<table>
<thead>
<tr>
<th>Year</th>
<th>Name</th>
<th>Office</th>
<th>Phone</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>Stephen McAleavey</td>
<td>Goergen 309</td>
<td>5-7768</td>
<td><a href="mailto:stephen.mcaleavey@rochester.edu">stephen.mcaleavey@rochester.edu</a></td>
</tr>
<tr>
<td></td>
<td>Edward Brown</td>
<td>MC 5-6224A</td>
<td>3-5918</td>
<td><a href="mailto:edward_brown@urmc.rochester.edu">edward_brown@urmc.rochester.edu</a></td>
</tr>
<tr>
<td></td>
<td>Hani Awad</td>
<td>MC1-8453</td>
<td>3-5268</td>
<td><a href="mailto:hani_awad@urmc.rochester.edu">hani_awad@urmc.rochester.edu</a></td>
</tr>
<tr>
<td></td>
<td>Seidman, Scott</td>
<td>MC 6-7423</td>
<td>3-2122</td>
<td><a href="mailto:seidman@bme.rochester.edu">seidman@bme.rochester.edu</a></td>
</tr>
<tr>
<td></td>
<td>Waugh, Rick</td>
<td>Goergen 210</td>
<td>5-3768</td>
<td><a href="mailto:waugh@bme.rochester.edu">waugh@bme.rochester.edu</a></td>
</tr>
<tr>
<td>2014</td>
<td>Benoit, Danielle</td>
<td>Goergen 307</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Carney, Laurel</td>
<td>Goergen 218</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diane Dalecki</td>
<td>Goergen 310</td>
<td>5-7378</td>
<td><a href="mailto:dalecki@bme.rochester.edu">dalecki@bme.rochester.edu</a></td>
</tr>
<tr>
<td></td>
<td>Davis, Kevin</td>
<td>MC 5-6418</td>
<td>3-4844</td>
<td><a href="mailto:kevin_davis@bme.rochester.edu">kevin_davis@bme.rochester.edu</a></td>
</tr>
<tr>
<td>2015</td>
<td>Regine Choe</td>
<td>MC 6-7614</td>
<td>3-4374</td>
<td><a href="mailto:regine.choe@rochester.edu">regine.choe@rochester.edu</a></td>
</tr>
<tr>
<td></td>
<td>Jong-Hoon Nam</td>
<td>Hopeman</td>
<td>3-4555</td>
<td><a href="mailto:jong-hoon.nam@rochester.edu">jong-hoon.nam@rochester.edu</a></td>
</tr>
<tr>
<td></td>
<td>Jim McGrath</td>
<td>Goergen 306</td>
<td>3-5489</td>
<td><a href="mailto:jmcgrath@bme.rochester.edu">jmcgrath@bme.rochester.edu</a></td>
</tr>
<tr>
<td></td>
<td>Scott Seidman</td>
<td>MC 6-7423</td>
<td>3-2122</td>
<td><a href="mailto:seidman@bme.rochester.edu">seidman@bme.rochester.edu</a></td>
</tr>
<tr>
<td>2016</td>
<td>Luebke, Anne</td>
<td>MC 6-8547</td>
<td>3-1635</td>
<td><a href="mailto:anne_luebke@urmc.rochester.edu">anne_luebke@urmc.rochester.edu</a></td>
</tr>
<tr>
<td></td>
<td>Lerner, Amy</td>
<td>Goergen 307</td>
<td>5-7847</td>
<td><a href="mailto:amy.lerner@rochester.edu">amy.lerner@rochester.edu</a></td>
</tr>
<tr>
<td></td>
<td>Waugh, Rick</td>
<td>Goergen 210</td>
<td>5-3768</td>
<td><a href="mailto:waugh@bme.rochester.edu">waugh@bme.rochester.edu</a></td>
</tr>
</tbody>
</table>
BME PRIMARY FACULTY

Chair of the Department
Richard E. Waugh, Ph.D. (Duke) Professor of Biomedical Engineering, of Pharmacology and Physiology, of Biochemistry and Biophysics, and of Mechanical Engineering
Research Area - Mechanical and thermodynamic properties of biological membranes; cellular mechanics and function of cytoskeletal proteins

Laurel Carney, Ph.D. (Wisconsin) Professor of Biomedical Engineering and of Neurobiology and Anatomy
Research Area – Auditory Neuroscience; neurophysiological, behavioral, and computational studies of hearing; signal processing for hear aids

Hani Awad, Ph.D. (Cincinnati) Associate Professor of Biomedical Engineering and of Orthopaedics
Research Area - Biomechanics of connective tissues, functional biomaterials of connective tissue, physicochemical regulation of engineered tissues, tissue engineering bioreactors, differentiation of stem cells, skeletal phenotyping of genetically altered mice

Edward Brown III, Ph.D. (Cornell) Associate Professor of Biomedical Engineering
Research Area - Multi-photon microscopy for studies of vasculogenesis and tumor diagnostics

Diane Dalecki, Ph.D. (Rochester) Associate Professor of Biomedical Engineering and of Electrical and Computer Engineering, and Director of The Rochester Center for Biomedical Ultrasound
Research Area - Biomedical ultrasound, acoustics, lithotripsy, biological effects of ultrasound

Kevin Davis, Ph.D. (Boston) Associate Professor of Biomedical Engineering and of Neurobiology and Anatomy
Research Area- Auditory neurophysiology, neural circuitry & information processing, and computational neuroscience

Amy Lerner, Ph.D. (Michigan) Associate Professor of Biomedical Engineering and of Mechanical Engineering
Research Area - Orthopedic biomechanics, bone growth and development, cartilage mechanics, medical image-based finite element modeling, knee biomechanics

Anne E. Luebke, Ph.D. (Johns Hopkins) Associate Professor of Biomedical Engineering and of Neurobiology and Anatomy
Research Area - Gene transfer to the cochlear, stem cell transfection, molecular biology of auditory efferent system receptors

Axel Wismüeller, M.D., Ph.D. (Tech. Univ. of Munich, Germany), Associate Professor of Biomedical Engineering and of Imaging Sciences
Research Area - Tissue engineering, polymers, scaffolds, stem cells, musculoskeletal tissues, biomaterials, drug delivery, siRNA

Regine Choe, Ph.D. (U Penn) Assistant Professor of Biomedical Engineering
Stephen McAleavey, Ph.D. (Rochester) Assistant Professor of Biomedical Engineering
Research Area - Biomedical ultrasound, medical imaging, image guided therapy, applications of time delay estimation

James McGrath, Ph.D. (M.I.T.) Assistant Professor of Biomedical Engineering
Research Area - Cell mechanics and motility, endothelial monolayer function, actin-based motility of pathogens

Joon Hoon Nam, PhD. (VA Tech) Assistant Professor of Mechanical Engineering and Biomedical Engineering
Scott Seidman, Ph.D. (Case Western) Assistant Professor of Biomedical Engineering and of Neurobiology and Anatomy
Research Area - Neural control and mathematical modeling of reflex eye movements, physiological control systems
Andrew Berger, Ph.D. (MIT) Associate Professor of Optics and of Biomedical Engineering

David Borkholder (Stanford) Assistant Professor, Electrical Engineering, Rochester Institute of Technology, and Adjunct Associate Professor of Biomedical Engineering

Ankur Chandra, M.D. (Case Western) Assistant Professor of Surgery, and of Biomedical Engineering

Patricia Chess, M.D. (Columbia) Associate Professor of Pediatrics and of Biomedical Engineering

Alfred Clark, Jr., Ph.D. (M.I.T.) Professor of Mechanical Engineering, of Mathematics, and of Biomedical Engineering

Robert Clark, Ph.D. (Virginia polytechnic Inst) Professor of Mechanical Engineering and of Biomedical Engineering

Benjamin Crane, M.D., Ph.D. (UCLA) Assistant Professor of Neurobiology and Anatomy and of Biomedical Engineering

Gregory DeAngelis Ph.D. (California, Berkeley) Professor of Brain and Cognitive Sciences, of Biomedical Engineering, of Neurobiology and Anatomy and in the Center for Visual Science

David Dean, Ph.D. (UC Berkeley) Professor of Pediatrics and Biomedical Engineering

Lisa A. DeLouise, Ph.D. (Pennsylvania State) Assistant Professor of Dermatology and of Biomedical Engineering

Virkram Dogra, Ph.D. (University of Madras, India) Professor of Radiology and Biomedical Engineering

Marvin Doyley, Ph.D. (University of London) Assistant Professor of Electrical and Computer Engineering and of Biomedical Engineering

Alfredo Dubra, Ph.D. (Imperial College, UK) Assistant Professor of Optics and of Biomedical Engineering

Philippe M. Fauchet Ph.D. (Stanford) Distinguished Professor of Electrical and Computer Engineering, of Materials Science, of Optics, and of Biomedical Engineering, and Senior Scientist in the Laboratory for Laser Energetics, and Director of the Center for Future Health

Thomas Foster, OPh.D. (Rochester) Professor of Imaging Sciences, and of Biomedical Engineering

Edward G. Freedman, Ph.D. (Pennsylvania) Associate Professor of Neurobiology and Anatomy, of Biomedical Engineering, and in the Center for Visual Science

Keigi Fujiwara, Ph.D. (U Penn) Professor of Medicine and of Biomedical Engineering

Sheryl Graciewski, Ph.D. (Pennsylvania State) Assistant Professor of Dermatology and of Biomedical Engineering

Denise Hocking, Ph.D. (Albany) Associate Professor of Pharmacology and Physiology and of Biomedical Engineering

Luiz Meirelles, Ph.D. (University of Gothenburg) Assistant Professor of Dentistry and Biomedical Engineering

Ben Miller, PhD. (Stafford) Associate Professor of Dermatology, of Biochemistry and Biophysics, and of Biomedical Engineering

Duncan T. Moore, Ph.D. (Rochester) Professor of Optics and of Biomedical Engineering and Rudolph and Hilda Kingslake Professor of Optical Engineering Science

Jack G. Mottley, Ph.D. (Washington, St. Louis) Associate Professor of Electrical and Computer Engineering and of Biomedical Engineering

Maiken Nedergaard, P.D. (University of Copenhagen) Professor of Neurosurgery and of Biomedical Engineering

Ruola Ning, Ph.D. (Utah) Professor of Radiology and of Electrical and Computer Engineering

Lukas Novotny, Ph.D. (Swiss Federal Institute of Technology) Professor of Optics, of Physics and of Biomedical Engineering and Scientist in the Laboratory for Laser Energetics

Gary Paige, M.D. (Chicago) Kilian J. and Caroline F. Schmitt Professor of Neurobiology and Anatomy, of Neurology, of Ophthalmology, of Brain and Cognitive Sciences, in the Center for Visual Science, and of Biomedical Engineering; Chair of Neurobiology and Anatomy

Kevin J. Parker, Ph.D. (M.I.T.) Professor of Electrical and Computer Engineering, of Radiology, and of Biomedical Engineering; Dean, School of Engineering and Applied Sciences

Renato Perucchio, D. Engr. (Pisa, Italy) Professor of Mechanical Engineering and of Biomedical Engineering, and Associate Professor of Pediatrics

J. Edward Puzas, Ph.D. (Rochester) Donald and Mary Clark Professor of Orthopaedics and of Biomedical Engineering
JOINT APPOINTMENTS WITH BIOMEDICAL ENGINEERING

Janick Rolland, Ph.D. (University of Arizona) Professor of Optics and of Biomedical Engineering
Deborah Rubens, M.D. (Rochester) Professor of Imaging Sciences; Associate Chair of Imaging Sciences
Ingrid H. Sarelius, Ph.D. (Auckland, New Zealand) Professor of Pharmacology and Physiology and of Biomedical Engineering
Michael C. Schell, Ph.D. (Wisconsin, Madison) Professor of Radiation Oncology and of Biomedical Engineering
Edward M. Schwarz, Ph.D. (Albert Einstein College of Medicine) Associate Professor of Orthopaedics, of Microbiology and Immunology, of Urology, of Medicine, of Pathology and Laboratory Medicine, and of Biomedical Engineering
Denham S. Ward, M.D. (Miami) Professor of Anesthesiology and of Biomedical Engineering
David R. Williams, Ph.D. (California, San Diego) William G. Allyn Professor of Medical Optics, Professor of Brain and Cognitive Sciences, of Optics, of Psychology, of Optics, of Ophthalmology, and of Biomedical Engineering; and in the Center for Visual Science; Director of the Center for Visual Sciences
J. H. David Wu, Ph.D. (M.I.T.) Professor of Chemical Engineering, of Microbiology and Immunology, and of Biomedical Engineering
Geunyoung Yoon, Ph.D. (Osaka) Assistant Professor of Ophthalmology, of Biomedical Engineering, and in the Center for Visual Science
James M. Zavislan, Ph.D. (Rochester) Associate Professor of Optics, of Dermatology, of Ophthalmology, and of Biomedical Engineering
Jianhui Zhong, Ph.D. (Brown) Professor of Radiology and of Biomedical Engineering, and of Physics

AFFILIATED FACULTY

Arthur Moss, M.D. (Harvard) Professor of Medicine
Alice Pentland, M.D. (Michigan) James H. Sterner Professor of Dermatology; Medical Director of Center for Future Health and Chair of Dermatology
Deborah Rubens, M.D. (Rochester) Professor of Imaging Sciences; Associate Chair of Imaging Sciences
Shey-Shing Sheu, Ph.D. (Chicago) Professor of Pharmacology and Physiology, of Medicine, and of Anesthesiology
Peter G. Shrager, Ph.D. (California, Berkeley) Professor of Neurobiology and Anatomy
Paul E. Bigeleisen, M.D. (California, Davis) Associate Professor of Anesthesiology
Karl Schwarz, M.D. (Rochester) Associate Professor of Medicine and of Biomedical Engineering
Xucai Chen, Ph.D. (Yale) Assistant Professor of Medicine, of Electrical and Computer Engineering, and of Biomedical Engineering
Jean-Philippe Couderc, Ph.D. (National Institute of Applied Science, Lyon, France) Research Assistant Professor of Medicine
Edwin Carstensen, Ph.D. (University of Pennsylvania) Arthur Gould Yates Professor Emeritus of Engineering and Senior Scientist in Electrical and Computer Engineering
INTRODUCTION

Biomedical Engineering (BME) involves the application of engineering science and technology to solve problems in biology and medicine. This broad area offers many career opportunities, ranging in scope from advanced research to engineering practice in industrial or clinical settings. The Department of Biomedical Engineering, in conjunction with strong academic programs in the basic sciences and other engineering disciplines at the University of Rochester, offers outstanding training in this rapidly growing field.

B.S. IN BIOMEDICAL ENGINEERING

The Bachelor of Science degree program in biomedical engineering at the University of Rochester is one of 71 programs (as of October 2010) that is accredited by ABET. Our curriculum emphasizes fundamental engineering and design principles taught in the context of current problems in medicine and biology. A series of nine core courses required of all BME students provides a solid foundation in engineering principles relevant to biomedical engineering practice. To ensure in-depth training in engineering, students are required to complete a sequence of four engineering courses in a focus area of biomedical engineering. These areas of concentration are Biomechanics, Biosignals and Biosystems, Cell and Tissue Engineering, and Medical Optics. The program is capped with a biomedical engineering senior design course required for all students. This program requires a total of 130 credit hours, including a minimum of 51 credit hours devoted to mathematics and natural sciences and a minimum of 51 credit hours devoted to engineering.

The Undergraduate Program

The interdisciplinary nature of biomedical engineering requires expertise in both the biological and engineering sciences. The University of Rochester offers several avenues of academic study in biomedical engineering, each of which can be structured to satisfy pre-medical or pre-dental requirements. The University of Rochester offers B.S., M.S. and Ph.D. programs in biomedical engineering. The Minor in biomedical engineering (24 credits) provides opportunities for students majoring in other disciplines to obtain substantive exposure to the field of biomedical engineering. Minor requirements are listed on the BME website: http://www.urmc.rochester.edu/bme/

DEPARTMENTAL MISSION AND PROGRAM EDUCATIONAL OBJECTIVES

Mission

“As members of the Department of Biomedical Engineering at the University of Rochester, our mission is to create and disseminate knowledge in engineering related to basic biomedical sciences and health care applications, and to provide students with the foundational knowledge and skills in biomedical engineering that they will need to become and remain leaders in their chosen field.”

Undergraduate Program Educational Objectives

The overall educational objective of our program is to develop effective practitioners in biomedical engineering and associated fields. We expect that our graduates will contribute to the advancement of their chosen field, while remaining mindful of the ethical and social implications of their work. They will confidently apply knowledge in the basic sciences, mathematics, engineering analysis, and design to address problems in medicine and biology. In keeping with the continuously evolving nature of the field of biomedical engineering, we expect that our alumni will effectively communicate, engage in lifelong learning, and that many of them, inspired by research experiences as undergraduates, will continue their education in advanced degree programs.
BME CURRICULUM AND REQUIREMENTS

Basic Science & Math Courses (38 credit hours) See Appendix #1 for full course names
Nine courses in natural sciences and mathematics divided as follows:
Four Math courses - MTH 161, 162, 163 or 165, 164
(MTH 141, 142, & 143 are equivalent to MTH 161 & 162)
Two Chemistry courses - CHM 131 and CHM 132 (5 credits each)
Two Physics courses - PHY 121, 122
One Biology course - BIO 110

Core BME Courses (35 credit hours)
The curriculum features a series of core BME courses that aims to provide students with a breadth of knowledge and skills in the field of biomedical engineering. The following courses form the BME Core.
(See Appendix#2 for course descriptions)
BME 101/EAS101- Introduction to Biomedical Engineering
BME 201 - Fundamentals of Biomechanics
BME 201P - MATLAB for Biomechanics (1 credit)
BME 210- Biosystems and Circuits
BME 221- Biomedical Computation & Statistics
BME 230- Biomedical Signals, Systems, & Imaging
BME 245- Biomaterials
BME 260- Quantitative Physiology with lab
BME 295- BME Design Seminar (2 credits)
BME 296- BME Senior Design

Basic Science Electives (12 credit hours)
All students must complete at least three additional courses (at least 12 credit hours) in the basic sciences beyond the required introductory biology (BIO 110), chemistry (CHM 131 & CHM 132), and physics (PHY 121/141 & PHY 122/142) courses. Any biology, microbiology, neuroscience, chemistry, or physics course with number greater than 109 may be used to fulfill this requirement (excluding BIO 111, 112, 113). At least two of these courses must have a laboratory component. At least two courses must be life science courses (i.e., biology, microbiology, neuroscience). Students are encouraged to choose their basic science electives to complement their BME concentration area. Independent study courses cannot be used to satisfy this requirement.

Some recommendations for Basic Science Elective sequences are provided below.
Example 1:
BME 258 - Human Anatomy (4 credits, spring, includes laboratory component)
BIO 204 – Mammalian Physiology (4 credits, spring, includes laboratory component)
PHY 123 – Modern Physics (4 credits, spring, includes laboratory component)

Example 2: (This sequence is required for students in the Cell & Tissue Engineering Concentration)
CHM 203 – Organic Chemistry I (4 credits, fall) with CHM 207 – Organic Chem. Lab I (1 credit, fall)
BIO 250 – Biochemistry (4 credits, spring) with BIO 151 – Intro. to Biochemistry Lab (1 credit, spring)
BIO 210 – Molecular Cell Biology (4 credits, fall, no laboratory component)

Example 3:
CHM 203 – Organic Chemistry I (4 credits, fall) with CHM 207 – Organic Chemistry Lab I (1 credit, fall)
BIO 250 – Biochemistry (4 credits, spring) with BIO 151 – Intro. to Biochemistry Lab (1 credit, spring)
BIO 190 – Principles of Genetics (4 credits, fall) with BIO 198L – Genetics Lab (1 credit, fall)
Example 4:
BME 258 – Human Anatomy 4 credits, spring, includes laboratory component
NSC 201 – Basic Neurobiology (4 credits, fall), no laboratory component
NSC 221 – Audition (4 credits, spring)

Example 5: (Pre-Med -these requirements include two semesters of organic chemistry with laboratories and two semesters of biology with laboratories. Thus, students will need to use at least one free elective to fulfill pre-medical science requirements.

CHM 203 – Organic Chemistry I (4 credits, fall) with CHM 207 – Organic Chemistry Lab I (1 credit, fall)
BIO 204 – Mammalian Physiology (4 credits, spring, includes laboratory component)
BIO 190 – Principles of Genetics (4 credits, fall) with BIO 198L – Genetics Lab (1 credit, fall)

Technical Elective (4 credit hours) required for classes <2015; not required for >2015
An engineering course with the course number higher than 109 can be used to fulfill the technical elective requirement. Suitable courses must have significant engineering design, analysis, synthesis, or technical components.

The following courses may not be used towards the technical elective requirement ECE 111, ECE 113, ECE 399, ChE 150, ChE211, ChE 290, ME 120, ME 163, ME 164, ME 202, ME 211, OPT 287, any EAS course. Classes that are primarily mathematics or science courses may not be used. Classes that are equivalent to core or concentration courses are disallowed, e.g. ME 225 Fluid Mechanics cannot be used as a technical elective when ChE 243 Fluid Dynamics has already been taken to fulfill the concentration requirements and vice versa. Courses that are cross-listed with non-SEAS departments (e.g. ChE277/AAS277) must be taken under the SEAS registration. Petition forms can be obtained from Dottie Welch, Goergen 206.

Cluster and Humanities & Social Sciences (H/SS) (16 credit hours)
All BME majors must complete a total of four courses in humanities and/or social sciences. Three of these courses must constitute an approved Cluster in Humanities or Social Sciences and must be passed with a 2.0 average or better. See the Cluster Search Engine on the UR website to review courses and descriptions:
http://www.rochester.edu/College/CCAS/clusters/cluster_directory7.html
The fourth course can be chosen from any recognized Humanities or Social Science field. Courses in the business field may not be used to satisfy the additional course requirement. Students are expected to take some of these courses beyond the introductory level.
Some tracks for the Certificate of Management Studies will satisfy the cluster requirement. Those stating Social Science Cluster - See the website:
http://www.rochester.edu/College/CCAS/certificates/cert_management.html
**A second major or minor in a Humanities or Social Science (H/SS) area will also satisfy the cluster and additional H/SS course requirement.
No computer courses offered in humanities or social science fields may be used as a H/SS distribution course.

Primary Writing Requirement (4 credit hours)
The Primary Writing Requirement must be satisfied before admission to the program. (WRT 105 - Reason and Writing) See the website:
http://www.rochester.edu/College/CCAS/AdviserHandbook/PrimWrReq.html
and the listings for CAS 105 course schedules website:
http://www.rochester.edu/college/Writing/schedules.html
Free Electives (9 credit hours)
Any courses taken at the UR, AP courses or transfer courses

Upper Level Writing Requirement
Significant writing experience in one's discipline is an important adjunct to the technical material one learns. As of 7/01, the courses that fulfill the University's Upper Level Writing Requirement courses by placing significant weight on the effectiveness of written communication are: BME 221, BME 230, BME 260, BME 296, and any upper level BME course.

BME Concentration Courses (16 credit hours)
Students choose to concentrate in one of four BME specialty areas. Four engineering courses are required to form a sequence in one of the following areas. Biosignals & Biosystems, Biomechanics, Cell & Tissue Engineering, or Medical Optics. Each concentration includes an upper level BME course in the specialty area. Courses for each concentration and example course schedules are given below.

Biosignals & Biosystems
ECE 230- Electromagnetic Waves
ECE 221-Electronic Devices & Circuits or BME 228 Physiological Control Systems
ECE 246 – Digital Signal Processing
Upper Level BME: e.g. BME 251-Biomedical Ultrasound, ECE 452-Medical Imaging, BME 218 Introduction to Neuroengineering

Biomechanics
ME 226-Introduction to Solid Mechanics
ME 225-Introduction to Fluid Dynamics
ME 123-Thermodynamics
Upper Level BME: e.g. BME 283-Biosolid Mechanics

Cell & Tissue Engineering
CHE 243-Fluid Dynamics
CHE 244-Heat & Mass Transfer
CHE 225-Thermodynamics
Upper Level BME: e.g. BME 262 Cell & Tissue Engineering

Medical Optics
OPT 241-Geometrical Optics
OPT 261-Interference & Diffraction
OPT 262-Electromagnetic Theory or OPT 224-Laser Systems
PHY 123 – Wave and Modern Physics Basic Science Elective
Upper Level BME: e.g. OPT 276-Biomedical Optics or BME 270 –Biomedical Microscopy
FIRST & SECOND YEAR
FOR ALL BME STUDENTS

1st Year
Fall
- MTH 161* - Calculus IA
- CHM 131 - Chem. Concepts I (lab)
- EAS/BME 101 - Intro. to BME (Core)
- Primary Writing or H/SS

Spring
- MTH 162* - Calculus IIA
- CHM 132 - Chem. Concepts II (lab)
- PHY 121 - Mechanics (lab)
- H/SS or Primary Writing

2nd Year
Fall
- MTH 163 or 165** - Differential Equations
- PHY 122 - Electricity & Magnetism (lab)
- BIO 110 - Principles of Biology I
- BME 201 - Fund. of Biomechanics (Core)
- BME 201L - MATLAB for Biomechanics - 1cr.

Spring
- MTH 164 - Multidimensional Calculus ***
- Basic Science Elective or 1st concentration course****
- H/SS*****

* An alternative to the MTH 161 and 162 sequence is the MTH 141, 142 and 143 sequence. Careful attention must be paid to the effects of this longer sequence, including the possible need to take a course in the summer following the first year. MTH171 series can be used to fulfill the Math requirements
** Either MTH 163 or 165 will satisfy the math requirements of the BME program.
*** The following courses are required as concentration courses in the Spring of Sophomore year: Cell & Tissue - CHE243; Biomechanics - ME226 or ME123; Medical Optics - PHY123
**** In each concentration one of the four electives must be a Technical Elective. Humanities, Social Sciences, and Elective courses can be taken in any semester.
*****

CELL & TISSUE ENGINEERING

3rd Year
Fall
- ELECTIVE
- CHE 244 - Heat & Mass Transfer
- BME 230 - Signals, Systems & Imaging (lab) (Core
- CHM 203 - Orgo I & 207 Lab

Spring
- BME 245 - Biomaterials (Core >2015)
- BME 221 - Biomedical Computation & Statistics (Core)
- BIO 250-Biochemistry & 151 Lab

4th Year
Fall
- BME 260 - Quantitative Physiology (Core)
- BME 295 - Design Seminar (2 cr.) (Core)
- BIO210 - Molecular Cell Biology
- CHE 225-Thermodynamics
- H/SS

Spring
- BME 296 - Senior Design (lab)(Core)
- BME 262 – Cell & Tissue Engineering
- ELECTIVE
- ELECTIVE
# BIOSIGNALS & BIOSYSTEMS

### 3rd Year
**Fall**
- ECE 221 - Electronic Devices & Circuits or BME 228 - Physiological Control Systems
- BME 230 - Signals, Systems, & Imaging (lab) *(Core)*
- Basic Science Elective
- H/SS

**Spring**
- BME 245 - Biomaterials *(Core > 2015)*
- BME 221 - Biomedical Computation & Statistics *(Core)*
- Basic Science Elective

### 4th Year
**Fall**
- BME 260 - Quantitative Physiology *(Core)*
- BME 295 - Design Seminar (2 cr.) *(Core)*
- ELECTIVE or Upper Level BME
- ECE 246 - Digital Signal Processing
- ECE 230 - Electromagnetic Waves

**Spring**
- BME 296 - Senior Design *(Core)*
- Upper Level BME or ELECTIVE
- ELECTIVE

# BIOMECHANICS

### 3rd Year
**Fall**
- ELECTIVE
- H/SS
- BME 230 - Signals, Systems, & Imaging (lab) *(Core)*
- Basic Science Elective

**Spring**
- ME 123 - Thermodynamics
- ME 226 - Introduction to Solid Mechanics
- BME 221 - Biomedical Computation & Statistics *(Core)*
- BME 245 - Biomaterials *(Core > 2015)*

### 4th Year
**Fall**
- BME 260 - Quantitative Physiology *(Core)*
- BME 295 - Design Seminar (2 cr.) *(Core)*
- ME 225 - Introduction to Fluid Dynamics
- BME 283 - Biosolid Mechanics
- Basic Science Elective

**Spring**
- BME 296 - Senior Design *(Core)*
- ELECTIVE
- H/SS
- Basic Science Elective

# MEDICAL OPTICS

### 3rd Year
**Fall**
- OPT 241 - Geometrical Optics
- H/SS
- BME 230 - Signals, Systems, & Imaging (lab) *(Core)*
- Basic Science Elective

**Spring**
- ELECTIVE
- OPT 261 - Interference & Diffraction
- BME 221 - Biomedical Computation & Statistics *(Core)*
- BME 245 - Biomaterials *(Core > 2015)*

### 4th Year
**Fall**
- BME 260 - Quantitative Physiology *(Core)*
- BME 295 - Design Seminar (2 cr.) *(Core)*
- Upper Level BME or Elective
- ELECTIVE or OPT 224 - Laser Systems
- H/SS

**Spring**
- BME 296 - Senior Design *(Core)*
- OPT 262 - Electromagnetic or ELECTIVE
- ELECTIVE or Upper Level BME
- H/SS
ADMISSION REQUIREMENTS

Students wishing to major in Biomedical Engineering must file a completed "BME Curriculum Planning Form" (See Page 16) ordinarily during the fourth semester of study. This form constitutes application to the upper-division BME program.

To be considered for admission to the biomedical engineering major a student must have taken courses in the first two years to enable a program of study that satisfies the requirements of the program and that can be completed in a total of four years.

The minimum requirements for admission to the BME program are:
• satisfactory completion of BME 101 (by the end of the sophomore year)
• two engineering courses (usually BME 210, BME 201/201P)
• a minimum ADMIT GPA of 2.30 in these four courses (BME101, BME201, BME201P, & BME 210)
• satisfactory completion of the basic science and math requirements
• a minimum overall cumulative GPA of 2.0
• satisfactory completion of the University primary writing requirement
• completion of Career Planning Form

A BME career planning form (See Appendix 3) must accompany the major declaration forms. The university requirement that a student should be free of academic probation also applies. The submitted career plan, though never binding, is very useful in helping students to focus their interests within the field of biomedical engineering. Before preparing and submitting a course plan, each student should study available written material and then discuss the alternatives fully with his or her faculty advisor or with other faculty. The Curriculum Planning Form, approved and signed by the student’s faculty advisor, will then be attached to a Declaration of Major Approval form and submitted to the SEAS Dean's Office.

Under special circumstances, such as transfer from another institution or a change of intended major in the early years of study, students may not complete all the requirements for admission by the end of the sophomore year. Students in such a situation may qualify for conditional admission by submitting a form, available from the BME Undergraduate Office, to the BME Undergraduate Committee along with an up-to-date BME Curriculum Planning Form. The application must present a realistic plan, approved by the student’s advisor, for completion of all BME program admission requirements within one year. Failure to meet the requirements within one year will result in removal from the major.

Only the Administrative Committee of the School of Engineering and Applied Sciences can make exceptions from the general degree requirements published in the Official Bulletin of the University. Petition forms for Administrative Committee consideration may be obtained from the BME Undergraduate Office - Goergen 206.

GRADUATION REQUIREMENTS

For graduation biomedical engineering majors must achieve satisfactorily complete all course requirements consisting of a total of 130 credits with an overall cumulative grade point average of 2.00.

TRANSFER CREDITS

Prior approval is required if a student wishes to take a course at another institution to satisfy a BME degree requirement. An "Undergraduate Transfer Credit Approval Form," is available in the BME Undergraduate Office - Goergen 206. Students are strongly advised to seek the advice of their advisor before registering for a course at another institution.
MINOR IN BIOMEDICAL ENGINEERING

The biomedical engineering minor provides substantive exposure to the biological and engineering sciences and gives students a basic perspective on the complex structure and function of living systems and their analysis by physical and engineering principles. The minor is available to students in all majors, but engineering and biology students find it easier to complete these requirements. Students may not use more than two of the courses required for the BME minor to also satisfy requirements in their major (including technical electives). All students that propose a minor in BME must fulfill the basic math requirements (MTH 163/165).

Biological Science Courses (8 credit hours)
Students must complete two life science courses (i.e., biology, microbiology, or neuroscience above 110)

Engineering Courses (12 credit hours)
Choose three engineering courses, two of which must be BME courses, including any 400-level BME courses or cross-listed courses. 
Note: Students are warned to confirm that all prerequisites for the courses below are fulfilled

Examples
• BME 201/201P Fundamentals of Biomechanics/MATLAB for Bioengineers (1 credit)
• BME 218. Introduction to Neuroengineering
• BME 221. Biomedical Computation
• BME 228. Physiological Control Systems
• BME 230. Biomedical Signals and Measurements
• BME 245. Biomaterials
• BME 251. Biomedical Ultrasound
• BME 260. Quantitative Physiology
• BME 262. Cell and Tissue Engineering
• BME 267 Models and Simulations of Biomedical Systems. (???)
• BME 270 Biomedical Microscopy
• BME 283. Biosolid Mechanics
• BME 391. Independent Study
• CHE 243 or ME 225. Fluid Dynamics/Introduction to Fluid Dynamics
• CHE 259. Transport Phenomena in Biological Systems
• ECE 210 or 113. Circuits for Scientists and Engineers/Circuits and Signals
• ME 226. Introduction to Solid Mechanics
• OPT 224. Laser Systems
• OPT 241. Geometrical Optics

FIVE-YEAR BS/MS PROGRAM (3/2 Program)
BME juniors contemplating graduate work should consider the special five-year, BS/MS program offered by the BME Department. This program provides the advantage of a smooth transition between undergraduate and graduate study. Program enrollment is competitive and students must apply for admission in the spring of their junior year. Successful applicants can begin their masters-level study in the senior year. Through a special program initiated by the School of Engineering and Applied Science, students who have been formally accepted into the 3/2 program will be considered for a partial tuition scholarship for the fifth year of study. Students should consult the UR Graduate Studies Official Bulletin for the MS degree requirements and they should meet with a faculty member to develop an integrated BS/MS program of study (required for admission.) UR Graduate Studies Official Bulletins are available in the BME Undergraduate Office - Goergen 206.
TAKE FIVE SCHOLAR PROGRAM

The Take Five Scholar Program provides students with opportunities to explore additional disciplines and courses that might not otherwise be available to them within the four year degree path. Accepted students will be granted one or two tuition-free semesters to take courses in addition to those needed to complete their degree. Students may apply from the time they have been formally accepted into their major through the first semester of their senior year. Transfer students must have completed one full semester at the University before applying.

Website: http://www.rochester.edu/College/CCAS/TakeFive/

INTERNSHIPS AND INDUSTRY PRACTICUM

BME majors are strongly encouraged to participate in internships with local or nationally based engineering firms or research institutions. Only in a few cases can internship experiences be used for academic credit. Students who wish to obtain such credit for an internship must obtain prior approval from the BME Undergraduate Committee.

The Industry Practicum program is a way to gain valuable work experience. A student in this program takes one semester, and the summer preceding or following that semester to work for a company. Academic credit is not granted, but the work experience and references obtained are valuable in later career placements. Typically, graduation is delayed by one semester, but some students with Advanced Placement credit or summer classes can graduate on time. Additional information, including example programs, is available from the SEAS office or Career Center in Lattimore Hall.

Website: http://www.seas.rochester.edu/SEAS/options/ip.html

STUDY ABROAD

If you are considering spending a semester, a year or summer in another country please check out the UR website to explore the opportunities available to you. You will find numerous resources to help you plan your studies overseas.

See the website: http://www.rochester.edu/College/abroad/programs/index.html
Visit the Center for Study Abroad and Inter-department Programs as you plan. The Center is located in Lattimore 206, and is there to help you, to share your excitement and to assist you in making it all work.

PRE-MEDICAL PROGRAM

BME students interested in a pre-med program are urged to obtain related materials from the Health Professions Advisor at the Center for Academic Support, Lattimore 312. It is essential that such students begin program planning very early and involve both their BME advisor and the Health Professions Advisor.

Website: http://www.bcs.rochester.edu/programs/undergraduate/pre-med.html

All of the courses usually required for admission to medical school are readily accommodated within the B.S., in BME curricular requirements. These include two semesters of general physics, two semesters of general chemistry, two semesters of Organic Chemistry with labs, two semesters of biology with labs, two semesters of math, and two semesters of English.

GEAR PROGRAM

Students can accelerate and complete their master’s degree in engineering and applied sciences in a 3-2 B.S./M.S. program. The GEAR program provides selected students with an assurance of admission into one of seven engineering master’s programs at the University of Rochester’s Edmund A. Hajim School of Engineering and Applied Sciences: biomedical engineering, chemical engineering, computer science, electrical and computer engineering, materials science, mechanical engineering, or optics. GEAR students receive a 50 percent tuition award in their fifth year of study in the form of a teaching assistantship. To remain eligible, GEAR students are required to maintain a 3.3 GPA through the first seven semesters (3.5 for optics). Applicants for this program will have demonstrated strong aptitude for engineering throughout their high school academic and co-curricular activities.
KAUFFMAN ENTREPRENEURIAL YEAR (KEY) PROGRAM

The University of Rochester defines entrepreneurship as "transforming an idea into an enterprise that generates value," implying that the enterprise outlives the creator and that it positively affects others. Qualified students may propose to devote as much as an entire academic year to internships, special projects, business plan development, research into various facets of entrepreneurship, or analysis of how culture and public policy influence entrepreneurial activity. Students may apply from the time that they have been accepted into a major through the second semester of their senior year.

* Participation is open to all undergraduates in the College and the Eastman School of Music with the following exceptions:
  * Transfer students may not apply during their first semester at the University.
  * Take Five Scholars may not apply for the KEY Program.

Applications are available at each of several information sessions held each semester, at the Academic Services Counter outside Lattimore 312 and on the web at http://www.rochester.edu/entrepreneurship/. Applications are due no later than November 1st in the fall semester or the first Thursday after Spring Break in the spring term. Students should submit their KEY Program materials to Juliet Sullivan, Lattimore 312. Letters of recommendation are due the same day as the application and should be sent directly to Lattimore 312.

A list of courses that has been developed with entrepreneurship in mind can be found at www.rochester.edu/entrepreneurship/courses. Students should also consult the faculty with whom they want to study, and/or the appropriate departmental administrators to be sure that the courses they want to take will be offered, and that they are adequately prepared for the courses they intend to take. Each applicant needs to arrange for two full-time faculty members to send letters of recommendation to the KEY Review Board on his or her behalf.

TEAM

The Master of Science in Technical Entrepreneurship And Management, or TEAM, degree program at the University of Rochester offers students the opportunity to immerse themselves in a technical cluster of their choice while receiving a strong foundation in entrepreneurial management. Through a fast-paced curriculum at the University’s Edmund A. Hajim School of Engineering and Applied Sciences and the William E. Simon Graduate School of Business, students can complete the program in as little as one academic year.

TEAM graduates are equipped with detailed technical knowledge in their field as well as business-savvy. They have the tools to innovate, lead, and strategically manage in an industry that increasingly rewards interdisciplinary expertise. Seventy-five percent of the Class of 2010 received multiple job offers before graduation.

NROTC

A maximum of two NROTC courses (8 credits) may be taken as free electives toward the 130 credits required for graduation. Additional NROTC courses must be taken as overloads.
BIOMEDICAL ENGINEERING COURSES AND PRE-REQUISITES

BME 101/EAS 101 - Introduction to Biomedical Engineering
This course provides an introductory overview of the multi-disciplinary field of biomedical engineering. Application of elementary engineering principles to the analysis of physiological systems. Topics include biomechanics, cell and tissue engineering, biosignals and bioinstrumentation, medical imaging, neuroengineering and medical optics. Includes instruction on the use of computers in engineering. This course is open to all freshmen (or sophomores with permission of instructor) interested in an introduction to the field of biomedical engineering. (Cross listed as EAS 101.) Semester Taught: Fall - CREDITS 4

BME 201 - Fundamentals of Biomechanics
BME 201 teaches elementary mechanical equilibrium and motion with extended applications to biology. Lectures present a traditional analysis of idealized particles and rigid bodies. Topics include force and moment balances, frames, trusses and pulleys, systems with friction, mass centers, area moments, and the linear and rotational kinetics and kinematics of rigid bodies. Weekly exercises apply fundamental principles to non-biological problems in two and three dimensions. Weekly problems extend the application to biological problems ranging from human motion to the mechanics of cells. In an end-of-term project students analyze human motion using the MATLAB programming language. This is a required course for BME majors typically taken in the sophomore year. Prerequisites: MTH 161 and 162, BME 101, PHY 121. Concurrent with BME 201. Semester Taught: Fall - CREDITS 4

BME 201 P - MATLAB for Biomechanics
Fundamentals of computer programming in MATLAB. Emphasis on programming basics, such as syntax, loop structures, logic, input/output, and graphics.- CREDITS 1

BME 210 – Biosystems & Circuits
Introduction to electrical circuit theory. Examples will include bioelectric systems and signals and models of biological systems. Semester Taught: Spring - CREDITS 4

BME 218/418 – Introduction to Neuroengineering
This course introduces many aspects of neuroengineering research, with an emphasis on biologically plausible models of neurons, circuits, and systems. The course begins with a brief review of passive membrane properties and Hodgkin-Huxley channel dynamics, and extends to advanced topics including neural circuits, control systems, and biologically plausible neural models of behavior. There is an emphasis on theory, modeling, and simulation of single neurons, neural networks, and systems. Prerequisites: BME 260, strong computing skills recommended or permission of instructor  Semester Taught: Spring - CREDITS 4

BME 221 - Biomedical Computation & Statistics
Numerical and statistical methods of scientific computing and their applications to modeling of biomedical systems and interpretation of experimental data, using the MATLAB programming language. Prerequisites: BME 201 and 201P, or permission of instructor. Semester Taught: Spring– CREDITS 4

BME 228/448 – Physiological Control Systems
This course focuses on the application of control theory to physiological systems. Lectures present modern control theory in the context of physiological systems that utilize feedback mechanisms. Prerequisites: juniors with MTH164, MTH163/165, BME201L and ECE241 or equivalent. Seniors need BME230 in place of ECE241. Semester Taught: Fall - CREDITS 4
BME 230 – Biomedical Signals, Systems, and Imaging
Introduction to continuous and discrete time signals and linear time invariant systems, with applications to BME including imaging. Topics include convolution. Laplace and Z transforms, stability of systems, the Fourier series and transform, noise and filtering, and fundamental concepts in image processing and enhancement. Prerequisites: BME 210 or equivalent, MTH163/165  Semester Taught: Fall  CREDITS 4

BME 245/445 – Biomaterials
This course provides a background in biomaterials. It covers basic material properties, specifics on ceramics, polymers and metals used in the body, biological responses to implanted materials, and special topics related to biomaterials including tissue engineering, drug delivery, and sensors. At the end of the course, students are expected to articulate design criteria for engineered biomaterials with respect to chemistry, mechanics, lifetime, tissue integration, and FDA approval and be able to recommend optimum designs for different applications. The class is divided into three general sections: 1) Basic material structures of common biomaterials: Metals, Ceramics, and Polymers and how these structures are tested, 2) Cell and Tissue Interactions with Biomaterials (inflammation, wound healing, immune response, etc.), 3) FDA approval and applications of biomaterials (including drug delivery, tissue engineering, sensors). Semester Taught:  Spring (starting 2011) - CREDITS 4

BME 251/451 – Biomedical Ultrasound
The physical basis for the use of high-frequency sound in medicine (diagnosis, therapy, and surgery) and biology. Topics include acoustic properties of tissues, sound propagation (both linear and nonlinear) in tissues, interactions of ultrasound with gas bodies (acoustic cavitation and contrast agents), thermal and non-thermal biological effects of ultrasound, ultrasonography, dosimetry, hyperthermia and lithotripsy. Prerequisites: Math 163, Math 164, Physics 122 or permission of instructor. Semester Taught: Spring - CREDITS 4

BME253/453 – Ultrasound Imaging
Introduction to the principles and implementation of diagnostic ultrasound imaging. Topics include linear wave propagation and reflection, fields from pistons and arrays, beamforming, B-mode image formation, Doppler, and elastography. Prerequisites: BME 451 or permission of instructor. Semester Taught: Fall - CREDITS 4

BME/BIO 258 – Human Anatomy
Human Anatomy is the detailed study of the human organism at the cellular, tissue and organ systems levels. The relationship between structure and function is covered with emphasis on structural relationships. The course includes both lectures and laboratory sessions, an provides a basis for further professional and clinical experience. (Students can not take both BME (or BIO) 258 and BIO 203.). Semester Taught:  Spring  - CREDITS 4

BME 259 Transport Phenomena in Biological Systems
This course will provide an overview of transport phenomena in biological systems that are critical to the function of all living organisms. The fundamental laws and equations of transport phenomena will be applied to topics including cellular, cardiovascular, respiratory, liver and kidney transport, blood flow and reology, and circulation in tissues and arteries. Homework assignments, in-class quizzes, final exam and a technical paper or presentation. Semester Taught: Fall – CREDITS 4

BME 260 - Quantitative Physiology
A quantitative, model-oriented approach to physiological systems is presented. Topics include: muscle and nerve tissue, the cardiovascular system, the respiratory system, the renal system, and a variety of neural systems. Prerequisite: ECE 113 or BME 210 or permission of instructor. Semester Taught: Fall,  CREDITS 4
BME 262/462 - Cell & Tissue Engineering
This course teaches the principles of modern cell and tissue engineering with a focus on understanding the fundamental interactions between cells and their environment and an emphasis on the concepts relevant to the practice of cell and tissue engineering. The course covers the following modules: Prerequisites: BME 260, CHE 225, CHE 243, CHE 244 or permission of instructor. Elements of Embryonic Development and Tissue Healing in Tissue Engineering; Cell and Molecular Biology Technologies (cell sourcing, cell culture, growth, differentiation, gene transcription and translation); Stem Cells; the ECM (types of tissues and extracellular matrix constituents); Biomaterials (natural polymers, degradable synthetic polymers, degradable bioceramics, scaffold design and fabrication); Biocompatibility and Basic Immunology; Controlled Drug Release Strategies; Cell Signaling; Strategies to Improve Cell Nutrition, Diffusion & Mass Transport in Engineered Tissues; Bioreactor Technologies; Gene Therapy; and Tissue Mechanics and Mechanobiology. Prerequisites: BME 260, CHE 225, CHE 243, CHE 244, or permission of instructor In a term project, graduate students must identify a technological need and present orally and in writing a proposal to meet the need. Semester Taught: Spring - CREDITS 4

BME 267/467 Models and Simulations of Biomedical Systems
Introduction to analytical modeling and computational simulations of systems. Examples include cardiovascular, respiratory, muscle, neural and population models. Prerequisites: BME 221 and BME 230 Semester Taught: Fall - CREDIT 4

BME270/470 - Biomedical Microscopy
This course covers the principles and practice of light microscopy as applied to biological and medical questions. Topics include basic light microscopy, epifluorescence, confocal and multiphoton laser-scanning microscopy, and selected methods such as CARS< FRET< FRAP< FCS, etc. This course is jointly listed as BME 470 for graduate students. Some homework problems are “BME470 only”. Prerequisites: OPT 241, OPT 261, BME201L, MTH 163/165, MTH 164 or permission of instructor. Fall – Taught alternate Fall semesters with OPT276 - CREDITS 4

BME274/474 Biomedical Sensors, Circuits & Interfacing
Course will cover circuits and sensors used to measure physiological systems at an advanced level. Both signal conditioning and sensor characteristics will be addressed. Topics will include measurement of strain, pressure, flow, temperature, biopotentials, and physical circuit construction. The co requisite Laboratory will focus on the practical implementation of electronic devices for biomedical measurements. CREDITS 4

BME/OPT 276. Biomedical Optics. Major topics are biomedical spectroscopy (absorption, fluorescence, Raman, elastic scattering); propagation of photons in highly scattering media (such as tissue); techniques for high-resolution imaging in biological media: confocal imaging, multi-photon imaging, and optical coherence tomography Semester Taught: Fall alternate years – CREDITS 4

BME 283/483 - Biosolid Mechanics
Application of engineering mechanics to biological tissues including bone, soft tissue, cell membranes, and muscle. Realistic modeling of biological structures, including musculoskeletal joints and tissues. Investigations of the responses of biological tissues to mechanical factors. Experimental methods and material models. Same as ME 483 and BPH 483. Prerequisites: ME 226, BME 201, and 201L. Semester Taught: Fall - CREDITS 4

BME 295 - BME Design Seminar
Guided sessions for project development will be held, using brainstorming and other techniques, and then students will develop proposals and specifications for their projects. Presentations will be given describing all the proposed projects and students will be given an opportunity to turn in resumes to apply to work on
projects of their choice. Students who wrote the proposals will select teams for the applicants, and final project execution will be carried out in the spring semester. Prerequisites: math, science, and engineering courses appropriate for fourth-year students in BME. Semester Taught: Fall - CREDITS: 2

**BME 296 - BME Senior Design Project**
Senior capstone design course in the Biomedical Engineering Program. Students work in teams to design, build, and test a medical device or instrument for a faculty, community or industrial sponsor. Accompanying lectures and discussions introduce issues related to ethics, economics, project management, regulation, safety, and reliability. Prerequisites: math, science, and engineering courses appropriate for fourth-year students in BME, BME 295, BME 260, or permission of instructor. Semester Taught: Spring - CREDITS 4

**BME 404. Computational Methods Applied to Biology Systems.**
The aim of this class is to gain experience solving analytically intractable research problems using computational methods. At the beginning of the course, general numerical analysis topics are reviewed. The rest of the course is oriented toward projects. Examples will be drawn from problems of biological systems. For final project, students are asked to bring their own research problems, express them in mathematical equations, solve them using custom written computer programs and interpret their solutions.

**BME 442 – Cell Motility and Molecular Machines**
From single molecule motors transporting materials within cells to contracting muscle fibers, molecular engines come in a range of sizes and produce some of the most fascinating phenomena in biology. This course teaches the modern theories behind molecular engines, presuming only an elementary background in cell biology and mechanics. Prerequisites: permission of instructor. Semester Taught Second 1/2 of the Spring semester – CREDITS 2

**BME/OPT 448 - Principles of Eye Design**
This course explores the design of the human eye, revealing the optical and neural factors that limit color and spatial vision. The design of eyes (such as those of predatory birds and the compound eyes of insects) that evolved to operate in environments different from that of the human eye are examined. The course begins with a treatment of the information losses associated with the eye’s optics, the photoreceptor mosaic, and the ganglion cell array that transmits visual information to the brain. The course ends with a discussion of image processing by the visual cortex of the brain. Cross-listed: OPT 448/CVS492 –Taught alternate Spring semester CREDITS 4

**BME 452 - Medical Imaging-Theory & Implementation**
Physics and implementation of X-ray, ultrasonic, and MR imaging systems. Special attention is given to the Fourier transform relations and reconstruction algorithms of X-ray and ultrasonic-computed tomography, and MRI. Prerequisites: ECE 242 Cross-listed: ECE 452. Semester Taught: Spring - CREDITS 4

**BME 455 - Translational Biomedical Optics**
This course will focus on the macroscopic biomedical optics techniques (e.g., diffuse optical spectroscopy and tomography, photoacoustic tomography) with high potentials for clinical translation. Students will learn the aspects of instrumentation design, analytic and numerical approaches for optical data analysis, and validation of new technologies in the clinical setting.. Semester Taught: Spring (starting 2011) – CREDITS 4

**BME 468 - Industrial Microbiology**
Consideration of microbiological and engineering aspects of industrial fermentations, bioreactors, sterilization and disinfection, sewage treatment, food processing and environmental problems. Lectures on genetic engineering, process energetics, and economics are complemented with laboratory exercises. Cross-listed: CHE468, MBI445 - CREDITS 4

BME 485 – Membrane Mechanics and Cell Adhesion
This course focuses on the fundamental science underlying the mechanical behavior of cell membranes and the formation of adhesive contacts between cells and between cells and substrates. Our approach is to explore mathematical descriptions of the physical properties of biomembrane structures as well as the physics and chemical basis of cell adhesion. Basic aspects of the structure and composition of cell membranes and the classes of adhesion molecules found on cells are reviewed as a basis for the mathematical treatments. The course is typically taught in the first half of the spring semester.

Prerequisites: This course is designed for upper level undergraduates and graduate students. Some background in mechanics and cell biology is desirable. Semester Taught first 1/2 of the semester Spring - CREDITS 2