHRD.

\*\*\* STEM electives include courses offered by the School of Biomedical Engineering, Science and Health Systems, as well as select science, technology, and math courses from other academic units. An abbreviated list of 200 level and higher courses is shown here: ENVS, PHYS, INFO (including INFO 101, INFO 110), CS (including CS 171, CS 172, CS 175, CS 176), HSCI (excluding HSCI 205). Please see Biomedical Engineering STEM Elective List (<https://drexel.edu/biomed/resources/current-undergraduate/>) for a detailed list of approved courses

† Science, engineering, and medicine (SEM) electives may include graduate-level (500 level and above) courses from appropriate disciplines and departments (for example, MATH, PHYS, CS, MATE), including Biomedical Engineering (BMES). Please see (List\_SEM(BSMS)\_Electives (<https://drexel.edu/~media/Files/biomed/SEMSMSElectiveList20210430v2b.ashx?la=en>)) for a complete list and consult with your graduate advisor when formulating your plan of study and choosing electives.

†† Up to 9.0 credits of research and thesis credits may be applied toward the MS degree requirements. The research for the thesis may include work carried out during an internship.

## Concentration Requirements

Students must select one concentration and complete the listed required courses. The student also needs to take additional STEM electives, as described above. The credit total of the concentration required courses and the STEM electives must be at least 22.0 credits.

### Biomaterials Concentration Required Courses

BMES 460	Biomaterials I	4.0
BMES 461	Biomaterials II	4.0
CHEM 241	Organic Chemistry I *	4.0
<b>Total Credits</b>		<b>12.0</b>

\* CHEM 241 is a pre-requisite for BMES 460.

### Biomechanics Concentration Required Courses

BMES 441	Biomechanics I: Introduction to Biomechanics	4.0
BMES 442	Biomechanics II: Musculoskeletal Modeling and Human Performance	4.0
MEM 201	Foundations of Computer Aided Design	3.0
<b>Total Credits</b>		<b>11.0</b>

### Biomedical Imaging Concentration Required Courses

BMES 421	Biomedical Imaging Systems I: Images	4.0
BMES 422	Biomedical Imaging Systems II: Ultrasound	4.0
PHYS 201	Fundamentals of Physics III *	4.0
<b>Total Credits</b>		<b>12.0</b>

\* PHYS 201 is a pre-requisite for BMES 421.

### Biomedical Informatics Concentration Required Courses

BIO 219 [WI]	Techniques in Molecular Biology	3.0
BMES 483	Quantitative Systems Biology	4.0
BMES 484	Genome Information Engineering	4.0
<b>Total Credits</b>		<b>11.0</b>

### Neuroengineering Concentration Required Courses

BIO 462	Biology of Neuron Function *	3.0
BMES 477	Neuroengineering I: Neural Signals	3.0
BMES 478	Neuroengineering II: Principles of Neuroengineering	3.0
<b>Total Credits</b>		<b>9.0</b>

\* BIO 462 is a pre-requisite for BMES 477.

### Tissue Engineering Concentration Required Courses

BIO 219 [WI]	Techniques in Molecular Biology *	3.0
BMES 471	Cellular and Molecular Foundations of Tissue Engineering	4.0
BMES 472	Developmental and Evolutionary Foundations of Tissue Engineering	4.0

**Total Credits** **11.0**

\* BIO 219 [WI] is a pre-requisite for BMES 471.

## Sample Plan of Study

### 5 year, 3 coop

#### First Year

Fall	Credits Winter	Credits Spring	Credits Summer	Credits
BMES 101	2.0 BMES 102	2.0 BIO 122	4.5 VACATION	
BMES 124	2.0 CHEM 102	4.5 BMES 201	3.0	
CHEM 101	3.5 ENGL 102 or 112	3.0 COOP 101 <sup>†</sup>	1.0	
CIVC 101	1.0 MATH 122	4.0 ENGL 103 or 113	3.0	
ENGL 101 or 111	3.0 PHYS 101	4.0 MATH 200	4.0	
MATH 121	4.0	PHYS 102	4.0	
UNIV R101	1.0			
	<b>16.5</b>	<b>17.5</b>	<b>19.5</b>	<b>0</b>

#### Second Year

Fall	Credits Winter	Credits Spring	Credits Summer	Credits
BMES 202	3.0 BIO 218	4.0 COOP EXPERIENCE	COOP EXPERIENCE	
ECE 201	4.0 MEM 238	4.0		
ENGR 220	4.0 BMES 241	2.0		
MATH 201	4.0 BMES 338	3.0		
MEM 202	3.0 MATH 210 (UG) Bioscience Restricted Elective	4.0 3.0		
	<b>18</b>	<b>20</b>	<b>0</b>	<b>0</b>

#### Third Year

Fall	Credits Winter	Credits Spring	Credits Summer	Credits
BIO 201	4.0 BMES 303	2.0 COOP EXPERIENCE	COOP EXPERIENCE	
BMES 345	3.0 BMES 310	4.0		
BMES 375	4.0 BMES 341	2.0		
BMES 432	3.0 BMES 451	4.0		
CHEM 253 or ENGR 210	3.0-4.0 (UG) Bioscience Elective 200+ level or higher	3.0		
(UG) Laboratory Elective	2.0 (UG) Laboratory Elective	2.0		
	BMES 538	3.0		
	<b>19-20</b>	<b>20</b>	<b>0</b>	<b>0</b>

#### Fourth Year

Fall	Credits Winter	Credits Spring	Credits Summer	Credits
BMES 315	4.0 BMES 302	2.0 COOP EXPERIENCE	COOP EXPERIENCE	
BMES 381	2.0 BMES 337	3.0		

(UG) General Studies Electives	6.0 BMES 382	2.0		
BMES 550	4.0 BMES 444	3.0		
BMES 510	4.0 (UG) Concentration Requirement	3.0		
	(GR) Modeling Intensive Elective	3.0		
	(GR) BMES Elective	4.0		
	<b>20</b>	<b>20</b>	<b>0</b>	<b>0</b>
<b>Fifth Year</b>				
<b>Fall</b>	<b>Credits Winter</b>	<b>Credits Spring</b>	<b>Credits</b>	
BMES 491	3.0 BMES 492	2.0 BMES 493	3.0	
(UG) Concentration Requirement	3.0 (UG) Concentration Requirement	3.0 (UG) Gen Studies Elective	3.0	
(UG) Gen Studies Elective	3.0 (UG) Gen Studies Elective	3.0 (GR) BMES Elective	4.0	
(UG) STEM Elective	3.0 (UG) STEM Elective	4.0 (GR) Modeling Intensive Elective	3.0	
BMES 501	3.0 BMES 502	3.0 (GR) SEM Elective (counts as UG STEM Elective**)	3.0	
(GR) BMES Elective	4.0 (GR) BMES Elective	4.0 (GR) SEM Elective (counts as UG STEM Elective**)	3.0	
	<b>19</b>	<b>19</b>	<b>19</b>	

Total Credits 227.5-228.5

\* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

\*\* GR credits shared with BSE program.

## Biomedical Engineering, Science and Health Systems Faculty

Fred D. Allen, PhD (*University of Pennsylvania*) Associate Dean for Undergraduate Education. Teaching Professor. Tissue engineering, cell engineering, orthopedics, bone remodeling, wound healing, mechanotransduction, signal transduction, adhesion, migration.

Hasan Ayaz, PhD (*Drexel University*) School of Biomedical Engineering, Science and Health Systems. Associate Professor. Neuroergonomics for Brain Health and Performance, Functional Neuroimaging, Biomedical Signal Processing, Biomedical Optics, Cognitive Neuroengineering, Brain Computer Interfaces, Neurotechnology, Clinical Neuroergonomics, Systems and Applied Neuroscience, Functional Near Infrared spectroscopy (fNIRS), Electroencephalogram (EEG), Brain Computer Interfaces (BCI), Mobile Brain/Body Imaging (MoBI)

Sriram Balasubramanian, PhD (*Wayne State University*). Assistant Professor. Structural characteristics of the pediatric thoracic cage using CT scans and developing an age-equivalent animal model for pediatric long bones.

Kenneth A. Barbee, PhD (*University of Pennsylvania*) Senior Associate Dean, Associate Dean for Research. Professor. Cellular biomechanics of neural and vascular injury, mechanotransduction in the cardiovascular system, mechanical control of growth and development for wound healing and tissue engineering.

Paul Brandt-Rauf, MD, DrPH (*Columbia University*) Dean. Distinguished University Professor. Environmental health, particularly the molecular biology and molecular epidemiology of environmental carcinogenesis, and protein engineering for the development of novel peptide therapies for the treatment and prevention of cancer.

Donald Buerk, PhD (*Northwestern University*). Research Professor. Biotechnology, physiology, systems biology, blood flow, microcirculation, nitric oxide, oxygen transport

Jaimie Dougherty, PhD (*Drexel University*). Associate Teaching Professor. Brain-computer interface, neural encoding, electrophysiological signal acquisition and processing.

Lin Han, PhD (*Massachusetts Institute of Technology*). Associate Professor. Nanoscale structure-property relationships of biological materials, genetic and molecular origins soft joint tissue diseases, biomaterials under extreme conditions, coupling between stimulus-responsiveness and geometry.

Kurtulus Izzetoglu, PhD (*Drexel University*). Associate Professor. Biomedical optics, biomedical signal processing, medical sensor design, functional brain imaging, cognitive neuro engineering, cognitive performance, anesthesia monitoring, brain injury models and assessment.

Andres Kriete, PhD (*University in Bremen Germany*) Associate Dean of Academic Affairs. Teaching Professor. Systems biology, bioimaging, control theory, biology of aging.

Steven Kurtz, PhD (*Cornell University*). Part-time Research Professor. Computational biomechanics of bone-implant systems and impact-related injuries, orthopaedic biomechanics, contact mechanics, orthopaedic biomaterials, large-deformation mechanical behavior and wear of polymers, and degradation and crosslinking of polyolefins in implant applications.

Peter A. Lewin, PhD (*University of Denmark, Copenhagen-Lyngby*) Richard B. Beard Professor. Distinguished University Professor. Biomedical ultrasonics, piezoelectric and polymer transducers and hydrophones; shock wave sensors., power ultrasonics, ultrasonic metrology, tissue characterization using nonlinear acoustics, biological effects of ultrasound (chronic wound healing and noninvasive drug delivery), applications of shock waves in medicine and image reconstruction and processing.

Hualou Liang, PhD (*Chinese Academy of Sciences*). Professor. Neuroengineering, neuroinformatics, cognitive and computational neuroscience, neural data analysis and computational modeling, biomedical signal processing.

Donald L. McEachron, PhD (*University of California at San Diego*) Coordinator, Academic Assessment and Improvement. Teaching

Professor. Animal behavior, autoradiography, biological rhythms, cerebral metabolism, evolutionary theory, image processing, neuroendocrinology.

Banu Onaral, PhD (*University of Pennsylvania*) *H.H. Sun Professor; Senior Advisor to the President, Global Partnerships*. Professor. Biomedical signal processing; complexity and scaling in biomedical signals and systems.

Kambiz Pourrezaei, PhD (*Rensselaer Polytechnic University*). Professor. Thin film technology; nanotechnology; near infrared imaging; power electronics.

Christopher Rodell, PhD (*University of Pennsylvania*). Assistant Professor. Biomaterials, supramolecular chemistry, and drug delivery. Therapeutic applications including the etiology of disease, organ injury, cardiovascular engineering, immune engineering, and biomedical imaging.

Ahmet Sacan, PhD (*Middle East Technical University*). Associate Teaching Professor. Indexing and data mining in biological databases; protein sequence and structure; similarity search; protein structure modeling; protein-protein interaction; automated cell tracking.

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drug delivery), controlled release technology (bioactive compounds), microencapsulated allografts (ex vivo gene therapy) for spinal cord repair.

Ming Xiao, PhD (*Baylor University*). Associate Professor. Nanotechnology, single molecule detection, single molecule fluorescent imaging, genomics, genetics, genome mapping, DNA sequencing, DNA biochemistry, and biophysics.

Yinghui Zhong, PhD (*Georgia Institute of Technology*). Assistant Professor. Spinal cord repair, and engineering neural prosthesis/brain interface using biomaterials, drug delivery, and stem cell therapy.

Leonid Zubkov, PhD, DSc (*St. Petersburg State University, Russia*). Research Professor. Physiology, wound healing, physiologic neovascularization, near-infrared spectroscopy, optical tomography, histological techniques, computer-assisted diagnosis, infrared spectrophotometry, physiologic monitoring, experimental diabetes mellitus, penetrating wounds, diabetes complications, skin, animal models, radiation scattering, failure analysis

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