

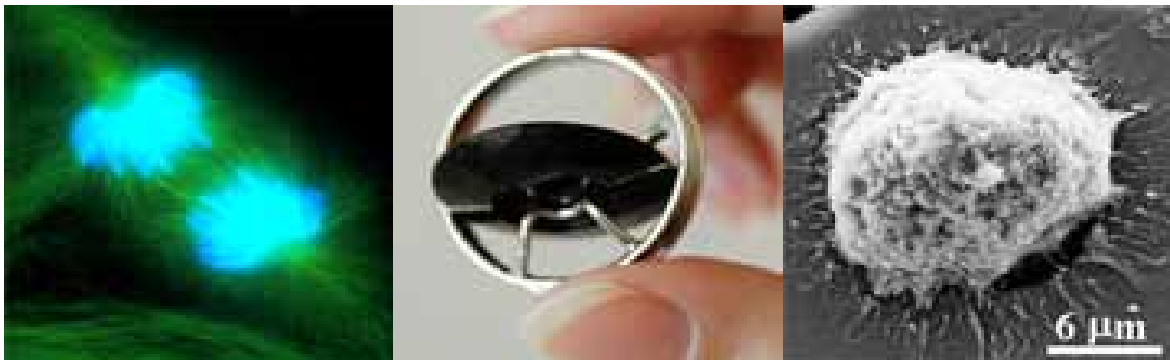
Bioengineering

Undergraduate Handbook

FALL 2009

The Pennsylvania State University
Department of Bioengineering
Undergraduate Programs Office
206 Hallowell Building
University Park, PA 16802
814-863-6614

<http://www.bioe.psu.edu>



Welcome to Bioengineering! At Penn State, Bioengineering is both a Department and an Inter-college Graduate Program, whose mission is to serve as the focal point of engineering activities in the life sciences. Bioengineering, often synonymous with Biomedical Engineering, is usually taken as the application of engineering to the solution of problems in medicine and biology. The strength of our program lies in its strong integration of biology and engineering in the curriculum, thus providing the student with sufficient breadth in both life and physical sciences. In many of our courses, traditional engineering methods are applied to specific problems in medicine and biology. During the course of your studies it is hoped that you will receive a wide breadth of experiences in the field and develop an awareness of future needs and potential applications.



Dr. Herbert H. Lipowsky, Professor
and Head of Bioengineering

In this handbook you will find an overview of the course requirements for the bachelor's degree in Bioengineering at Penn State. In addition, essential information is presented on policies, procedures, options, and opportunities that will enhance your educational experience. Most importantly, it offers a road map of where faculty have been and where the faculty anticipate that you will be going. Toward our goal of fulfilling accreditation requirements we have described a set of Educational Objectives that aim to provide students with a target for their future (page 3). Based upon the experiences of the faculty and the expectations of potential employers, graduate programs in bioengineering, and other professional disciplines, we have attempted to design an academic program that provides each student with the flexibility to explore their dreams as well as develop a solid foundation in engineering fundamentals and their application to the life sciences. During the last three years, 38% of our graduates have gone on to positions in industry, 38% to graduate and professional schools, and 24% to medical or dental schools. It is our hope that we can provide you with sufficient breadth in your academic experience at Penn State to make an informed choice for your career plans.



Mrs. Carol Boring,
Undergraduate Staff Assistant

To assist you in charting your own future, our department maintains a valuable staff of professionals who can advise and guide you in seeking your goals. First, is our undergraduate staff assistant, Carol Boring, who can be found in the Bioengineering office, 206 Hallowell Building and reached at 863-6614 or cxb192@psu.edu. Carol is the keeper of all forms and records needed for petitioning course changes or admission to Bioengineering courses with controlled enrollments. She can also answer all questions and direct you to a faculty adviser who can assist you in academic matters.

The department also benefits from having a faculty member who is devoted mainly to coordinating our undergraduate academic activities, Dr. Maggie Slattery. Dr. Slattery serves as the primary adviser for first and second year engineering students interested in Bioengineering. She also provides academic guidance to juniors and seniors in the Chemical Engineering option. In addition, Dr. Slattery is responsible for signing off all special requests by undergraduates for curricular matters. She can be found in 206 Hallowell Bldg. and reached at 865-8092 or mjs436@psu.edu.



Dr. Maggie Slattery, Bioengineering
Undergraduate Coordinator

If you have any needs or concerns during your studies, please contact me at any time. All of the faculty and staff look forward to working with you throughout your academic career and wish you much success in your studies in Bioengineering.

A handwritten signature in black ink that reads "Herbert H. Lipowsky".

Dr. Herbert H. Lipowsky
Professor and Head of Bioengineering

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BIOENGINEERING PROGRAM EDUCATIONAL OBJECTIVES

Consistent with the mission of Penn State University and the College of Engineering, the Penn State Bachelor of Science program in bioengineering aims to create world-class engineers who will contribute to social and economic development through the application of engineering to the solution of problems in medicine and biology.

Three to five years after graduation graduates will be:

- employed in industry positions which include, but are not limited to, research and development, manufacturing, quality assurance and sales and marketing,
- enrolled in graduate school, continuing education, or other professional development programs related to biomedical sciences and engineering, or,
- enrolled in medical school, dental school, or other health-related professional training programs

PROGRAM OUTCOMES

Upon graduation from the Penn State Bioengineering Undergraduate program, students will have:

- An ability to apply knowledge of advanced mathematics, (including differential equations and statistics), science, and engineering to solve problems at the interface of engineering and biology.
- An ability to design and conduct experiments, as well as to analyze and interpret data from living and non-living systems.
- An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
- An ability to function on multi-disciplinary teams.
- An ability to identify, formulate, and solve engineering problems.
- An understanding of professional and ethical responsibility.
- An ability to communicate effectively.
- The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
- A recognition of the need for, and an ability to engage in, life-long learning.
- A knowledge of contemporary issues.
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
- An understanding of physics, chemistry, and of physiology at molecular, cellular and organ levels.
- An ability to address problems associated with the interaction between living and non-living materials and systems.

OPTION AREAS

There are four option areas in the bioengineering curriculum: Electrical (E E), Chemical (CH E), Mechanical (ME) and Material Science (MATSE). These option areas serve to provide depth in a particular area of interest in combination with the breadth of material in bioengineering. Several of the courses to be scheduled in the 4th semester are option-specific. Generally, changing your option could add time to your academic program.

SENIOR DESIGN PROJECT

The Bioengineering baccalaureate curriculum leads to a culminating senior design experience, BIOE 450W "Bioengineering Senior Design." Students will be working in groups on a project, and each member of the group will be required to contribute actively to the design, conduct background design studies and write up progress and final reports. The courses BIOE 401 Introduction to Bioengineering Research and Design, BIOE 404 Data Analysis and Experimental Design, BIOE 440 Clinical Correlations are associated with this process of choosing a design project, considering design constraints and presenting and defending design results. Examples of completed senior design projects are found at :

<http://www.bioe.psu.edu/students/design.html>

OTHER PENN STATE CAMPUS LOCATIONS

Students in residence at a different Penn State Campus may generally satisfy the course requirements for Bioengineering for the first three semesters. Students should enroll in E MCH 211 and E MCH 213 to substitute for the E MCH 210 requirement. Provided progress has been made toward the Bioengineering requirements, students should request a transfer to the University Park Campus beginning with the Spring semester of their second year. This is required so that they can enroll in BIOE 201 and CMPSC 200, which is only offered at University Park.

SCHOLARSHIP SUPPORT

All applicants to the College of Engineering are automatically considered for financial assistance based upon academic merit and need. Entry into the College is in the Fall semester, but the decision for awarding of scholarships is made in Spring. Additional scholarships may be awarded in the spring semester, and will be awarded based upon academic performance in the fall semester. More information can be obtained at the College of Engineering web site: <http://www.engr.psu.edu/CurrentStudents/finaid.aspx>

BIOMEDICAL ENGINEERING SOCIETY STUDENT CHAPTER

There is an active student chapter of the Biomedical Engineering Society (BMES) at Penn State. Graduate students and undergraduate students pursuing bioengineering degrees or the bioengineering minor are encouraged to participate. Student leaders organize professional and social functions and exchange information about careers and other professional opportunities. Additional information can be found at : <http://www.clubs.psu.edu/up/bmes/>

The Biomedical Engineering Society national web site has a listing of summer work internship opportunities, and provides a great deal of information about job openings, salaries and industry trends: www.bmes.org

SCHEDULING RECOMMENDATIONS

Remember it is essential to complete prerequisites for your courses. If you do not, you may not be permitted to enroll in required classes and your graduation will be delayed.

The following page is a suggested schedule for completing the Bioengineering BS program in four years. Please keep in mind the necessity of completing course prerequisites in time to schedule core Bioengineering courses (BIOE 201, 301, 303, 313, 401, 402, 403, 404). Most Bioengineering courses are taught only once per year, the semester they are scheduled to be taken.

Fall Semester Courses: BIOE 301, 302, 303, 313, 406, 413, 440, and 443

Spring Semester Courses: BIOE 201, 401, 404, 402, 403, 409, 419, 423, 444, and 450W

Since BIOE 201 and BIOE 401 are only available in the Spring semester, students will be allowed to register for PHYS 212 and BIOE 201 concurrently with the permission from the instructor and with the understanding that some material from PHYS 212 is needed in BIOE 201 and it may require the student to read ahead in the physics text. Students will only be allowed to register for BIOE 201 and BIOE 401 concurrently with department or instructor approval.

Core bioengineering courses will generally be offered in either the Fall or the Spring semester, according to the semester recommendations on the following pages. Students are responsible for completing the prerequisites for core requirements in time to stay on-schedule. In particular, bioengineering students should insure that prerequisites are complete at the start of the semester for core 5th semester courses.

Courses in Bioengineering will not be offered during the summer months. However some of the required prerequisites for Bioengineering courses may be available at University Park and other Penn State Campus locations, through Continuing Education and the World Campus program.

Computer Science Requirement: It is recommended that you take CMPSC 200 because its course contents focuses on MatLab, which will be used extensively in future BIOE classes, specifically BIOE 302, 401 & 404. As an alternative, you may take CMPSC 201 C++ Programming.

BIOENGINEERING ELECTIVES

BIOE 406 Medical Imaging (not E E Option)

BIOE 409 Bioengineering Fluid Mechanics (not CH E or ME Options)

BIOE 413 Biotransport Phenomena (not CH E Option)

BIOE 419 Artificial Organs

BIOE 443 Biomedical Materials (not MATSE Option)

BIOE 444IL Biomedical Surface Interactions (not MATSE Option)

BIOE 494H Thesis (up to 3 credits of a completed honors thesis)

BIOE 496*(by petition) Independent Study (A maximum of three credits and not in conjunction with 494H)

BIOE 497G Tissue Engineering

Other Bioengineering 4XX or Bioengineering 5XX courses will be considered by student petition.

At least three credits of the six credit bioengineering elective requirements must be filled by a lecture type engineering science course carrying bioengineering credit.

To enroll in 500 level courses, students must complete a "Request for Undergraduate Student to Take 500- or 800-Level Courses" form. For students in the Schreyer Honors College and for seniors (students who have completed 92 credits or more) with a 3.50 or higher cumulative grade-point average permission of the course instructor is required. Other students, in addition to the instructor's permission, must obtain the signature of an academic adviser and Graduate Enrollment Services. If you are interested in taking a 500 level course, speak with the Undergraduate Assistant, as she will be able to assist you with the required paperwork.

E E OPTION ELECTIVES

(6 credits required)

E E 3XX

E E 4XX

CHEM 210 Organic Chemistry I

CHEM 212 Organic Chemistry II

CHEM 213 Lab in Organic Chemistry

ME OPTION ELECTIVES

(6 credits required)

Themes: (F) Fluids; (S) Solids; (K) Kinematics

M E 360 Mechanical Design (K)

M E 370 Dynamics of Mechanical Systems (K)

M E 400 Thermodynamics II (F)

M E 410 Heat Transfer (F)

M E 421 Viscous Flow (F)

M E 420 Compressible Flow (F)

M E 450 Modeling of Dynamic Systems (K)

E MCH 402 Applied and Experimental Stress Analysis (S)

E MCH 403 Strength Design in Materials & Structures (S)

E MCH 408 Elasticity and Engineering Applications (S)

E MCH 416H Failure and Failure Analysis of Solids (S)

E MCH 446 Mechanics of Viscoelastic Materials (F/S)

E MCH 461/M E 461 Applied Finite Element Analysis (F/S)

BIOE 413 Biotransport Phenomena (F)

BIOE 419 Artificial Organs (F/S)

BIOE 443 Biomedical Materials (F/S)

BIOE 444 IL Biomedical Surfaces (F/S)

CHEM 210 Organic Chemistry I

CHEM 212 Organic Chemistry II

KINES 384 Biomechanics (K)

KINES 488 Mechanics of Locomotion (K)

CH E OPTION ELECTIVES

(8 credits required)

At least 3 credits must be in the College of Engineering

College of Engineering Courses

BIOE 419 Artificial Organs (F/S)

BIOE 443 Biomedical Materials (F/S)

BIOE 444 IL Biomedical Surfaces (F/S)

BIOE 4XX and 5XX by petition

CH E 340 Introduction to Biomolecular Engineering

CH E 438 Bioprocess Engineering

BE 468 Microbiological Engineering

E SC 483 Simulation and Design of Nanostructures

E SC 484 Biologically Inspired Nanomaterials

Courses not in the College of Engineering

BMB 401 General Biochemistry I

BMB 402 General Biochemistry II

BMB 437 Physiological Biochemistry

CHEM 203 Fund. of Organic Chem II (only if 202 was taken)

CHEM 212 Organic Chemistry II

CHEM 213 Lab in Organic Chemistry

NOTE: CHEM 210, 212, 213 is the proper Chemistry sequence for students considering health professions.

SCIENCE OR ENGINEERING ELECTIVES

Any course in the College of Engineering at the 300 or 400 level, any course in BIOL, BMB, PHYS, MATH or a military science course from a **completed** ROTC program. Appropriate courses offered by other colleges may be considered by petition. Any course in the College of Engineering at the 300 or 400 level The Science and Engineering Elective course must be above the required content level (e.g. PHYS 250 & MATH courses below 140 can not apply to the course requirements).

CURRICULUM PREREQUISITES

A course must not be taken before the prerequisite courses have been passed. A prerequisite course provides knowledge upon which the subsequent course depends. Under unusual circumstances (transferring degree programs, universities, etc), in which other courses may possibly substitute for a prerequisite, the student must obtain the permission of the course instructor to waive or substitute prerequisites.

Prerequisites for Bioengineering Courses

BIOE 201: Prereq: BIOL 141, CHEM 112, MATH 141. Prereq or Concurrent: PHYS 212

BIOE 301: Prereq: BIOL 141, PHYS 212, MATH 250 or 251. Concurrent: BIOE 302

BIOE 302: Prereq: CMPSC 200 or 201 Concurrent: BIOE 301

BIOE 303: Prereq: BIOL 141, E MCH 210, MATH 230, MATH 251

BIOE 313: Prereq: BIOL 141, CHEM 112, MATH 251, MATH 230

BIOE 401: Prereq: BIOE 201, BIOE 303. Concurrent: BIOE 404

BIOE 402: Prereq: MATH 250 or 251; BIOE 301 or E E 210 or E E 212 or PHYS 402

BIOE 403: Prereq or Concurrent: BIOE 402

BIOE 404: Prereq: BIOE 302. Concurrent: BIOE 401

BIOE 406: Prereq: PHYS 212

BIOE 409: Prereq: MATH 230, MATH 251, BIOE 303

BIOE 413: Prereq: BIOE 303, BIOE 313, or CHEM 450

BIOE 419: Prereq: MATH 250 or 251, Prereq/Concurrent: BIOL 141 or BIOL 472

BIOE 423 Prereq: BIOL 141, BIOE 313 or CH E 210, Prereq/Concur: BIOE 413 or CH E 302 & 413

BIOE 440: Prereq: BIOE 402

BIOE 443: Prereq: MATSE 201 (For BIOE students, the prerequisite can be satisfied by E MCH 210 & BIOE 313)

BIOE 444: Prereq: CHEM 111, CHEM 113

BIOE 450W: Prereq: ENGL 202C, BIOE 440, BIOE 403

BIOE 497G: Prereq: none

GENERAL EDUCATION

Arts, Humanities and Social Sciences Electives

There are 15 credits of Arts, Humanities and Social Sciences courses to complete in addition to 3 credits of Social Sciences specified as Economics (002, 004 or 014). Keep in mind that at least 6 credits, 3 each of US and IL, Culture (intercultural/international) designated courses are required. Refer to the Engineering: Undergraduate Programs Guide you were given at the time you entered Penn State as a resource of information for General Education requirements. The requirements for your class are specific to your Entry-To-Major pool.

The Accreditation Board for Engineering and Technology (ABET) requires the curricula to include courses in mathematics, science, communication skills, humanities, social sciences, analysis and design. ABET's criteria is intended to broaden the student's liberal education through the development of understanding in depth.

General Education courses in the Arts are denoted by the "GA" after the course number. Humanities general education courses are divided into literature, history and culture, language and philosophy and will have a "GH" after the course number. General Education courses in the Social and Behavioral Sciences are denoted by "GS" after the course number.

The Arts/Humanities/Social Science requirements for students in the College of Engineering are identical to those for the rest of the university. Students may select courses from a broad list to fulfill these requirements. Refer to the following web site for additional General Education Requirements:

http://bulletins.psu.edu/bulletins/bluebook/general_education.cfm

Note: Three credits of a foreign language taken at the 12th credit level (level III at Penn State, e.g. SPAN 003), or higher, may be used as a course in any of the Arts, Humanities, or Social Science categories, but the foreign language course cannot be the only course in that category. The student must submit a petition and indicate the category in which the language is to be used.

Additional Requirements

All students must take three credits each of US Culture denoted by (US) and International Culture (IL). These courses can also be found at the above web site. Students may use a study abroad or work abroad program to fulfill the IL requirement. Generally, it is best to use your GA, GH or GS courses to fulfill US/IL requirements.

All students must take three credits in Health & Physical Activity. These courses are labeled GHA and may be found using the Advanced Search feature on the Schedule of Courses.

All Bioengineering students must take a three-credit economics course. Students may select from ECON 002, 004 or 014 and it will count towards your Social and Behavioral Science General Education requirement.

GENERAL EDUCATION PLANS

Plan I (6-6-6)

Two courses in the Arts

Two courses in the Humanities

Two courses in the Social and Behavioral Sciences

Plan II (9-6-3)

Three courses in one category

Two courses in the second category

One course in the third category

Students wishing to pursue a 9-6-3 sequence must notify the department of their intention. So that we have record of your plan and to ensure your audit is updated submit a petition form to the Undergraduate Assistant. The form does not require an adviser's signature, however, a copy will be kept in your student file. Forms can be obtained from the Undergraduate Assistant in Room 206 Hallowell or on the web at:

<http://www.engr.psu.edu/Forms/GeneralPetition.pdf>

PETITIONS

Students wishing a waiver, an exception, or a substitution for any requirement must submit a College Petition describing their request and justification. After completing the form, please submit to your adviser for signature; then drop off the form to Room 206 to the Undergraduate Assistant for the Undergraduate Coordinator's signature. The petition will be forwarded to the Assistant Dean of Student Services for approval if it affects the general education requirements. Any petitions affecting only Bioengineering requirements will be approved by the Undergraduate Coordinator. Once approved, the exceptions will be added to your audit.

Schreyer College Honor students submitting petitions need only their adviser's signature and then drop off the petition form to the Undergraduate Assistant in Room 206 Hallowell.

Forms can be obtained from the Undergraduate Assistant in Room 206 Hallowell or on the web at:

<http://www.engr.psu.edu/Forms/GeneralPetition.pdf>

EDSGN 100 SUBSTITUTION

Students who have not satisfied the EDSGN 100 requirement by their 5th semester must take either M E 461 or E MCH 461 as the replacement course. EDSGN 100 is a entry level first year level course and it is inappropriate for upper level students to take the course.

FIRST-YEAR SEMINAR SUBSTITUTION

Students who began at Penn State prior to Summer 2009 and students who began at University Park after Summer 2009: If you have not completed your First-Year Seminar requirement prior to your 5th semester you must take a 3 credit course to substitute for the FYS. Suggested courses are S T S (Science, Technology and Society) classes. Other courses will be considered on an individual basis and all substitutions will require a petition.

Students who began at Commonwealth campuses after Summer 2009: If you completed the First-Year experience required by your initial campus location, 1 extra credit from any non-remedial course, not otherwise needed for graduation, may be used to meet the required credit total.

Students who were admitted as transfer students with ADVST standing are not required to take FYS and may substitute one extra credit from any non-remedial course, not otherwise needed for graduation, may be used to meet the required credit total.

REMEDIAL COURSES

The following courses cannot be used to satisfy any graduation requirement in Bioengineering. However, these courses may be important courses to correct an initial deficiency and may be required to complete degree requirements. If these courses are taken they will appear on your transcript and the associated grade will be calculated in the cumulative grade point average.

MATH 001-007, 021, 022, 026, 030, 036, 040, 041, 100, 198

CHEM 101, 108

PHYS 100, 150, 151, 191, 215, 250, 251, 265

PH SC 007, 008

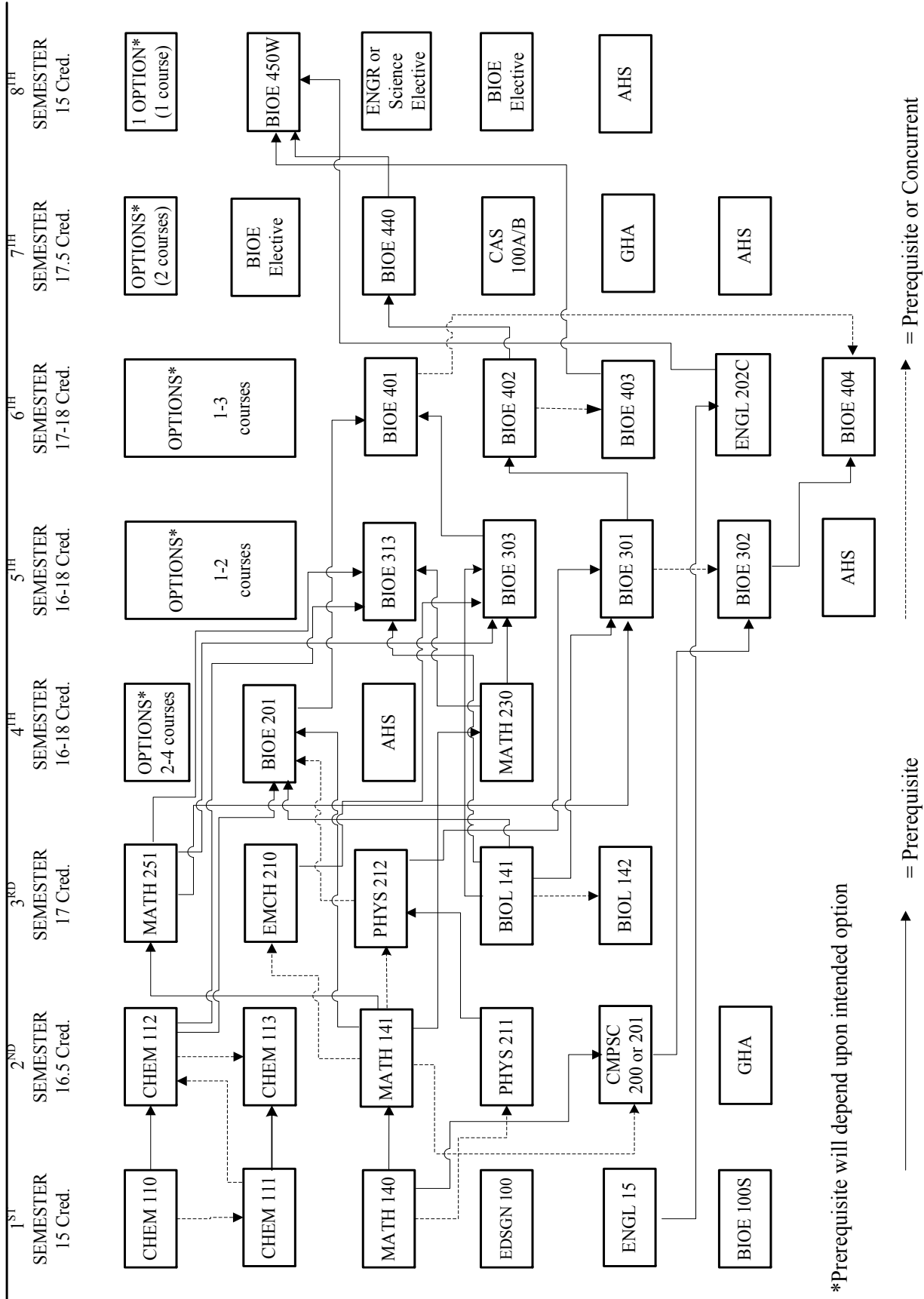
ENGL 004, 005

LL ED 005, 010

ESL 004

CAS 126

BIOENGINEERING ALL OPTIONS



*Prerequisite will depend upon intended option

→ = Prerequisite

→ = Prerequisite or Concurrent

**Students will be allowed to register for Phys 212 and BIOE 201 concurrently, with the understanding that some material from Phys 212 is needed in BIOE 201, and that this may require reading ahead in the Physics text. Students will be allowed to register for BIOE 201 and BIOE 401 concurrently with department or instructor approval only.

Scheduling Recommendations by Semester

Semester 1	Semester 2	Semester 3	Semester 4	Semester 5	Semester 6	Semester 7	Semester 8																																																																																																																																																																																																																																																																										
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*Total credits required to graduate 132-133 depending on option selection.

•List of acceptable courses for each elective category can be found on department website or by contacting the department.

•C or better required in each course marked with a *.

BIOENGINEERING HONORS THESIS

To graduate with Honors in bioengineering, a student must either major or minor in bioengineering. Special exceptions to this must be approved by the honors adviser and the department chair. A student can do a project in a bioengineering lab and receive honors in a different department; in that case, the rules for that department must be followed.

The policies described here also apply to non-honors students who wish to carry out thesis research and write a thesis.

Thesis Course Scheduling Students can receive up to 6 honors credits for thesis research/writing. The usual mechanism for this will be 3 credits of BIOE 494H in Fall semester leading to development of a written thesis draft. In Spring semester, 3 credits of BIOE 494H culminate in writing, review, and defense of the thesis.

Thesis Credit in the BS Curriculum Three credits of research (BIOE 496 or BIOE 494H) will satisfy either the Science and Engineering Elective or Bioengineering Elective. Only three credits of a course work used toward degree requirements can be research based credits (496 or 494H).

Time line for Thesis Work Students should prepare for their thesis work by finding a thesis adviser in the Junior year or earlier, in consultation with the honor's adviser. By the end of their Junior year, honors students submit a 1-2 page thesis proposal to the Schreyer Honors College. At this time, each student planning to undertake a thesis should identify a project topic, and thesis committee. The committee will consist of three faculty members: the project supervisor (generally, but not necessarily Bioengineering faculty), the Bioengineering Honors Adviser, and another faculty member in any department who has expertise in this area. At least two members of the committee must be Bioengineering faculty.

Requirements for the Thesis Proposal One semester before finishing the written report, students must write and submit a thesis draft. The purpose of this exercise is to consolidate progress-to-date and clearly propose the research/design work for the final semester. This writing will focus on the background, rationale for undertaking the project, analysis of alternative approaches, and laying out the work plan.

Requirements for Thesis Completion The preferred report format is that of the Masters thesis for which guidelines are available from the Graduate School (<http://forms.gradsch.psu.edu/thesis/thesisguide.pdf>). The report must be given to committee members at least three weeks before the proposal is due to SHC (which is generally in the last week of classes). At the oral exam (roughly one week before the end of classes), committee members will give the student back a corrected version of the report, including grammar and content edits, which the student will incorporate into the final version. The final corrected report is due to SHC before the last day of the semester. The student must also give committee members and the Bioengineering Department each a final version for their files.

If the thesis work has been submitted to a journal or published, this version can be submitted as the honors project. However, if the journal article has multiple authors, the student must clearly state what portion of the project he/she performed and what the relationship was with the collaborators on the project. The student must have participated in the writing of the journal article in order to receive thesis credit.

Students must do an oral presentation/defense of their thesis at least one week before turning in their thesis (at least one week before the end of the semester). The format is a 20 minute Power Point presentation followed by questions from the committee. The presentation is open to the public, but the questioning session by the committee is limited to the student and committee. At this time, the committee will give the student comments on the written portion of the thesis which are to be incorporated into the final draft.

Policy on Developing Internship and Co-op Research into Bioengineering Honors Theses

Senior Honors Theses in Bioengineering are generally carried out in laboratories on campus. It is possible to develop research performed on summer internships or co-ops into a senior honor thesis, but it requires preparation before the internship or co-op and development of the thesis by the student in their senior year.

The Honors Thesis involves an open-ended project that the student develops in collaboration with his or her adviser and which the student carries out and writes. The first requirement in developing an internship or co-op into a thesis is to make sure the work is not proprietary and the company or lab where you conduct the work is comfortable with a student developing the work into a thesis that will be a public document. The second requirement requires the students to carry out independent research in an open ended way as opposed to just carrying out assigned tasks. The student is responsible for taking charge of their project; carrying out defined work tasks and writing it up is not sufficient. The third requirement requires the student to develop their thesis in their senior year under the supervision of an adviser in Bioengineering or another department at Penn State. The adviser will help the student develop their work into a coherent thesis and help guide the development of the project.

Although these requirements may sound restrictive, there are a number of ways they can work. For example, if the project involves a significant amount of modeling or computational work that the student can continue to develop during their senior year, it is fairly straightforward to expand the internship or co-op work into a thesis. Second, a significant amount of work can be achieved by collecting a large amount of data that needs analyzed and then the analysis interpreted. All this work could be done during the students' senior year.

Students interested in trying to incorporate their co-op or internship experience into their honors thesis are encouraged to plan ahead. Contact your boss/adviser and confirm that the work is not proprietary or restricted. For further questions or advice, please contact your honors adviser, Dr. Hancock or Dr. Butler.

FACULTY AREAS OF EXPERTISE

The Penn State Bioengineering faculty consists of a group of core professors with their primary academic appointment, their labs and their teaching assignments in Bioengineering, and a much larger group of associated faculty in several engineering departments, as well as in the Colleges of Medicine, Health and Human Development, and the Eberly College of Science. Details of research programs can be found at www.bioe.psu.edu. A brief summary of faculty research interests for those faculty with primary academic appointment in Bioengineering Department:

Herbert Lipowsky, Ph.D., professor and department head. Studies the role of the intrinsic mechanical properties of the blood, which affect the aggregability and deformability of red and white blood cells, and their interaction with the micro vascular endothelium.

Peter Butler, Ph.D., associate professor of bioengineering. Studies the effects of mechanical forces (e.g. fluid shear stress) on the mechanics and dynamics of molecules in living cells and tissues involved in mechanotransduction.

Cheng Dong, Ph.D., professor of bioengineering. Studies the biomechanical, biophysical and biochemical aspects of cellular function in the circulatory system.

George Engelmayr, Ph.D., assistant professor of bioengineering. Studies the development of functional engineered tissues for basic science and regenerative medicine applications.

William Hancock, Ph.D., associate professor of bioengineering. Seeks to better understand the role of kinesin (molecular motor) in normal and diseased states, to define targets for future therapeutics, and to establish building blocks for future nano-scale diagnostic or therapeutic devices.

Keefe Manning, Ph.D., assistant professor of bioengineering. Studies hemodynamics, pediatric heart defects, blood rheology, and development of cardiovascular prosthetics (including cardiac assist devices and mechanical heart valves).

Margaret Slattery, Ph.D., assistant professor of bioengineering. Studies the thrombogenicity of cardiovascular prosthetics and blood rheology

Nadine Smith, Ph.D., associate professor of bioengineering. Studies the therapeutic applications of ultrasound and its combination with diagnostic magnetic resonance imaging (MRI)

Andrew Webb, Ph.D., professor of bioengineering. Studies of functional magnetic resonance imaging and MRI spectroscopy.

Siyang Zheng, Ph.D., assistant professor of bioengineering. Developing and applying micro/nano technologies for biological and medical applications.

BIOENGINEERING OPTION ADVISERS

Students will be required to select an Option at the time they enter Bioengineering. At that time they will be assigned an adviser who is familiar with the requirements of the Option they have chosen and should plan on meeting with their adviser at regular intervals. The department schedules advising week once per semester. Advising week is a time during which advisers make additional time in their schedule to meet with students. E-mail will be sent notifying you of the dates of advising week each semester and how to make an appointment with your adviser. Take advantage of this opportunity to check in with your adviser. You can discuss your course selections, career goals, summer internship and research opportunities. Of course, if issues or problems arise you may schedule an appointment with your adviser at anytime.

CHEMICAL ENGINEERING OPTION AND BIOENGINEERING MINOR

Dr. Maggie Slattery
Room 206 Hallowell
865-8092
mjs436@psu.edu

MECHANICAL ENGINEERING OPTION

Dr. Keefe Manning
Room 219 Hallowell
863-6318
kbm10@psu.edu

MATERIAL SCIENCE OPTION

Dr. Erwin Vogler
103 Steidle Building
863-7403
eav3@psu.edu

ELECTRICAL ENGINEERING OPTION

Dr. Siyang Zheng
Room 224 Hallowell
865-8090
siyang@psu.edu

SCHREYER SCHOLARS

(*ETM Years 2007, 2008, 2011, 2012)

Dr. Will Hancock
Room 218 Hallowell
863-0492
wohbio@enr.psu.edu

(*ETM Years 2009, 2010)

Dr. Peter Butler
Room 228 Hallowell
865-8086
pjbbio@enr.psu.edu

Schreyer scholar are also welcome to contact Option specific advisers for additional advising if they would prefer. All Schreyer scholars' petitions will need to be signed by Dr. Hancock or Dr. Butler.

*Entrance to Major

For office hours, check the professors' door. If hours are not posted or they conflict with your schedule, email them to set up an appointment.

COOPERATIVE EDUCATION AND INTERNSHIP PROGRAMS

Participating in the College of Engineering's Cooperative Education program is a great way to get industry experience and to help determine what career path and goals you will have after graduation. Usually 3 work periods complete a co-op and the work periods may alternate during semesters and/or summers. The 7th semester is a good semester to be away from campus making scheduling easier. For some students who are sufficiently ahead, the 4th semester may also be a good semester to consider a co-op experience. You should consult your adviser with regard to co-op and academic scheduling to accommodate your time off campus. Completion of a report for each work assignment is required. You may earn ENGR 295, 395, and 495 credit with each sequential semester of work. The three credits together maybe used to fulfill the Science and Engineering Elective requirement. Also, completion of the co-op will allow you to submit a portfolio for credit toward ENGL 202C. Continuing participation in the program is contingent upon satisfactory academic and work performance.

Summer internships may be either industrial or research experiences and are also a great way to gain experience in the field of Bioengineering. Announcements of openings will be posted on bulletin boards or via e-mail. Also some positions are posted through the College of Engineering Co-op office. You are encouraged to register for their online resume and job posting tool. ENGR 195 credit maybe earned for summer internship experiences.

To obtain additional information on the Co-op and internship programs, you are encouraged to attend one of the workshops presented by the Co-op office. The Co-op Office is located in 205 Hammond Building. (<http://www.engr.psu.edu/coop/>)

UNDERGRADUATE RESEARCH EXPERIENCE

Undergraduate research can be a very fulfilling and exciting part of bioengineering. It does require significant time and dedication to have a successful experience. Undergraduate students can participate in bioengineering research in laboratories in the department or across campus. See the research page on the Bioengineering web site for areas of specialization in the department. This research can range from instrumentation development to computational modeling to hands-on biological experiments. Research can be carried out during the academic year or during the summer as part of various Research Experiences for Undergraduates (REU) programs. Here at Penn State we offer the BBSI program. Other summer research opportunities can be found online. Specific announcements are made through E-news or department e-mail.

To become involved in research, contact a professor in a research area that interests you and set up an appointment to meet and talk about their research. Some specific research positions are posted <http://www.undergradresearch.psu.edu/> and <http://www.bioe.psu.edu/students/UGLabWork.html>. You may want to consider research in other engineering departments and Penn State Colleges (e.g. Science & BBH), in addition to Bioengineering depending on personal interest. To carry out research during the semester, you should try to set up blocks of time when you don't have classes and are available to work.

Undergraduate research is an important component of the Schreyer's Honors program, where this research leads to a thesis. However, any student in bioengineering can write a senior thesis and receive course credits for this work. Students who carry out undergraduate research are encouraged to focus their work towards a Bioengineering Senior Thesis.

For all students, while any number of research credits (BIOE 494H or 496) may be taken, only 3 may be used toward the Bioengineering degree requirements.

CONCURRENT MAJORS

At the baccalaureate level, students may be approved for admission to more than one major under the Sequential or Concurrent Majors Program. A Concurrent Majors Program is one in which students take courses to concurrently meet the requirements of at least two majors, with graduation for all majors in the program occurring during the same semester. Concurrent majors must be all at the baccalaureate degree level. Any student requesting more than one major program shall, for each major, meet the same acceptance standards and graduation requirements as met by all other students. Please see the following web site for additional information: <http://www.psu.edu/ufs/policies/60-00.html>.

Because Bioengineering is an enrollment controlled major it is required that students first gain admission to Bioengineering then add the concurrent major. Generally, the concurrent major may not be another enrollment controlled major. One specific exception is described below.

A special arrangement has been made with the Mechanical Engineering Program to accommodate those Bioengineering students interested in a concurrent major with Mechanical Engineering. This is a special arrangement because both majors are enrollment controlled. Students must be first admitted to Bioengineering through Entrance to Major, and then they may apply to add Mechanical Engineering as a concurrent major. A sample course plan which accommodates the requirements for both majors in nine semesters and an application are available as PDFs on the Bioengineering web site or at 206 Hallowell. Students considering this special program may also want to contact the Mechanical Engineering Undergraduate Programs Office in room 139 Reber Bldg.

MINORS

A student may elect to take a minor in addition to a major at Penn State. A complete list may be found in the Baccalaureate Degree Programs Bulletin (<http://bulletins.psu.edu/bulletins/bluebook/minors.cfm>). Students must apply for a minor in the department in which the minor is offered. Students must satisfy all entrance requirements and prerequisites to the required courses. Many times with creative course selection and scheduling a minor can be completed with 9- 12 extra credits.

Some specific minors that have been popular with previous Bioengineering undergraduate students include:

Chemistry - <http://bulletins.psu.edu/bulletins/bluebook/minors.cfm?letter=C&program=chemmi.htm>

Economics - <http://bulletins.psu.edu/bulletins/bluebook/minors.cfm?letter=E&program=econmin.htm>

Engineering Entrepreneurship (E-SHIP) - <http://www.e-ship.psu.edu/>

Engineering Leadership Development (E L D) - <http://www.eldm.psu.edu/>

Engineering Mechanics (E MCH) - <http://www.esm.psu.edu/programs/undergraduate/emch/>

Math - <http://www.math.psu.edu/ug/minor>

Nanotechnology - <http://www.esm.psu.edu/programs/undergraduate/nano/>

Six Sigma - <http://www.ie.psu.edu/Academics/Undergraduate/Minors/SixSigma.html>

ROTC

Students in the ROTC programs may apply their Military Science coursework credits to satisfy course requirements in the major. Upon **completion** of a ROTC program, a student may petition for 6 credits of Military Science to be used toward the Science and Engineering Elective and 3 credits of General Health and Activity (GHA) general education requirements in the Bioengineering major.

MEDICAL SCHOOL AND OTHER HEALTH PROFESSIONS PREPARATION

Approximately 25-30% of Bioengineering graduates pursue a health professions degree. The Health Professions Advising Office (213 Whitmore) is an additional resource for information about the application process. They have guidebooks with medical and dental school requirements specific to each program.

Most medical schools require, in addition to a course of general studies, one full year each of physics, inorganic chemistry, organic chemistry, and biology, each with appropriate labs. Be aware though that each school has a specific set of requirements and you should do some research to determine that you are working toward completing those. For example several schools are now requiring a biochemistry course. Also, increasingly some schools are not accepting credit from AP tests.

You need to consider three things during your undergraduate career to prepare for medical school:

- You need to complete the course requirements that medical schools expect to see on your transcript. There are general guidelines, but there is variation between schools. Also, you need to do this while keeping your GPA as high as possible.
- You need to prepare yourself for taking the MCAT – through both course work and individual study.
- You need to develop your resume to demonstrate significant clinical experience and make yourself stand apart from the thousands of other applications.

Coursework

The basic course requirements for medical school are 1 year (8 credits) each of: biology, chemistry, organic chemistry, and physics. You should plan to take the MCAT at the end (April) of your Junior year, so you need to have all the course requirements completed by that time. The courses you need to take, in addition to the Bioengineering core requirements, are as follows:

BIOL 110 – this is a basic biology course that needs to be taken in addition to BIOL 141/142 (physiology) and BIOE 201 (cell and molecular biology). It is offered in Fall semester for 1st and 2nd year students and in the Spring semester for upper level students. It is also offered in the first 6 week Summer session. You should try to take it before (or concurrently) with BIOL 141/142 and BIOE 201. You can use BIOL 110 as a Science & Engineering elective.

PHYS 213/214 – BIOE 313 satisfies the PHYS 213 (thermodynamics) requirement. PHYS 214 (2 credits of waves) may be a useful course to take if you do not want to learn any material on your own.

Organic Chemistry – You will need to take CHEM 210, CHEM 212 and CHEM 213. These courses can be completely fulfilled in the CH E Option, partially fulfilled in the Material Science Option and 3-6 credits can be used to fulfill requirements in the other options.

Biochemistry – Some schools are now requiring biochemistry, this varies by school, but it is something you should research before applying to schools.

General Education elective courses – Many schools either require or prefer you to have completed general Sociology and Psychology courses. These can be taken as your General Education courses. A very brief selection of relevant electives that maybe used as General Electives follow:

PHIL 132/RL ST 131 (GH) **Introduction to Bioethics** (3)

SOC 119 (GS;US) **Race and Ethnic Relations** (4)

S T S 124/HIST 124 (GH;US;IL) **History of Western Medicine** (3)

NUTR 251 (GHA) **Introductory Principles of Nutrition** (3)

MCATs

You should plan to take MCATs at the end of your Junior year. About 60% of Penn State students take prep courses (Kaplan or Princeton Review), it is your decision. You can do well without taking these courses, although some people like the structure of the courses.

Working in the Health Care System

To apply to medical school, you need experience working in the health care profession and demonstrate that you like to work with sick people and understand the rigors of clinical medicine. There are a number of ways to get this experience, including volunteering at a hospital, rehab center or nursing home, completing EMT training (available as a PSU class), shadowing a doctor at a hospital or clinic, etc. This is a critical experience necessary for medical school application.

Laboratory Research

Having experience in a research laboratory on campus or elsewhere strengthens your application package and provides depth for your Bioengineering coursework. If possible, try to work in a lab (for credit, for pay, or simply volunteering) to gain experience and learn how research is performed.

Extracurricular Activities and Minors

To be a strong applicant to medical school, it is good to have at least one extracurricular activity that you have done well. This can be a hobby, a volunteering experience (i.e. THON), being an officer in a club/organization, or many other options. Stress depth and leadership in an activity rather than spreading yourself thin across many small activities or clubs.

Having a second minor in engineering or science, while not bad, is not that important to medical school admissions boards. However, a second minor away from your major (i.e. in a Liberal Arts or Humanities) shows you are a well rounded student.

Final Notes

To prepare yourself for medical school, you need to organize your coursework and try to have a college experience that provides a well rounded education and training for working in health care. Don't try to do everything, do a few things well. Also, if you want to go abroad, add a minor, do a co-op, or engage in another experience that adds richness to your college experience but takes time, consider staying for an extra semester or year if your financial situation permits. There are some experiences that you can only get in college, and medical schools tend to look favorably on more mature students that have taken the time to pursue deep experiences during their college years.

Again, for more details on the specifics of the MCAT, medical school applications, consult the Premed web page <http://www.science.psu.edu/premed/>, AMCAS Yearly Admissions Guide or visit the Premed Office.

Health Professions Advising Office
213 Whitmore Lab
814-865-7620

COMPUTER LABORATORY

Department of Bioengineering
112 Hallowell Building
(Version 1.6, 05 January 2006, NBS)

1. No food whatsoever is allowed in the computer laboratory. If you are found eating or drinking in the computer lab, your privileges will be revoked.

2. Door: Students can access the laboratory using their student ID. Swipe it like a credit card in an ATM machine.

3. Accounts on the BIOENG-LABS domain (NOT the PSU_ENGINEERING domain or the local computer account: SIMULATIONXX)

Graduate and undergraduate students are given an account throughout the period they are enrolled in department. Non-bioengineering students are only given an account for the semester they are enrolled in a bioengineering class.

Login: For each student, your login is the same as your CAC user_id (i.e. abc123).

Password: To initially login, your password is

BioE(Last 4 digits of your PSU-ID_number)(3-CAC initials all in uppercase)

So for example, a password would be:

BioE8888ABC (very, very case sensitive).

After you initially login, the system will request that you change your password. Your password must be at least 8 characters, a combination of upper and lower case letters and have a number. If you have any trouble with the keycard door, your account or printing, see Mr. Wade Reeser (information below).

4. Mapped Drives

Each student has two drives mapped to the \\ENGRBIOELAB domain.

A) A personal drive as: user_id \$ on 'engrbioelab' (M:)

B) A shared drive as: BIOCOMM on 'engrbioelab' (N:)

If your personal share does not appear, click on

My Computer, then

Tools / Map Network Drive

Under Drive, select M:

At folder, type: \\ENGRBIOELAB\user_id and a dollar sign \$.

(i.e. \\ENGRBIOELAB\userid\$)

Click FINISH

Only you have access to your personal drive but everyone has access to the BIOCOMM drive. Save your data to your personal drive (M:) and not on the computer itself. Symantec Ghost is used on a weekly basis to erase all unauthorized programs or data saved on the individual computers named Simulation1, 2.....23 in 112 Hallowell. The server is also backed-up on a weekly basis to tape storage for recovery.

If you want to exchange data with other students in your class, save it to N: BIOCOMM. However note that N:BIOCOMM is on ENGRBIOELAB erased on a weekly basis.

5. Software Installed on Simulation2-23

Do not install software or programs on the computers without department approval. If you need special software please contact Mr. Wade Reeser (whr1@psu.edu). Currently installed on all of the computers:

MS Office (Word, Excel, Power Point ect.)

Adobe Reader 6.0

Matlab® 7.0

FEMLAB® or COMSOL®

EndNotes®

6. Printing

Default printing accounts have been set up for each students to print 100 sheets. If your printing account runs out of funds please see Mr. Wade Reeser (whr1@psu.edu) to add additional funds. The printer name should be set to \\ENGRBIOELAB\BIOE4100.

7. Logging Off

When you are finished log off, do not shut down the computer.

8. Hours

The computer lab is open for use 24 hours per day but only graduate research students have keys to the building which is locked at 6 pm daily. Scheduled classes which use the computers have priority for 112 Hallowell. Check the door for class times which have priority.

9. Help

If you have any problems, please see:

Mr. Wade Reeser

Room 111 Hallowell

whr1@psu.edu

865-6730

Hours: 8am-5pm

If Mr. Reeser cannot be found during the listed time, please go to the Bioengineering office (205 Hallowell) and ask that he be contacted.

UNIVERSITY POLICY STATEMENT ON COMPUTER AND SOFTWARE MISUSE

a) Access to and use of computer facilities, electronically stored data, and software shall comply with Federal laws, the laws of the Commonwealth of Pennsylvania, and the rules and regulations of the University including those rules and regulations set forth in Administrative Policies AD-20 and AD-23 and Administrative Guidelines ADG-1 and ADG-2. Misuse of computers, computer facilities, and software may violate federal or state criminal laws and may result in criminal charges against the user. Members of the University community may be subject to University sanctions, including disciplinary charges.

b) It is a violation of University regulations to:

(1) Intentionally and without authorization, access, alter, interfere with the operation of, damage or destroy all or part of any computer, computer system, computer network, computer software, computer program, or computer database.

(2) Intentionally or knowingly and without authorization, give or publish a password, identifying code, personal identification number or other confidential information about a computer, computer system, computer network or database.

c) University regulations apply to all University computers and computer equipment, computerized data and all data owned or held through agreement by the University. These regulations may also apply to computer equipment and data belonging to or held by agreement by members of the University community or others when violations are deemed to have a substantial adverse effect upon the University community or upon individual members of the University community.

d) It is important that members of the University community be aware of the intellectual rights involved in the unauthorized use and copying of computer software.

e) Respect for intellectual labor and creativity is vital to academic discourse and enterprise. This principle applies to the work of all authors and publishers in all media. It encompasses respect for the right to acknowledgment, right to privacy, and the right to determine the form, manner, and terms of publication and distribution.

f) Because electronic information is volatile and easily reproduced, respect for the work and personal expression of others is especially critical in computer environments. Violations of authorial integrity, including plagiarism, invasion of privacy, unauthorized access, and trade secret and copyright violation, may be grounds for sanctions against members of the academic community.

** University Policy Manual, AD-20, AD-23, ADG-1, and ADG-2*

UNIVERSITY STATEMENT ON INTOLERANCE

Purpose:

The University is committed to creating an educational environment which is free from intolerance directed toward individuals or groups and strives to create and maintain an environment that fosters respect for others. As an educational institution, the University has a mandate to address problems of a society deeply ingrained with bias and prejudice. Toward that end, the University provides educational programs and activities to create an environment in which diversity and understanding of other cultures are valued. Acts of intolerance violate the principles upon which American society is built and serve to destroy the fabric of the society we share. Such actions not only do untold and unjust harm to the dignity, safety and well-being of those who experience this pernicious kind of discrimination but also threaten the reputation of the University and impede the realization of the University's educational mission.

Definition:

An act of intolerance refers to conduct that is in violation of a University policy, rule or regulation and is motivated by discriminatory bias against or hatred toward other individuals or groups based on characteristics such as age, ancestry, color, disability or handicap, national origin, political belief, race, religious creed, sex, sexual orientation, gender identity or veteran status.

Policy:

The Pennsylvania State University is committed to preventing and eliminating acts of intolerance by faculty, staff and students, and encourages anyone in the University community to report concerns and complaints about acts of intolerance to the Affirmative Action Office or the Office of the Vice Provost for Educational Equity, and in cases involving students, reports also may be made to the Office of Judicial Affairs.

If any violation of University policy, rule or regulation is motivated by discriminatory bias against or hatred toward an individual or group based on characteristics such as age, ancestry, color, disability or handicap, national origin, political belief, race, religious creed, sex, sexual orientation, gender identity or veteran status, the sanction will be increased in severity and may include termination or expulsion from the University.

The University prohibits retaliation against anyone who files a complaint and/or participates in an investigation involving alleged acts of intolerance. Retaliation constitutes a separate violation and may result in a sanction independent of the outcome of a complaint.

Expression of Opinion:

The expression of diverse views and opinions is encouraged in the University community. Further, the First Amendment of the United States' Constitution assures the right of free expression. In a community which recognizes the rights of its members to hold divergent views and to express those views, sometimes ideas are expressed which are contrary to University values and objectives. Nevertheless, the University cannot impose disciplinary sanctions upon such expression when it is otherwise in compliance with University regulations.

UNIVERSITY POLICY STATEMENT ON SEXUAL MISCONDUCT AND ABUSE

a) The Pennsylvania State University will not tolerate sexual assault or abuse, such as rape (including acquaintance rape) or other forms of non-consensual sexual activity. These acts degrade the victims, our campus community, and society in general. While the University cannot control all the factors in society that lead to sexual assault and abuse, the University strives to create an environment that is free of acts of violence.

b) Violations of this policy will result in disciplinary action, which may include separation from the University.

c) Sexual assault and abuse is non-consensual physical contact of a sexual nature. Sexual assault and abuse can occur between acquaintances or parties unknown to each other.

** University Policy Manual, AD-12*

UNIVERSITY POLICY STATEMENT ON SEXUAL HARASSMENT

a) Sexual harassment of faculty, staff, or students will not be tolerated at The Pennsylvania State University. The University takes an active role in providing information and/or training to students and employees on the seriousness of such behavior and the importance of ensuring an educational and work environment in which all individuals are respected.

b) Sexual harassment has been defined as unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature when:

- (1) Submission to such conduct is a condition for employment, promotion, grades or academic status;
- (2) Submission to or rejection of such conduct is used as the basis for employment or academic decisions affecting an individual;
- (3) Such conduct has the purpose or effect of interfering unreasonably with the individual's work or academic performance or creates an offensive, hostile, or intimidating working or learning environment.

c) Any member of the University community who experiences sexual harassment should contact the Affirmative Action Office, or the appropriate resource person for the area.

** University Policy Manual, AD-42*

*** See Reference Section or listing of sexual harassment resource persons. Students may access a 24 hour help line at (814) 863-2020.*

BIOENGINEERING UNDERGRADUATE COURSE OFFERINGS

BIOE 100S BIOENGINEERING SEMINAR (1) First-year seminar to introduce the role of engineering in biomedical research and in instrument development for the medical device industry.

Offered in the Fall and Spring semester.

BIOE 201 CELL AND MOLECULAR BIOENGINEERING (3) An analytical study of molecular and cellular phenomena including functional and metabolic interactions.

Prerequisite: BIOL 141, CHEM 112, MATH 141 Prerequisite or concurrent: PHYS 212. Offered in the Spring semester.

BIOE 301 ANALYSIS OF PHYSIOLOGICAL SYSTEMS (3) Linear systems analysis applied to electrical networks and lumped parameter models of physiological control systems.

Prerequisite: BIOL 141, PHYS 212, MATH 250 or MATH 251. Concurrent: BIOE 302. Offered in the Fall semester.

BIOE 302 PHYSIOLOGICAL SIMULATION LABORATORY (1) Computer laboratory designed to illustrate applications of control systems theory to physiological systems.

Prerequisite: CMPSC 200 or 201. Concurrent: BIOE 301. Offered in the Fall semester.

BIOE 303 BIO-CONTINUUM MECHANICS (3) Mechanical properties of fluids and solids with applications to tissue mechanics and vascular system.

Prerequisite: BIOL 141, E MCH 210, MATH 230, MATH 251. Offered in the Fall semester.

BIOE 313 BIOENGINEERING THERMODYNAMICS (3) Chemical processes, including material and energy balances and phase equilibria, with emphasis on biological applications.

Prerequisite: BIOL 141, CHEM 112, MATH 230, MATH 251. Offered in the Fall semester.

BIOE 401 INTRODUCTION TO BIOENGINEERING RESEARCH AND DESIGN (3) Challenges and constraints of bioengineering research and design. Emphasis on immunoresponse, tissue mechanics, biological transport phenomena, and biomaterials.

Prerequisite: BIOE 201, BIOE 303 Concurrent: BIOE 404. Offered in the Spring semester.

BIOE 402 BIOMEDICAL INSTRUMENTATION AND MEASUREMENTS (3) Biomedical measurements, including consideration of techniques, equipment, and safety.

Prerequisite: MATH 250 or MATH 251, BIOE 301 or E E 210 or E E 305 or PHYS 402. Offered in the Spring semester.

BIOE 403 BIOMEDICAL INSTRUMENTATION LABORATORY (1) Biomedical measurements laboratory including measurement of biopotentials, experiments in medical imaging techniques, and use of cardiovascular and pulmonary system instrumentation.

Prerequisite or concurrent: BIOE 402. Offered in the Spring semester.

BIOE 404 DATA ANALYSIS AND EXPERIMENT DESIGN (1) Statistical measures of data, and selection of experiment sample size to meet criteria.

Prerequisite: BIOE 302 Concurrent: BIOE 401 Offered in the Spring semester.

BIOE 406 MEDICAL IMAGING (3) Physical principles and clinical applications of medical imaging methods.
Prerequisite: PHYS 212. Offered in the Fall semester.

BIOE 409 BIOFLUID MECHANICS (3) The fundamental relations in fluid mechanics and their application to biofluids including steady/unsteady flows, diseased states, devices and biorheology.
Prerequisite: MATH 230, MATH 251, BIOE 303. Offered in the Spring semester.

BIOE 413 BIOENGINEERING TRANSPORT PHENOMENA (3) An integrated study of the fundamentals of mass transport processes with emphasis on the analysis of physiological systems.
Prerequisite: BIOE 303, BIOE 313 or CHEM 450. Offered in the Spring semester.

BIOE 419 ARTIFICIAL ORGANS AND PROSTHETIC DEVICES (3) Analysis of function and consideration of design concerns for biomedical implants, including prosthetic joints, electrical stimulators, and cardiovascular pumps.
Prerequisite: MATH 250 or MATH 251. Prerequisite or concurrent: BIOL 141 or BIOL 472. Offered in the Spring semester.

BIOE 423 REACTION KINETICS OF BIOLOGICAL SYSTEMS (3) Chemical kinetics and reaction equilibria with applications to the analysis of physiological function and the design of synthetic organs.
Prerequisite: BIOL 141, BIOE 313, or CH E 210. Prerequisite or concurrent: BIOE 413 or (CH E 302 and CH E 413). Offered in the Spring semester.

BIOE 440 CLINICAL CORRELATIONS (1) Engineering analysis applied to common disease states and therapies.
Prerequisite: BIOE 402. Offered in the Fall semester.

BIOE 443 (MATSE 403) BIOMEDICAL MATERIALS (3) Describe properties of materials and composites and their in vivo interactions. Prerequisite: MATSE 201 (Special arrangement for Bioengineering students to accept E MCH 210 and BIOE 313 as alternate prerequisites). Offered in the Fall semester.

BIOE 444(IL) (MATSE 404) SURFACES AND THE BIOLOGICAL RESPONSE TO MATERIALS (3) Focus is on special properties of surface as an important causative and mediating agent in the biological response to materials.
Prerequisite: CHEM 111, CHEM 113. Offered in the Spring semester

BIOE 450W BIOENGINEERING SENIOR DESIGN (3) Application of engineering and physiological principles to design of artificial organs and life supportive devices.
Prerequisite: BIOE 440, ENGL 202C, senior standing. Offered in the Spring semester.

BIOE 494H HONORS THESIS (1 - 3 per semester) Independent study research and design, leading towards honors thesis.
Prerequisite: Permission of program. Offered in the Fall and Spring semester

BIOE 496 INDEPENDENT STUDIES

BIOE 497 SPECIAL TOPICS Courses which are offered irregularly.

Checklist of Course Requirements for Bioengineering

Course	Credits	Semester	Grade
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General Education Requirements

<i>General Arts (GA)</i>			
	3		
	3		

General Humanities (GH)

	3		
	3		

General Social and Behavioral Sciences (GS)

ECON 2 or 4 or 14	3		
	3		

Cultural Competence

US (can double count with other requirement)	3		
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IL (can double count with other requirement)

	3		
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Health and Physical Activities (GHA)

	1.5		
	1.5		

Communication

ENGL 15 or 30	3		
CAS 100A/B	3		
ENGL 202C	3		

First Year Seminar

	1		
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•Total credits required to graduate is 132-133 depending on option selection.

•Maximum number of research credits is 3.

•C or better required in each course marked with a *.

•List of acceptable courses for each elective category can be found on department website or by contacting the department.

Course	Credits	Semester	Grade
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Core Bioengineering Requirements

<i>Mathematics and Sciences</i>			
MATH 140 or 140E*	4		
MATH 141 or 141E*	4		
MATH 230	4		
MATH 251*	4		
BIOL 141*	3		
BIOL 142	1		
CHEM 110*	3		
CHEM 111	1		
CHEM 112	3		
CHEM 113	1		
PHYS 211*	4		
PHYS 212	4		

General Engineering and Computer Science

EDSGN 100	3		
EMCH 210	5		
CMPCSC 200 or 201	3		

Bioengineering Courses

BIOE 201*	3		
BIOE 301*	3		
BIOE 302	1		
BIOE 303*	3		
BIOE 313*	3		
BIOE 401*	3		
BIOE 402*	3		
BIOE 403	1		
BIOE 404	1		
BIOE 440	1		
BIOE 450W	3		

Bioengineering Electives

	3		
	3		

Science or Engineering Elective

	3		
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Course	Credits	Semester	Grade
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Option Requirements (Pick one option area)

<i>Chemical Engineering Option</i>			
CHEM 210	3		
CH E Option Elective	2-3		
CH E Option Elective	3		
CH E Option Elective	3		
BIOE 409	3		
BIOE 413	3		
BIOE 423	3		

Mechanical Engineering Option

MATH 220	2		
EMCH 212	3		
EMCH 315	2		
EMCH 316	1		
BIOE 409	3		
BIOE 443 or 444 or ME 360 or 370	3		
ME Option Elective	3		
ME Option Elective	3		

Material Science Option

CHEM 210	3		
PHYS 214	2		
MATSE 201	3		
MATSE 443	3		
MATSE 430	3		
BIOE 443 (MATSE 403)	3		
BIOE 444 (MATSE 404)	3		

Electrical Engineering Option

EE 210	4		
EE 310	4		
EE 330orCMPEN 270	4		
BIOE 406	3		
EE Option Elective	3		
EE Option Elective	3		

Bioengineering Undergraduate Curriculum with Options

EE OPTION

Semester #1		Semester #3		Semester #5		Semester #7		
MATH 140 Calculus I	4	MATH 251 Differential Equations	4	BIOE 301 Analysis Physiol Systems	3	BIOE 440 Clinical Correlations	1	
CHEM 110 Chemical Principles	3	PHYS 212 Electricity and Magnetism	4	BIOE 302 Physiol Sim Laboratory	1	BIOE Elective	3	
CHEM 111 Experimental Chem	1	BIOE 141 Physiology	3	BIOE 303 Bio-continuum Mech	3	BIOE 406 Medical Imaging	3	
ENGL 15 Rhetoric & Comp	3	BIOE 142 Physiology Lab	1	BIOE 313 Biothermodynamics	3	EE Option Elective	3	
EDSGN 100 Engr. Design	3	E MCH 210 Statics & Strength of Materials	5	E E 310 Elect Circuit Design	4	Arts, Humanities, Soc Sci (GA/GH/GS)	3	
First Year Seminar	1			Arts, Humanities, Soc Sci (GA/GH/GS)	3	ENGL 202C Technical Writing	3	
						Health & Physical Activity (GHA)	1.5	
	15		17		17		17.5	
Semester #2		Semester #4		Semester #6		Semester #8		
MATH 141 Calculus II	4	MATH 230 Calc/Vector Analysis	4	BIOE 401 Intro Bioeng Res Desgn	3	BIOE 450W Senior Design	3	
CHEM 112 Chemical Principles	3	BIOE 201 Cell and Molecular Bioe.	3	BIOE 402 Medical Instrumentation	3	BIOE Elective	3	
CHEM 113 Experimental Chem	1	E E 210 Circuits and Devices	4	BIOE 403 Med Instrumentation Lab	1	EE Option Elective	3	
PHYS 211 Mechanics	4	Arts, Humanities, Soc Sci (GA/GH/GS)	3	BIOE 404 Data Analy & Exp Desgn	1	Arts, Humanities, Soc Sci (GA/GH/GS)	3	
CMPSC 200 MATLAB Prgm	3	ECON 002, 004 or 014	3	E E 330 (ElectMag) or CSE 270	4	Sci & Engineering Elective	3	
Health & Physical Activity (GHA)	1.5			Arts, Humanities, Soc Sci (GA/GH/GS)	3			
				CAS 100A or B Effective Speech	3			
	16.5		17		18		15	
							Total =	133

CH E OPTION

Semester #1		Semester #3		Semester #5		Semester #7		
MATH 140 Calculus I	4	MATH 251 Differential Equations	4	BIOE 301 Analysis Physiol Systems	3	BIOE 440 Clinical Correlations	1	
CHEM 110 Chemical Principles	3	PHYS 212 Electricity and Magnetism	4	BIOE 302 Physiol Sim Laboratory	1	BIOE Elective	3	
CHEM 111 Experimental Chem	1	BIOE 141 Physiology	3	BIOE 303 Bio-continuum Mech	3	CHE Option Elective	3	
ENGL 15 Rhetoric & Comp	3	BIOE 142 Physiology Lab	1	BIOE 313 Biothermodynamics	3	Arts, Humanities, Soc Sci (GA/GH/GS)	3	
EDSGN 100 Engr. Design	3	E MCH 210 Statics & Strength of Materials	5	CHE Option Elective	2	Arts, Humanities, Soc Sci (GA/GH/GS)	3	
First Year Seminar	1			CHE Option Elective	3	CAS 100A or B Effective Speech	3	
				Humanities and Arts (GA/GH/GS)	3	Health & Physical Activity (GHA)	1.5	
	15		17		17		17.5	
Semester #2		Semester #4		Semester #6		Semester #8		
MATH 141 Calculus II	4	MATH 230 Calc/Vector Analysis	4	BIOE 401 Intro Bioeng Res Desgn	3	BIOE 450W Senior Design	3	
CHEM 112 Chemical Principles	3	BIOE 201 Cell and Molecular Bioe.	3	BIOE 402 Medical Instrumentation	3	BIOE Elective	3	
CHEM 113 Experimental Chem	1	CHEM 210 Organic Chemistry	3	BIOE 403 Med Instrumentation Lab	1	BIOE 423 Reaction Kinetics	3	
PHYS 211 Mechanics	4	ECON 002, 004 or 014	3	BIOE 404 Data Analy & Exp Desgn	1	Arts, Humanities, Soc Sci (GA/GH/GS)	3	
CMPSC 200 MATLAB Prgm	3	Arts, Humanities, Soc Sci (GA/GH/GS)	3	BIOE 409 Biofluid Mechanics	3	Sci & Engineering Elective	3	
Health & Physical Activity (GHA)	1.5			BIOE 413 Transport Phenomena	3			
				ENGL 202C Technical Writing	3			
	16.5		16		17		15	
							Total =	132

M E OPTION

Semester #1		Semester #3		Semester #5		Semester #7		
MATH 140 Calculus I	4	MATH 251 Differential Equations	4	BIOE 301 Analysis Physiol Systems	3	BIOE 440 Clinical Correlations	1	
CHEM 110 Chemical Principles	3	PHYS 212 Electricity and Magnetism	4	BIOE 302 Physiol Sim Laboratory	1	BIOE Elective	3	
CHEM 111 Experimental Chem	1	BIOE 141 Physiology	3	BIOE 303 Bio-continuum Mech	3	Arts, Humanities, Soc Sci (GA/GH/GS)	3	
ENGL 15 Rhetoric & Comp	3	BIOE 142 Physiology Lab	1	BIOE 313 Biothermodynamics	3	Arts, Humanities, Soc Sci (GA/GH/GS)	3	
EDSGN 100 Engr. Design	3	E MCH 210 Statics & Strength of Materials	5	ME 360, ME 370, BIOE 443 or BIOE 444	3	CAS 100A or B Effective Speech	3	
First Year Seminar	1			Arts, Humanities, Soc Sci (GA/GH/GS)	3	ECON 002, 004 or 014	3	
						Health & Physical Activity (GHA)	1.5	
	15		17		16		17.5	
Semester #2		Semester #4		Semester #6		Semester #8		
MATH 141 Calculus II	4	MATH 230 Calc/Vector Analysis	4	BIOE 401 Intro Bioeng Res Desgn	3	BIOE 450W Senior Design	3	
CHEM 112 Chemical Principles	3	MATH 220 Matrices	2	BIOE 402 Medical Instrumentation	3	BIOE Elective	3	
CHEM 113 Experimental Chem	1	BIOE 201 Cell and Molecular Bioe.	3	BIOE 403 Med Instrumentation Lab	1	ME Option Elective	3	
PHYS 211 Mechanics	4	E MCH 212 Dynamics	3	BIOE 404 Data Analy & Exp Desgn	1	Sci & Engineering Elective	3	
CMPSC 200 MATLAB Prgm	3	E MCH 315 Mech Resp Eng Mat	2	BIOE 409 Biofluid Mechanics	3	Arts, Humanities, Soc Sci (GA/GH/GS)	3	
Health & Physical Activity (GHA)	1.5	E MCH 316 Exp Det Mch Res	1	ME Option Elective	3			
		Arts, Humanities, Soc Sci (GA/GH/GS)	3	ENGL 202C Technical Writing	3			
	16.5		18		17		15	
							Total =	132

MAT SCI OPTION

Semester #1		Semester #3		Semester #5		Semester #7		
MATH 140 Calculus I	4	MATH 251 Differential Equations	4	BIOE 301 Analysis Physiol Systems	3	BIOE 440 Clinical Correlations	1	
CHEM 110 Chemical Principles	3	PHYS 212 Electricity and Magnetism	4	BIOE 302 Physiol Sim Laboratory	1	BIOE Elective	3	
CHEM 111 Experimental Chem	1	BIOE 141 Physiology	3	BIOE 303 Bio-continuum Mech	3	BIOE 443 Biomedical Materials	3	
ENGL 15 Rhetoric & Comp	3	BIOE 142 Physiology Lab	1	BIOE 313 Biothermodynamics	3	MATSE 430 Mat Characterization	3	
EDSGN 100 Engr. Design	3	E MCH 210 Statics & Strength of Materials	5	MATSE 201 Intro Material Science	3	CAS 100A or B Effective Speech	3	
First Year Seminar	1			Arts, Humanities, Soc Sci (GA/GH/GS)	3	Arts, Humanities, Soc Sci (GA/GH/GS)	3	
						Health & Physical Activity (GHA)	1.5	
	15		17		16		17.5	
Semester #2		Semester #4		Semester #6		Semester #8		
MATH 141 Calculus II	4	MATH 230 Calc/Vector Analysis	4	BIOE 401 Intro Bioeng Res Desgn	3	BIOE 450W Senior Design	3	
CHEM 112 Chemical Principles	3	BIOE 201 Cell and Molecular Bioe.	3	BIOE 402 Medical Instrumentation	3	BIOE Elective	3	
CHEM 113 Experimental Chem	1	CHEM 210 Organic Chemistry	3	BIOE 403 Med Instrumentation Lab	1	BIOE 444 Biomedical Surfaces	3	
PHYS 211 Mechanics	4	PHYS 214 Waves & Quantum Physics	2	BIOE 404 Data Analy & Exp Desgn	1	Sci & Engineering Elective	3	
CMPSC 200 MATLAB Prgm	3	ECON 002, 004 or 014	3	MATSE 443 Intro to Polymers	3	Arts, Humanities, Soc Sci (GA/GH/GS)	3	
Health & Physical Activity (GHA)	1.5	Arts, Humanities, Soc Sci (GA/GH/GS)	3	ENGL 202C Technical Writing	3			
	16.5		18		17		15	
							Total =	132

Color

Code: General Requirements

Bioengineering Core Curriculum

Option Specific Courses