Biomedical Engineering Undergraduate Advising Manual Class of 2022 (updated 9.17.18)

Contents

The Discipline of Biomedical Engineering

This department is a world leader in preparing students for careers in industry and business and for graduate education in engineering, medicine, and science. Biomedical engineering utilizes knowledge from other engineering disciplines to solve problems in living systems. The undergraduate program contains a set of "core knowledge," defined and taught by the faculty, that future biomedical engineers should possess. The core includes courses in molecular and cellular biology, linear systems, biological control systems, modeling and simulation, thermodynamic principles in biology, and engineering analysis of systems level biology and physiology. Building on these core subjects, each student then takes a cohesive sequence of advanced engineering courses appropriate to one of six focus areas:

- Biomedical Data Science
- Biomedical Imaging and Instrumentation
- Computational Medicine
- Genomics and Systems Biology
- Neuroengineering
- Regenerative and Immune Engineering

The curriculum challenges students to analyze problems from both an engineering and a biological perspective. Students work side by side with faculty across the Hopkins community in research labs where they are the forefront of discovery science. Students work in multidisciplinary teams to develop innovative design solutions to clinical problems. Beginning in the freshman year, the department strives to empower students to explore and define their own frontiers in Biomedical Engineering.

Career Opportunities in Biomedical Engineering

This program prepares student career paths in engineering and medicine in both the academic and industrial arenas.

1. **Basic and applied research in engineering, biology, or medicine.** Graduates from these programs conduct basic and applied research at universities, government laboratories, and large industries in an area of biomedical science or engineering.

2. **Medical practice or research.** These are graduates who have gone to medical or other professional schools. After completion, graduates practice medicine and/or perform research. Biomedical engineering has advantages as a premedical major due to the increasing technological complexity in medicine.

3. **Professional engineering practice.** Working in industrial settings, hospitals or other biomedical institutions, these graduates use multiple facets of science to pursue industrial jobs in biomedical engineering. This includes engineering research and development, engineering design and product development, and business aspects of engineering, such as sales, customer engineering, and technical management.

Degree Programs

- **Bachelor of Science in Biomedical Engineering** Students graduating with a B.S. must be competent engineers and therefore devote a major portion of their undergraduate education to engineering course work. The B.S. in Biomedical Engineering degree program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org. Those students who intend to work as engineers or pursue graduate programs in engineering must graduate with a B.S. degree. The requirements described in this guide are intended to ensure an excellent foundation in science, humanities and social sciences, engineering sciences and engineering design methods.

- **Bachelor of Arts in Biomedical Engineering** This program is designed for students who want more flexibility and diversity in their education than is possible within the B.S. program. The amount of required engineering is less than in the B.S. program leaving more time for electives. This program is suitable for a student who wants a general background in engineering but plans to continue his or her education at the graduate level in some field outside of engineering.

- **B.S.–M.S.E. Options in Biomedical Engineering**
  3+1 BS/MSE: The newest addition to our suite of master's degree offerings, the dual BS/MSE degree program is intended for highly motivated biomedical engineering students who wish to pursue advanced studies. Students will complete both degrees by the end of their fourth year, with the opportunity to pursue an additional research thesis during an optional fifth year. This accelerated timeline is designed to maximize students' training potential, making our graduates more competitive for careers in industry or admission to medical school and PhD programs. See https://www.bme.jhu.edu/undergraduate/3-plus-1-program/ for more information.

  Students may also pursue a terminal MSE at the completion of the B.S. degree regardless of the timeframe for completing the B.S.

  Information about any of the M.S.E. programs can be obtained from Samuel Bourne sbourne@jhu.edu or Dr. Raimond Winslow (rwinslow@jhu.edu).

Bachelor of Science Degree

The mission of the BS degree program of the Department of Biomedical Engineering is to provide state-of-the-art biomedical engineering education to students. Our Program Objectives have guided the development of the undergraduate degree curriculum and our fundamental aim is to instill a passion for learning, scientific discovery, innovation, entrepreneurial spirit, and societal impact in an extraordinary group of graduates who, because of their experiences in our program, will:

- continue to utilize and enhance their engineering and biological training to solve problems related to health and healthcare that are globally relevant and based on ethically sound principles,
- demonstrate leadership in their respective careers in biomedical engineering or interrelated areas of industry, government, academia, and clinical practice, and
- engage in life-long learning by continuing their education in graduate or professional school or through opportunities for advanced career or professional training.

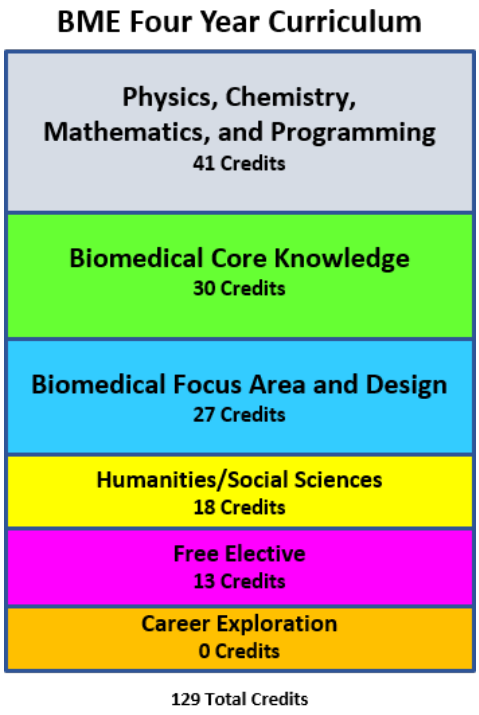
Student Outcomes:

To this end, our responsibility is as much to the future as it is to the present. Through a strong research and educational environment, we strive to empower our students to explore and define their own frontiers as well as instill the ethical principals that will foster rewarding professional endeavors. Upon completion of the B.S. in Biomedical Engineering, students will demonstrate:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) 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
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Structure of the Bachelor of Science Curriculum

The curriculum contains 6 main areas: Basic Science/Mathematics/Computer Programming, Biomedical Core Knowledge, Biomedical Engineering Focus Area and Design, Humanities/Social Sciences, Free Elective, and Career Exploration. No course may be counted in more than 1 of these areas. The only exception to this is for courses taken to fulfill the University's Writing Intensive (W) requirement. At least 129 credits must be completed. All general University requirements, as listed in the catalog and the undergraduate manual, must be met.



Physics, Chemistry, Mathematics, and Programming (41 credits)

At least 41 credits of physics, chemistry, mathematics and computing coursework must be taken (56 if pre-medical). The following courses must be taken for a letter grade and passed or completed by advanced placement examination.

Physics

(Credits) Course
(4) Physics for Physical Science & Engineering Majors I (AS.171.101 or 171.107)
(4) Physics for Physical Science Engineering Majors II (AS.171.102 or 171.108)
(1) Physics Lab I (AS.173.111)*
(1) Physics Lab II (AS.173.112) *
*No lab credit is awarded for AP Physics. Students who receive credit for AP Physics I and/or Physics II will receive a waiver for the laboratory course(s). This will reduce the required number of credits for Physics by 1 or 2 credits. Students are still required to complete at least 129 credits.

Chemistry

(Credits) Course
(3) Introductory Chemistry I (AS.030.101)
(1) Introductory Chemistry Lab I (AS.030.105)
(3) Introductory Chemistry II (AS.030.102)
(1) Introductory Chemistry Lab II (AS.030.106)
Notes:
Students with a score of 4 on the Chemistry AP exam: are awarded credit for AS.030.101 and AS.030.105, but are not eligible to take AS.030.102 and AS.030.106 and still retain AP credit.

Students with a score of 4 are therefore encouraged to take AS.030.103 Applied Chemical Equilibrium and Reactivity w/lab.
Premedical students: Organic Chemistry I (AS.030.205), Organic Chemistry II (AS.030.206), and Organic Chemistry Lab (AS.030.225). (11 credits)
Students in the Regenerative and Immune Engineering Focus Area: Organic Chemistry I (AS.030.205) is highly recommended (4 credits).

Mathematics

Twenty* credits of mathematics courses must be taken. The following courses must be taken for a letter grade and passed or completed by advanced placement examination.

(Credits) Course
(4) Calculus I for Physical Science and Engineering Majors (AS.110.108)**
(4) Calculus II for Physical Science and Engineering Majors (AS.110.109)
(4) Calculus III (AS.110.202)
(4) Linear Algebra and Differential Equations (EN.553.291)***

One of the following Statistics courses:
(Credits) Course
(4) Prob/Stats for Physical and Information Science and Eng (EN.553.310)
(4) Prob/Stats for Biological Sciences and Eng (EN.553.311)
(4) Applied Statistics and Data Analysis (EN.553.413)
(4) Introduction to Statistics (553.430)
(3) Monte Carlo Methods (553.433)
(3) Probability and Statistics in Civil Engineering (EN.560.438)
*Approved 3 credit math or applied math courses will reduce this requirement by 1-2 credits. Students are still required to complete at least 129 credits.
**If Calculus I is waived without credit, Discrete Mathematics (EN.553.171), or an additional 300 level math course must be taken.
***Students planning to double major in the Applied Mathematics and Statistics Department should take the separate linear algebra and differential equations courses. (AS.110.201 Linear Algebra and AS.110.302).

Computer Programming

(Credits) Course
(3) EN.500.112 Gateway Computing (**recommended**)
(3) EN.510.202 Computation and Programming for Materials Science and Engineering
(4) EN.553.383 Scientific Computing with Python
(4) EN.553.385 Scientific Computing: Linear Algebra
(4) EN.553.386 Scientific Computing: Differential Equations
(3) EN.601.107 Introductory Programming in Java (students without prior exposure are advised co-register for 600.108 Intro to Programming Lab)

Biomedical Engineering Core (30 credits)

Thirty credits of core requirements must be taken. The following courses must be taken for a letter grade and passed.

(Credits) Course
(2) Biomedical Engineering Modeling and Design (EN.580.111)
(4) Molecules and Cells (EN.580.221)
(2) Statistical Physics (EN.580.241)
(2) Biological Models and Simulations (EN.580.242)
(2) Linear Signals and Systems (EN.580.243)
(2) Nonlinear Dynamics of Biological Systems (EN.580.244)
(2) Linear Systems and Controls (EN.580.246)
(2) Systems Biology of the Cell (EN.580.248)
(4) Systems Bioengineering I (580.421)
(4) Systems Bioengineering II (580.422)
(2) Systems Bioengineering Lab I (580.423)
(2) Systems Bioengineering Lab II (580.424)
(0) Career Exploration in BME*

*Career Exploration in BME is a 0-credit, self-identified set of career related events (lectures, panels, journal clubs, etc.) beginning in the spring semester of year one and continuing until graduation. Career Exploration is administered through a Community Blackboard site; students will be enrolled by the department.

Biomedical Engineering Focus Area and Design (27 credits)

Students will choose 21 credits from the appropriate focus area course list (courses can also be found by performing an advanced POS-tag search in SIS). At least 15-18 credits must be higher-level engineering courses (5xx.3xx or 6xx.3xx level or above, but not research or Design Team). A maximum of 6 credits from the Non Upper-Level Engineering Course list and the 200-Level Engineering Course list (if applicable) may be used. These courses must be taken for a letter grade and passed.

Biomedical Data Science
Biomedical Imaging and Instrumentation
Computational Medicine
Genomics and Systems Biology
Neuroengineering
Regenerative and Immune Engineering

Guidelines for Adding a Course to a Focus Area

Students may request faculty review of courses for possible inclusion on the list of focus area electives. To do this, students should send an email with the following information:

- course name
- course number
- instructor(s)
- course description (or course syllabus)

- brief rational for its inclusion as a focus area elective

This email should be sent to the faculty directing that focus area. The focus area leader will be responsible for review and decision. The focus area leaders are:

Biomedical Data Science – Dr. Joshua Vogelstein jovo@jhu.edu
Biomedical Imaging & Instrumentation – Dr. Wojtek Zbijewski wzbijewski@jhu.edu
Computational Medicine – Dr. Raimond Winslow rwinslow@jhu.edu
Genomics & Systems Biology – Dr. Patrick Cahan patrick.cahan@jhmi.edu
Neuroengineering – Dr. Angelo All hmn@jhu.edu
Regenerative and Immune Engineering – Dr. Kevin Yarema kyarema1@jhu.edu

Guidelines for Specialty Focus Areas

Although the six focus areas in the undergraduate curriculum are broadly defined by the focus area lists (and contain much overlap), certain areas of biomedical engineering still may not be entirely encompassed within a single area. One example is medical robotics and surgical systems, which may draw upon neuroengineering and biomedical data science. Another is biomechanics, which may draw upon genomics and systems biology and regenerative and immune engineering. To allow additional flexibility in the choice of focus areas, students may opt to focus in a specialty area. However, because the six predefined focus areas are already quite broad, it is envisioned that the specialty focus area will be the exception and not the norm. The rules for this option are as follows.

1) Students must submit a written petition for a specialty focus area to the undergraduate program manager prior to their graduating year.

2) The petition should give a name to the specialty area (such as biophotonics or biomechanics) and clearly articulate the definition of this area. In general, the area must be an accepted specialty of biomedical engineering.

3) The proposed combination of courses for the specialty area must be drawn from the focus area lists, consistent with the definition of the specialty area. For each different list that is used, a minimum of 2 courses (that do not jointly appear on the lists that are chosen) must be selected. The requirements for total number of credits and distribution of credits is otherwise the same as for the six predefined focus areas.

4) The petition will be reviewed by the program manager and undergraduate program director, and either approved or returned for editing or clarification. Please email Cathy Jancuk cjancuk@jhu.edu to request a sample specialty focus area petition.

Research as Focus Area Credit and Free Elective

Up to 6 credits of **Undergraduate Research** (EN.580.51X, EN.580.55X) may be applied toward the focus area requirement (up to 3 credits toward non-ULE focus area with approved write-up, and up to 3 credits toward ULE*). Additionally, students may use research to fulfill the free elective category if they wish.

*Using an advanced research experience as ULE requires an approval process and presentation at the JHU DREAMS event, JHU BMES Research Day, or approved research conference.

Individual Research EN.580.510-511 should be used for laboratory work, computer programming, design and construction of devices, or other practical work or bench work.

Group Research EN.580.550-551) should be used for laboratory work, computer programming, design and construction of devices, or other practical work or bench work. What distinguishes 511 from 551 is that students in the category meet regularly, as a group, with the laboratory PI and other undergraduate and/or graduate students.

- Students registering for intersession research should use 580.547.
- Students registering for summer research should use 580.597.

For student using 3 credits of research toward the non-ULE category in the Focus Area: students must submit a 1-2 page write-up summarizing the work done, justification for focus area credit, and the basis for grading. This should be emailed to Cathy Jancuk cjancuk@jhu.edu no later than the semester prior to graduation. THIS APPLIES TO RESEARCH DONE IN THE BME DEPARTMENT AND TO RESEARCH DONE ELSEWHERE.

Design Requirement

At least two courses for a minimum of 6 credits must be taken. All design experiences must have some biological component. The design experience is a structured, 2-semester long 300-level or higher approved design course (see list below), or a research design experience (course EN.580.580 & EN.580.581) for which a student will submit a proposal outlining the project, document the experience in a substantial research paper or publication, and formally present the work.

One semester of design team (EN.580.311, 411) or one semester of independent design (EN.580.580) may count toward 3 credits of non-ULE focus area. The second semester (EN.580.312, 412 and EN.580.581) may count in the ULE category.

– Approved Design Courses

Courses in this list are a two-semester sequence that must be taken in its entirety.

(3) EN.510.433 Senior Design in Materials Science & Engineering I
(3) EN.510.434 Senior Design in Materials Science & Engineering II

(3) EN.520.462 Leading Innovation Design Team
(3) EN.520.463 Leading Innovation Design Team

(3) EN.520.498 Senior Design Project in Electrical Engineering
(3) EN.520.499 Senior Design Project in Electrical Engineering

(3) EN.540.400	Project in Design: Pharmacokinetics
(3) EN.540.421	Project in Design: Pharmacodynamics
(3) EN.580.311	BME Design Team – Juniors (see additional information below)
(3) EN.580.312	BME Design Team
(3) EN.580.411	BME Design Team – Seniors (see additional information below)
(3) EN.580.412	BME Design Team
(4) EN.580.437	Neuro Data Design I
(4) EN.580.438	Neuro Data Design II
(3) EN.580.456	Rehabilitation Engineering
(3) EN.580.457	Rehabilitation Engineering Design Lab
(4) EN.580.471	Biomedical Instrumentation
(2) EN.580.571	Biomedical Instrumentation Honors (offered during the January Intersession that follows the course)
(4) EN.580.480	Precision Care Medicine I
(4) EN.580.481	Precision Care Medicine II
(3) EN.580.580	BME Independent Design (see additional information below)
(3) EN.580.581	BME Independent Design
(4) EN.601.455	Computer Integrated Surgery I
(3) EN.601.456	Computer Integrated Surgery II

- **EN.580.580/EN.580.581 Research Design Project Option**

The objective of EN.580.580 and EN.580.581 is to conceive and carry out a research-based design project over a two-semester period. These research projects, developed between a student and faculty member and carried out in laboratories throughout Johns Hopkins University, require a substantial design component in accordance with the following ABET (Accreditation Board for Engineering and Technology) definition:

“The process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective. The engineering design component of a curriculum must include at least some of the following features: development of student creativity, use of open-ended problems, development and use of design methodology, formulation of design problem statements and quantitative specifications, consideration of alternative solutions, feasibility considerations, and detailed system descriptions.”

The requirement for EN.580.580-581 is that you write a design proposal before registering, prepare a project paper upon completion, attend regularly scheduled project update meetings, and formally present your work at the completion of the project. The proposal **must** be approved by your design advisor and by Dr. Amir Manbachi who supervises all independent projects. Students are not required to register for EN.580.580 and EN.580.581 in consecutive semesters (ex: a student could register for EN.580.580 in their junior year spring semester and EN.580.581 in their senior year spring semester), however, registering consecutive semesters provides continuity to the project.

Registering for the class is not nearly as important as having a proposal approved; this should be done as soon as possible. The course can be added any time before the end of the 6-week semester deadline.

There are no formal guidelines for a design proposal. Common items within a proposal should be the following:

1) title page,
2) abstract (what you will do, how, & what your MEASURABLE GOALS (quantify) are,
3) introduction and background,
4) statement of proposed work and how will you do it.
5) expected outcomes and how they are to be measured, and
6) time line and bibliography.

Not including 1) and 2), five pages or so should be sufficient. For a sample project, a reasonable title could start, "Evaluating and Characterizing Sensing Technology to Measure Hand Applied Forces." and your first abstract sentence could read, "We propose to explore sensing technology to ..." Attached is the remainder of the abstract. Note that it **does not** describe the clinical problem; that should be reserved for background.

- ## Design Team Option

BME Design Team (580.211-212, 580.311-312, and 580.411-412) is a full year course. Team Leaders are solicited each November each year for the following academic year. After the interview process, those who are selected to lead teams take an immersion course during Intersession and a team leader course during the spring semester. https://www.bme.jhu.edu/news-events/news/students-train-to-become-design-team-leaders/. Applications for Upperclassmen team members (sophomore, junior and senior) are solicited via email each March. After the interview process for team members is complete, students are contacted by individual team leaders.

Remember that you are making a commitment to be part of a team for the entire year. BME upperclassmen (soph-sr) must complete the entire year to receive credit.

Students may count a maximum of 12 credits of design courses in meeting the focus area and design requirement:

- 3 credits non-ULE focus area – EN.580.112 or 1 instance of EN.580.211/311/411
- 3 credits ULE focus area – EN.580.212/312/412
- 6 credits of Design

    - Students already counting 6 credits of Design Team toward non-ULE and ULE focus area may not double-count that in fulfilment of the design requirement.
    - In order to fulfill the design requirement a student must take a second full year of EN.580.311-312 or EN.411.412.
    - EN.580.211-212 does not fulfill the design requirement.
- Any additional credits received from Design Team can be applied to the free elective requirement.

Humanities and Social Sciences (18 credits)

At least 6 courses for a minimum of 18 credits must be taken These courses must be taken for a letter grade and passed. This must include at least two semesters (6 credits) of coursework in which substantial attention is paid to developing written communication skills; these courses are considered writing-intensive and are marked with by a designator (W) in the course description. Humanities and Social Science courses should form a coherent program relevant to the student's goals and must include at least one course at the 300 level. A course in which economic, ethical, political, or social issues related to technology are discussed is recommended.

Many times, students use these credits as an opportunity to pursue a minor or to look at science from a humanistic view through courses in the department of Science, Medicine, and Technology.

– Writing Requirement

All undergraduates are required to fulfill the University writing requirement before graduation. "W" courses, which require a number of written papers, are found throughout the curriculum. Any course taken to satisfy the writing requirement cannot be taken on a satisfactory/unsatisfactory basis. Students pursuing a BS must complete 2 "W" courses.

– Courses without H/S Designation (limited applicability)

Introductory Language Courses: Note that the Whiting School (and the BME Department) allows the first two semesters of any elementary course in a foreign language to count toward the fulfillment of the H/S requirement, as long as both semesters are successfully completed.

Free Electives (13 credits)

Students may place any course (art, music, engineering, science, math, internship credit, etc.) in this category. Students may count up to 3-credits of coursework graded S/U in this category counted. (Note: AP Biology and Statistics cannot be used.) Some suggestions for efficient use of these 13 credits include:

- Organic Chemistry I, Organic Chemistry II, and Organic Chemistry Lab – for students planning to apply to medical school
- Extra courses needed for double majors or minors
- Music performance courses
- Research or Design beyond what can be used in the focus area category

- Intersession courses (Intersession courses are graded S/U; Research can be graded or S/U)

Career Exploration (0 credits)

Career Exploration is a 0-credit self-identified set of career related events (lectures, panels, journal clubs, etc.) beginning in the spring semester of year one and continuing until graduation. Career Exploration is administered through a Community Blackboard site; students are enrolled by the department. Each semester students will attend a minimum of 3 career-related events.

Bachelor of Arts Degree

This program is designed for students who want more flexibility and diversity in their education than is possible with the BS program. The amount of required engineering coursework is considerably less – leaving more time for electives. This program is suitable for a student who is interested in a general background in engineering but plans to pursue graduate level work or a career in a field outside of engineering.

Structure of the Bachelor of Arts Curriculum

The curriculum contains 4 main areas: Basic Science/Mathematics/Computer Programming, Biomedical Engineering Core, Humanities/Social Sciences, and Other Electives. No course may be counted in more than 1 of these areas. Within 1 area, a course can fill multiple requirements (i.e. H&S and Writing Intensive). At least 120 credits must be taken. All general University requirements, as listed in the catalog and the undergraduate manual, must be met.

Physics, Chemistry, Mathematics, and Programming (41 credits)

At least 18 credits* of basic science courses must be taken (29 if pre-med). The following courses must be taken for a letter grade and passed or completed by advanced placement examination. (*Note: AP labs are counted even though no credit is awarded)

Physics

(4) Physics for Physical Science & Engineering Majors I (AS.171.101)
(4) Physics for Physical Science Engineering Majors II (AS.171.102)
(1) Physics Lab I (AS.173.111)
(1) Physics Lab II (AS.173.112)

Chemistry

(3) Introductory Chemistry I (AS.030.101)
(1) Introductory Chemistry Lab I (AS.030.105)

(3) Introductory Chemistry II (AS.030.102)
(1) Introductory Chemistry Lab II (AS.030.106)

Mathematics

(4) Calculus I for Physical Science and Engineering Majors (AS.110.108)*
(4) Calculus II for Physical Science and Engineering Majors (AS.110.109)
(4) Calculus III (AS.110.202)
(4) Linear Algebra and Differential Equations (EN.553.291)
(4) Probability and Statistics (EN.553.310 OR EN.553.311)

*Note: If Calculus I is waived without credit, Discrete Mathematics (550.171), or an additional 300 level math course must be taken.

Computer Programming

(3) EN.500.112 Gateway Computing (**recommended**)
(3) EN.510.202 Computation &Programming for Materials Science and Eng.
(4) EN.553.383 Scientific Computing with Python
(4) EN.553.385 Scientific Computing: Linear Algebra
(4) EN.553.386 Scientific Computing: Differential Equations
(3) EN.601.107 Introductory Programming in Java (students without prior exposure are advised co-register for 600.108 Intro to Programming Lab)

Biomedical Engineering Core (30 credits)

At least 30 credits of core requirements must be taken. The following courses must be taken for a letter grade and passed.

(2) Biomedical Engineering Modeling and Design (EN.580.111)
(4) Molecules and Cells (EN.580.221)
(2) Statistical Physics (EN.580.241)
(2) Biological Models and Simulations (EN.580.242)
(2) Linear Signals and Systems (EN.580.243)
(2) Nonlinear Dynamics of Biological Systems (EN.580.244)
(2) Linear Systems and Controls (EN.580.246)
(2) Systems Biology of the Cell (EN.580.248)
(4) Systems Bioengineering I (580.421)
(4) Systems Bioengineering II (580.422)
(2) Systems Bioengineering Lab I (580.423)
(2) Systems Bioengineering Lab II (580.424)

Humanities and Social Sciences (24 credits)

At least 8 courses for a minimum of 24 credits should be taken. At least two semesters of a modern foreign language must be taken. Student must also include at least 12 credits of coursework in which substantial attention is paid to developing written communication skills; these courses are

considered writing-intensive and are marked with by a (W) in the course catalog. The H & S courses should form a coherent program and include at least 9 credits chosen from one department, including at least one course at the 300-level. A course in which economic, ethical, political, or social issues related to technology are discussed is recommended.

Many times, student use these credits as an opportunity to pursue a minor or to look at science from a humanistic view through courses in the department of Science, Medicine, and Technology.

- **Writing Requirement**

All undergraduates are required to fulfill the University writing requirement before graduation. "W" courses, which require a number of written papers, are found throughout the curriculum. Any course taken to satisfy the writing requirement cannot be taken on a satisfactory/unsatisfactory basis. Students pursuing a BA must complete 4 "W" courses.

- **Courses without H/S Designation (limited applicability)**

Introductory Language Courses: Note that the Whiting School (and the BME Department) allow the first two semesters of any elementary course in a foreign language to count toward the fulfillment of the H/S requirement as long as both semesters are successfully completed.

Other Electives (28 credits)

At least 28 additional credits (11 credits for premedical students counting Intermediate Organic Chemistry and Lab) are needed to complete the 120 credit requirement for the BA Degree. A course in computer programming is highly recommended.

Information for All Degree Programs

Advanced Placement Credit

Please consult the Arts and Science/Engineering Catalog http://e-catalog.jhu.edu/. All current University policy is posted there. If you do not see a course/test listed, then Johns Hopkins does not accept credit for it. Please note that while the University does accept AP credit for Biology and Statistics, these courses cannot be counted toward the 129 credits required for the BS, nor the 120 credit requirement for the BA.

Advising Procedures

The Director of Undergraduate Studies is Dr. Eileen Haase (ehaase1@jhu.edu).
Undergraduate advisor, liaison with dean's office, writer of recommendations for REUs, awards, and graduate school, curriculum development.

The Associate Director of Academic Programs is Dr. Elizabeth Logsdon (elogsdo1@jhu.edu). Freshman Advisor, curriculum development, undergraduate design team program director.

The Undergraduate Program Manager is Ms. Cathy Jancuk (cjancuk@jhu.edu). Freshman Advisor, signatory for students registering for research, overloading, transfer coursework, graduation clearance, assistance/referral for all facets of academic, career, and campus life.

During the freshman year all students are advised by Dr. Elizabeth Logsdon and Ms. Cathy Jancuk. There are mandatory advising meetings in November (for planning the second term freshman course schedule) and April (to plan the first term sophomore course schedule). In late summer (August) all sophomores will be asked to indicate their intended BME Focus Area with an October 15 deadline to respond. Students will be matched as closely as possible to a faculty member in BME that represents the students focus area. If a student is still undecided about their focus area at the deadline, a match based on other criteria will be made. (Please note that students can request advising assignment changes at any time thereafter for any reason – including a change of focus area.)

Beyond the freshman year, students are required to make appointments with their faculty advisors during spring and fall advising when they are planning their course of study. It is imperative that the student bring a copy of his/her graduation checklist to the meeting for planning purposes. Advising holds will not be released for students who have not met with their advisor. Approximately one week prior to the start of the advising period, electronic sign-up lists will be sent out to all students (usually done via a scheduling website like Doodle). Students must also consult their advisors when making changes to their classes. This may be accomplished by sending an e-mail to the advisor.

D/D+ Grades

No more than 2 courses (maximum of 6 credits) **in which a grade of D/D+ was received** may be applied to engineering, science and mathematics requirements. Students may absolve any grade that is a C+ or below by repeating a course. Repeated courses must be taken at Johns Hopkins.

Research

Students may not register for more than 6 credits of Research per year (the year begins in June and ends in May). Students may register for research as S/U or Graded – only graded may be counted toward focus area credit (limited applicability).

Satisfactory/Unsatisfactory (S/U) Grading

Engineering courses beyond the required engineering coursework for the B.S. (or B.A.), 20 mathematics, 18 basic science, and 18 (24 for the B.A.) humanities/social science credits may be taken **S/U.** Students may count up to 3 credits of S/U graded courses in the free elective category.

Study Abroad

It is possible for all BME majors to study abroad with appropriate planning. Please consult the JHU Study Abroad website (https://studyabroad.jhu.edu/) for more information on specific protocol and programs. Dr. Lori Citti jhuabroad@jhu.edu is the person with whom one should speak about specifics of the study abroad programs.

The Vredenburg Scholarship is open to all current sophomores and juniors. It provides the opportunity for School of Engineering students to have summer exploration opportunities including academic experiences (research and study abroad) and internships with a private company, nonprofit organization or NGO (paid or unpaid). There are both early decision and regular decision deadlines. Please consult the Vredenburg web site (http://engineering.jhu.edu/academicaffairs/vredenburg/) or the Office of Engineering Academic Affairs in Shaffer 102 for more information.

Transfer Coursework

Summer school courses (up to 12 credits) taken at other institutions (including courses offered online) may be included in the student's program, but only with prior approval from the student's advisor and the Office of Academic Advising. This limit does not apply to AP courses or course taken through the Study Abroad Program. Such courses may be used to fulfill requirements if a similar course taught at Hopkins would be appropriate.

Complete the pdf document: Permission to Transfer Courses Form. Each course must be listed separately. Use multiple forms if you are planning to take more than two courses.
Bring a printed course description and/or syllabus from the host institution (along with the permission form) to the BME Advising Office and the WSE Advising Office* (email is also acceptable). A complete syllabus with topical breakdown is required for all math and chemistry courses. Full syllabi are encouraged for all courses. The course description must include:

- Your name and Hopkins ID
- The name of the host institution
- The course number and name at the host institution
- The course credits assigned by the host institution
- Whether the host institution is on a semester or quarter system
- Intended use – is it a required course or an elective
- Additional approval signature (Econ, Physics or German/ Romance Languages) if required

*To obtain an Advising Office signature, visit walk-in advising hours or (if the form is complete and the course description(s) attached) drop off your form at the front desk of

When your grade is posted at the end of the term, you must request that the host institution send a transcript to:
Johns Hopkins University
Registrar's Office, Garland Hall Room 75
3400 N. Charles St.
Baltimore, MD 21218

Graduation Checklist and Sample Schedules

Graduation Checklist

Course Plan for Class of '22 (6.20.18)	Credits	Semester	✔

Core Requirements (30)

Required for all BME majors.

Career Exploration in BME*	0	Fr,S-Sr,S	
580.111 Modeling and Design	2	Fr, F	
580.221 Molecules and Cells	4	So, F	
580.241 Statistical Physics	2	So,F or J,F	
580.242 Biological Models and Simulations	2	So, S	
580.243 Linear Signals and Systems	2	So, F	
580.244 Nonlinear Dynamics of Biological Systems	2	So, S	
580.246 Systems and Controls	2	So, S	
580.248 Systems Biology of the Cell	2	So, S	
580.421 Systems Bioengineering I	4	J, F	
580.423 Systems Bioengineering Lab I	2	Jn, F	
580.422 Systems Bioengineering II	4	Jn, S	
580.422 Systems Bioengineering Lab II	2	Jn, S	

Physics & Chemistry (18)

Required for all BME majors.

171.101 General Physics for Physical Science Majors I	4	Fr, F	
173.111 General Physics I Lab	1	Fr, F	
171.102 General Physics for Physical Science Majors II	4	Fr, S	
173.112 General Physics II Lab	1	Fr, S	
030.101 Introductory Chemistry I	3	Fr, F	
030.105 Introductory Chemistry Lab I	1	Fr, F	
030.102 Introductory Chemistry II	3	Fr, S	
030.106 Introductory Chemistry Lab II	1	Fr, S	

Mathematics (20)**

Required for all BME majors.

110.108 Calculus I	4	Fr, F	
110.109 Calculus II	4	Fr, S	
110.202 Calculus III	4	So, F	
553.291 Linear Algebra & Differential Equations	4	b4 So, S	
Advanced Statistics (Prob/Stat is typical)	4	So, S	
*** LinAlg + DiffEq	8		

Computing (3)

An introductory programming course must be taken (see handbook for approved courses).

500.200 Gateway Computing (or equivalent)			

* Note: Students will be enrolled via a Blackboard Community page beginning Freshman spring and every semester throughout their remaining semesters in the program.

** Note: Completion sequence of required math courses is based on student's placement from AP and/or transfer credit. See sample programs for more information.

*** Note: Students planning to minor or double major in AMS should take the separate Linear Algebra (AS.110.201) and Differential Equations (AS.110.302).

Other Notes:

- Fr = Freshman, So = Sophomore, Jn = Junior, Sn = Senior, F = Fall, S = Spring, by = take before that semester.
- Semesters that have already been typed in are the recommended ones for that particular course.

	Credits	Semester	✔

BME Focus Area and Design (27)

At least 21 credits chosen from Focus Area Course Sheets.

At Least 6 credits chosen from Approved Design Course List.

*3 credits from the 2nd semester of Design Team, 2nd semester of Indp. Design (580.581), or a 2nd semester of Research may be counted. Research will required an additional approval step.

*3 or fewer credits can be chosen from the non-ULE list for the focus area course list - research, the first half of Design Team, or 580.580.

*3 or fewer credits can be chosen from list of 200-level focus area course list (available in certain focus areas.

Focus Area Total (21)			
Design Total (6)			

Other Electives (13)

*These can be **any** courses taken at JHU, but are often pre-requisite or courses required for medical school (i.e. Orgo I, Orgo II, and Orgo Lab).*

Humanities/Social Sciences (18)

Courses need an H or S designation.

At least 1 course must be 300-level.

300-level:			

THE FOLLOWING BOXES (Writing Intensive) DOES NOT REQUIRE ANY EXTRA CREDITS, THEY CAN BE SATISFIED USING COURSES THAT ARE IN OTHER BOXES:

Built-In Requirement: Writing Intensive Courses

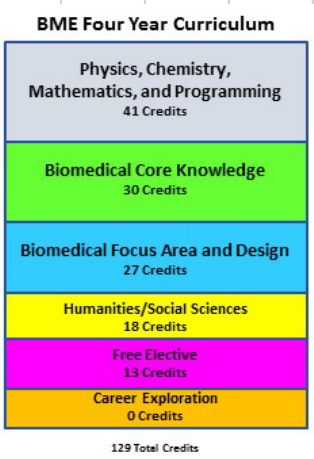
At least 6 credits of courses with the "W" designation must be completed (courses filled into the Electives or Humanities/Social Sciences boxes may be used here).

TOTAL CREDITS (≥129 needed): ____

Sample Course Schedules

4-Year Sample Schedule - Assumes No AP Credit

	Year 1	
Freshman Fall (15 cr)		**Freshman Spring (16 cr)**
AS.110.108 Calculus I (4)	31	AS.110.109 Calculus II (4)
AS.030.101 Introductory Chemistry I (3)		AS.030.102 Introductory Chemistry II (3)
AS.030.105 Introductory Chemistry Lab (1)		AS.030.106 Introductory Chemistry Lab (1)
AS.171.101 General Physics I (4)		AS.171.102 General Physicss II (4)
AS.173.111 General Physics Lab I (1)		AS.171.112 General Physics Lab II (1)
EN.580.111 BME Modeling and Design (2)		EN.500.112 Gateway Computing (3)
		Career Exploration in BME (0)
	Year 2	
Sophomore Fall (16)		**Sophomore Spring (18)**
AS.110.202 Calculus III (4)	34	EN.553.311 Probability and Statistics or equiv (4)
EN.553.291 Linear Algebra & Differential Equations (4)		EN.580.242 Biological Models and Simulations (2)
EN.580.221 Molecules and Cells (4)		EN.580.244 Nonlinear Dynamics of Biological Systems (2)
EN.580.241 Statistical Physics (2)		EN.580.246 Linear Systems and Controls (2)
EN.580.243 Linear Signals and Systems (2)		EN.580.248 Systems Biology of the Cell (2)
Career Exploration in BME (0)		Humanities/Social Sciences (3)
		Free Elective (3)
		Career Exploration in BME (0)
	Year 3	
Junior Fall (18)		**Junior Spring (18)**
EN.580.421 Systems Bioengineering I (4)	36	EN.580.422 Systems Bioengineering II (4)
EN.580.423 Systems Bioengineering Lab I (2)		EN.580.424 Systems Bioengineering Lab II (2)
Focus Area (3)		Focus Area (3)
Focus Area (3)		Focus Area (3)
Humanities/Social Sciences (3)		Humanities/Social Sciences (3)
Free Elective (3)		Humanities/Social Sciences (3)
Career Exploration in BME (0)		Career Exploration in BME (0)
	Year 4	
Senior Fall (15)		**Senior Spring (13)**
Focus Area (3)	28	Focus Area (3)
Focus Area (3)		Design (3)
Design (3)		Humanities/Social Sciences (3)
Humanities/Social Sciences (3)		Free Elective (4)
Free Elective (3)		Career Exploration in BME (0)
Career Exploration in BME (0)		



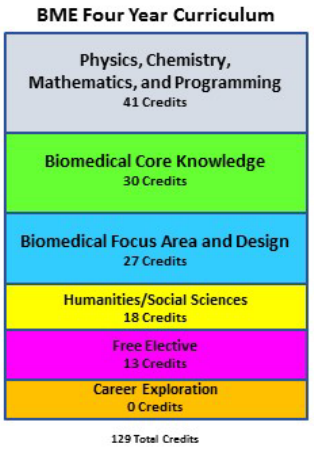
4-Year Sample Schedule for Pre-Meds - Assumes No AP Credit

Year 1		
Freshman Fall (18 cr)		**Freshman Spring (16 cr)**
AS.110.108 Calculus I (4)	34	AS.110.109 Calculus II (4)
AS.030.101 Introductory Chemistry I (3)		AS.030.102 Introductory Chemistry II (3)
AS.030.105 Introductory Chemistry Lab (1)		AS.030.106 Introductory Chemistry Lab (1)
AS.171.101 General Physics I (4)		AS.171.102 General Physicss II (4)
AS.173.111 General Physics Lab I (1)		AS.171.112 General Physics Lab II (1)
EN.580.111 BME Modeling and Design (2)		EN.500.112 Gateway Computing (3)
Humanities/Social Sciences (3)		Career Exploration in BME (0)

Year 2		
Sophomore Fall (18)		**Sophomore Spring (18)**
EN.553.291 Linear Algebra & Differential Equations (4)	36	EN.553.311 Probability and Statistics or equiv (4)
AS.110.202 Calculus III (4)		EN.580.246 Linear Systems and Controls (2)
EN.580.221 Molecules and Cells (4)		EN.580.248 Systems Biology of the Cell (2)
EN.580.243 Linear Signals and Systems (2)		Humanities/Social Sciences (3)
AS.030.205 Introduction to Organic Chemistry I (4)		AS.030.206 Introduction to Organic Chemistry II (4)
Career Exploration in BME (0)		AS.030.223 Introduction to Organic Chemistry Lab (3)
		Career Exploration in BME (0)

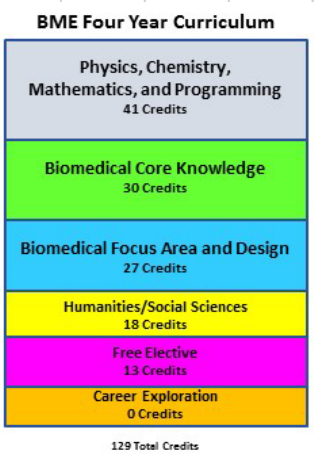
Year 3		
Junior Fall (18)		**Junior Spring (18)**
EN.580.241 Statistical Physics (2)	36	EN.580.422 Systems Bioengineering II (4)
EN.580.421 Systems Bioengineering I (4)		EN.580.424 Systems Bioengineering Lab II (2)
EN.580.423 Systems Bioengineering Lab I (2)		Focus Area (3)
Focus Area (3)		Focus Area (3)
Focus Area (3)		Humanities/Social Sciences (3)
Humanities/Social Sciences (3)		Humanities/Social Sciences (3)
Career Exploration in BME (0)		Career Exploration in BME (0)

Year 4		
Senior Fall (15)		**Senior Spring (13)**
Focus Area (3)	27	Focus Area (3)
Focus Area (3)		Design (3)
Design (3)		Humanities/Social Sciences (3)
Humanities/Social Sciences (3)		Free Elective (2)
Career Exploration in BME (0)		Career Exploration in BME (0)



4-Year Sample Schedule - Calculus I and II AP Credit (8 credits)

	Year 1	
Freshman Fall (15 cr)		**Freshman Spring (16 cr)**
AS.110.202 Calculus III (4)	31	EN.553.291 Linear Algebra & Differential Equations (4)
AS.030.101 Introductory Chemistry I (3)		AS.030.102 Introductory Chemistry II (3)
AS.030.105 Introductory Chemistry Lab (1)		AS.030.106 Introductory Chemistry Lab (1)
AS.171.101 General Physics I (4)		AS.171.102 General Physicss II (4)
AS.173.111 General Physics Lab I (1)		AS.171.112 General Physics Lab II (1)
EN.580.111 BME Modeling and Design (2)		EN.500.112 Gateway Computing (3)
Humanities/Social Sciences (3)		Career Exploration in BME (0)
	Year 2	
Sophomore Fall (18)		**Sophomore Spring (17)**
EN.553.311 Probability and Statistics or equiv (4)	35	EN.580.242 Biological Models and Simulations (2)
EN.580.221 Molecules and Cells (4)		EN.580.244 Nonlinear Dynamics of Biological Systems (2)
EN.580.241 Statistical Physics (2)		EN.580.246 Linear Systems and Controls (2)
EN.580.243 Linear Signals and Systems (2)		EN.580.248 Systems Biology of the Cell (2)
Humanities/Social Sciences (3)		Focus Area (3)
Free Elective (3)		Humanities/Social Sciences (3)
Career Exploration in BME (0)		Free Elective (3)
		Career Exploration in BME (0)
	Year 3	
Junior Fall (15)		**Junior Spring (15)**
EN.580.421 Systems Bioengineering I (4)	30	EN.580.422 Systems Bioengineering II (4)
EN.580.423 Systems Bioengineering Lab I (2)		EN.580.424 Systems Bioengineering Lab II (2)
Focus Area (3)		Focus Area (3)
Focus Area (3)		Focus Area (3)
Humanities/Social Sciences (3)		Humanities/Social Sciences (3)
Career Exploration in BME (0)		Career Exploration in BME (0)
	Year 4	
Senior Fall (12)		**Senior Spring (13)**
Focus Area (3)	25	Focus Area (3)
Design (3)		Design (3)
Humanities/Social Sciences (3)		Humanities/Social Sciences (3)
Free Elective (3)		Free Elective (4)
Career Exploration in BME (0)		Career Exploration in BME (0)



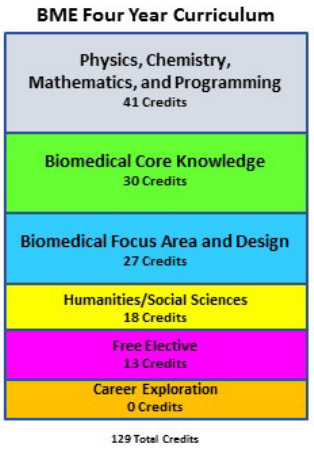
4-Year Sample Schedule for Premeds - Calculus I and II AP Credit (8 credits)

Year 1		
Freshman Fall (15 cr)		**Freshman Spring (16 cr)**
AS.110.202 Calculus III (4)	31	EN.553.291 Linear Algebra & Differential Equations (4)
AS.030.101 Introductory Chemistry I (3)		AS.030.102 Introductory Chemistry II (3)
AS.030.105 Introductory Chemistry Lab (1)		AS.030.106 Introductory Chemistry Lab (1)
AS.171.101 General Physics I (4)		AS.171.102 General Physicss II (4)
AS.173.111 General Physics Lab I (1)		AS.171.112 General Physics Lab II (1)
EN.580.111 BME Modeling and Design (2)		EN.500.112 Gateway Computing (3)
Humanities/Social Sciences (3)		Career Exploration in BME (0)

Year 2		
Sophomore Fall (16)		**Sophomore Spring (15)**
EN.553.311 Probability and Statistics or equiv (4)	35	EN.580.242 Biological Models and Simulations (2)
EN.580.221 Molecules and Cells (4)		EN.580.244 Nonlinear Dynamics of Biological Systems (2)
EN.580.241 Statistical Physics (2)		EN.580.246 Linear Systems and Controls (2)
EN.580.243 Linear Signals and Systems (2)		EN.580.248 Systems Biology of the Cell (2)
AS.030.205 Introduction to Organic Chemistry I (4)		AS.030.206 Introduction to Organic Chemistry II (4)
Career Exploration in BME (0)		AS.030.223 Introduction to Organic Chemistry Lab (3)
		Career Exploration in BME (0)

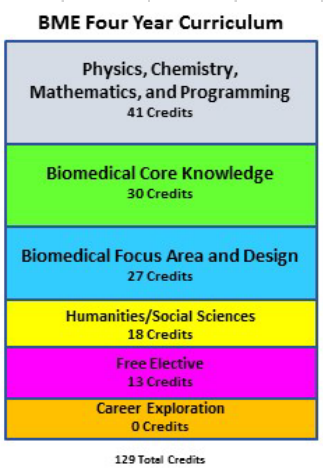
Year 3		
Junior Fall (15)		**Junior Spring (15)**
EN.580.421 Systems Bioengineering I (4)	30	EN.580.422 Systems Bioengineering II (4)
EN.580.423 Systems Bioengineering Lab I (2)		EN.580.424 Systems Bioengineering Lab II (2)
Focus Area (3)		Focus Area (3)
Humanities/Social Sciences (3)		Focus Area (3)
Humanities/Social Sciences (3)		Humanities/Social Sciences (3)
Career Exploration in BME (0)		Career Exploration in BME (0)

Year 4		
Senior Fall (14)		**Senior Spring (12)**
Focus Area (3)	25	Focus Area (3)
Focus Area (3)		Focus Area (3)
Design (3)		Design (3)
Humanities/Social Sciences (3)		Humanities/Social Sciences (3)
Free Elective (2)		Career Exploration in BME (0)
Career Exploration in BME (0)		



4-Year Sample Schedule - 24 AP Credits/3+1 Program

	Year 1	
Freshman Fall (17 cr)		**Freshman Spring (16 cr)**
EN.500.112 Gateway Computing (3)	33	AS.110.202 Calculus III (4)
EN.553.291 Linear Algebra & Differential Equations (4)		EN.553.311 Probability and Statistics or equiv (4)
EN.580.111 BME Modeling and Design (2)		EN.580.242 Biological Models and Simulations (2)
EN.580.221 Molecules and Cells (4)		EN.580.244 Nonlinear Dynamics of Biological Systems (2)
EN.580.241 Statistical Physics (2)		EN.580.246 Linear Systems and Controls (2)
EN.580.243 Linear Signals and Systems (2)		EN.580.248 Systems Biology of the Cell (2)
		Career Exploration in BME (0)
	Year 2	
Sophomore Fall (18)		**Sophomore Spring (18)**
EN.580.421 Systems Bioengineering I (4)	36	EN.580.422 Systems Bioengineering II (4)
EN.580.423 Systems Bioengineering Lab I (2)		EN.580.424 Systems Bioengineering Lab II (2)
Focus Area (3)		Focus Area (3)
Focus Area (3)		Focus Area (3)
Humanities/Social Sciences (3)		Humanities/Social Sciences (3)
Free Elective (3)		Free Elective (3)
Career Exploration in BME (0)		Career Exploration in BME (0)
	Year 3	
Junior Fall (18)		**Junior Spring (18)**
Focus Area (3)	34	Focus Area (3)
Focus Area (3)		Design (3)
Design (3)		Humanities/Social Sciences (3)
Humanities/Social Sciences (3)		Humanities/Social Sciences (3)
Humanities/Social Sciences (3)		Free Elective (6) *
Free Elective (3)		Career Exploration in BME (0)
Career Exploration in BME (0)		*If Physics Lab is waived 2 add'l credits are needed.
	Year 4	
MSE Degree Coursework		**MSE Degree Coursework**
	30	



4-Year Sample Schedule - 24 AP Credits/3+1 Program with Premed

	Year 1	
Freshman Fall (17 cr)		**Freshman Spring (16 cr)**
EN.500.112 Gateway Computing (3)	33	AS.110.202 Calculus III (4)
EN.553.291 Linear Algebra & Differential Equations (4)		EN.553.311 Probability and Statistics or equiv (4)
EN.580.111 BME Modeling and Design (2)		EN.580.242 Biological Models and Simulations (2)
EN.580.221 Molecules and Cells (4)		EN.580.244 Nonlinear Dynamics of Biological Systems (2)
EN.580.241 Statistical Physics (2)		EN.580.246 Linear Systems and Controls (2)
EN.580.243 Linear Signals and Systems (2)		EN.580.248 Systems Biology of the Cell (2)
		Career Exploration in BME (0)
	Year 2	
Sophomore Fall (18)		**Sophomore Spring (18)**
EN.580.421 Systems Bioengineering I (4)	36	EN.580.422 Systems Bioengineering II (4)
EN.580.423 Systems Bioengineering Lab I (2)		EN.580.424 Systems Bioengineering Lab II (2)
AS.030.205 Introduction to Organic Chemistry I (4)		AS.030.206 Introduction to Organic Chemistry II (4)
Free Elective (2)		AS.030.223 Introduction to Organic Chemistry Lab (3)
Focus Area (3)		Free Elective (2)*
Humanities/Social Sciences (3)		Humanities/Social Sciences (3)
Career Exploration in BME (0)		Career Exploration in BME (0)
		*If Physics Lab is waived 2 add'l credits are needed.
	Year 3	
Junior Fall (18)		**Junior Spring (18)**
Focus Area (3)	36	Focus Area (3)
Focus Area (3)		Focus Area (3)
Focus Area (3)		Focus Area (3)
Design (3)		Design (3)
Humanities/Social Sciences (3)		Humanities/Social Sciences (3)
Humanities/Social Sciences (3)		Humanities/Social Sciences (3)
Career Exploration in BME (0)		Career Exploration in BME (0)
	Year 4	
MSE Degree Coursework		**MSE Degree Coursework**
	30