Department of Biomedical Engineering Undergraduate Handbook 2022/23*

University of Utah Department of Biomedical Engineering

(Revision: Nov 6, 2022)

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Salt Lake City, Utah 84112
585-3651

* The Year of this handbook corresponds to the year of regular entry into the program, typically the academic year in which a student takes BME 3301 (Computational Methods) and BME 3070 - Statistics for Engineers, ideally the spring semester of the sophomore year. This will also become the "catalog year" for each student.

The Department of Biomedical Engineering (BME) offers a Bachelor of Science degree in Biomedical Engineering, as well as a program for earning a combined BS/MS degree in BME. The Department also offers MS, and PhD degrees (described at this web page).

This handbook is intended to give information about policies and procedures for the undergraduate program in Biomedical Engineering but it cannot replace discussing your questions with academic advisors. Please come to the Department office at Sorenson Molecular Biotechnology Building Suite 3100, Office 3221, or email one of the undergraduate academic advisors: Heather Palmer (Heather.J.Palmer@utah.edu), Kelly Broadhead (Kelly.Broadhead@utah.edu), and Erica Fearnley (Erica.Fearnley@utah.edu) to get answers to questions not answered here. The information in this handbook as well as various downloadable forms are also available online at https://bme.utah.edu.

The University of Utah is committed to policies of equal opportunity, affirmative action, and nondiscrimination. The University seeks to provide equal access to its programs, services and activities for people with disabilities.

Each year, there are changes in the Handbook and we mark such changes from the previous edition with a vertical bar in the right margin, as with this paragraph.

1 Contact Information and Links

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Minor Advisor: Dr. Doug Christensen, Ph.D.	email: christen@ee.utah.edu	MEB 2456	581-8528
Director of Undergraduate Studies: Dr. Rob MacLeod	email: macleod@sci.utah.edu	4602 WEB	585-7596
Honors Advisor: Dr. Kelly Broadhead, Ph.D.	email: Kelly.Broadhead@utah.edu	3222 SMBB	585-7605
Biomaterials advisor: Dr. Michael Yu	email: michael.yu@utah.edu	SMBB 4501	587-1264
BS/MS advisor: See Undergrad advising			
Department Web Site:	https://bme.utah.edu		
See the site for links to:	Course Descriptions Faculty Directory Undergraduate Studies		
College of Engineering Web Site:	www.coe.utah.edu		
University of Utah Web Site:	www.utah.edu		
Biomedical Engineering Society	www.bmes.org		
Engineering in Medicine & Biology:	www.embs.org		

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2 Program description

2.1 Mission

The mission of the Department of Biomedical Engineering (ABET accredited since 2010) is to

- advance human understanding, health, and the quality of life through internationally recognized research, discovery, and invention in the area of biomedical engineering;
- educate world-class Ph.D. scientists and engineers for accomplishment in research, academics, medicine, and industry;
- educate nationally-recognized B.S. and M.S. graduates for success and leadership in industry and in preparation for future study in medicine, science and engineering;
- transfer scientific discoveries and biomedical technology to the private sector nationwide;
- deliver of high-quality M.E. continuing education to enhance the economy by supporting biomedical industries;
- train students throughout the College of Engineering in biobased solutions to traditional engineering problems and in the application of their specialty to biological and biomedical science.

2.2 Educational objectives

The Biomedical Engineering undergraduate program is dedicated to preparing graduates for professional careers. We educate students such that our graduates will be:

- successful in graduate programs, in professional schools, including medicine and law, or in a biomedical engineering aligned career;
- able to effectively communicate and solve problems at the interface of engineering and biology appropriate to their chosen profession, as well as understand and apply standards of ethical behavior;
- motivated to pursue life-long learning, including understanding contemporary questions at the interface of science, medicine, technology, and society.

2.3 Student outcomes

The Undergraduate Engineering Program Outcomes (ABET 1–7) are:

- an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics;
- an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors;
- an ability to communicate effectively with a range of audiences;
- an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts;

- an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives;
- an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions; and
- an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

The BME Specific Program Outcomes include:

- Applying principles of engineering, biology, human physiology, chemistry, calculus-based physics, mathematics (through differential equations) and statistics;
- Solving biomedical engineering problems, including those associated with the interaction between living and non-living systems;
- Analyzing, modeling, designing, and realizing biomedical engineering devices, systems, components, or processes; and
- Making measurements on and interpreting data from living systems.

3 Status and admissions

3.1 Pre-Major status

From 2016, all students wishing to study engineering are admitted to the College of Engineering and hence have formal status at the University. However, such admission does not mean that the student has also received admission to major status in any program within the College. To receive a degree in Biomedical Engineering (BME) requires admission to the BME program and for this, there is a well defined process that all students must pursue.

Students beginning their undergraduate studies who have not been admitted to the BME program as freshmen, including transfer students, should choose the Pre-BME category as their major for registration purposes. All students are eligible to register for BME 1010. Pre-major students may enroll for BME 1020 and 2100 if they have met the prerequisites. Junior- and senior-year courses in the Biomedical Engineering program are usually open only to students with major status. Pre-majors may also apply for admission to upper division classes by special permission of the instructor and the department. Pre-majors are strongly encouraged to meet early with one of the undergraduate advisors in the Department to outline a course of study that will prepare them to apply for major status in a timely manner.

3.2 Admission to major status

3.2.1 Freshmen admission

A number of highly qualified students are admitted directly to major status in the program as freshmen. Such admission is based on academic excellence and results from a careful screening of students' records upon their application for admission to the University. No direct action is required from students wishing to be considered for freshman admission. Students who are admitted as freshman **must, at a minimum, maintain the same academic standard as required for students pursuing the standard admission to major status described below**.

3.2.2 Standard admission

Admission to major status in the Biomedical Engineering program is limited by the availability of Department teaching and laboratory resources and based solely on academic achievement. Admission to major status is based on a combination of two components:

1. the student's cumulative University of Utah GPA (*i.e.,* not including transfer credit), and
2. the student's Technical GPA from the following technical courses:

BME 1010	Careers in Biomedical Engineering
BME 1020	Fundamentals of Biomedical Engineering I
BME 2100	Fundamentals of Biomedical Engineering II
BIOL 2020 (or BIOL 2021)	Cell Biology (or equivalent)*
CHEM 1220 (or CHEM 1221)	General Chemistry II (or honors)
CHEM 1225 (or CHEM 1241)	General Chemistry II Lab (or honors)
MATH 1321 or 2310	Accel. Eng. Calc II or Calculus III
MATH 2250	Diff Eq/Lin Alg
PHYS 2210 (or 3210)	Physics for Scientists and Engineers I (honors)
PHYS 2220 (or 3220)	Physics for Scientists and Engineers II (honors)

A student must have a grade point average (GPA) in both categories of 3.0 or better to be even considered for the program. All students with a University GPA above 3.0 and also a Technical GPA above 3.4 will gain automatic admission to the major. Students with a University GPA above 3.0 and a Technical GPA between 3.0 and 3.4 will join an admission waiting list. Final decisions on applications in the waiting list will occur just before the spring semester of each year. See the Application Form at the end of this document and check with an Undergraduate Advisor for details.

Note that students may substitute a "C" grade for any class not yet taken and be considered for admission as long as their Technical and University GPA's, meet the requirements described above for admission.

To submit an addmissions application, see the Application Form at the end of this document (Section 10) and check with an Undergraduate Advisory in the Department office for details. In order to register for Department upper-division courses (3000-level or higher), a student must have major status or receive permission from the Department and course instructor for exceptional circumstances.

Conditional and Probationary Admission status There are several forms of admission into the BME program:

1. Conditional admission: Students who have completed most of the required courses in Section 4.3 but can meet admission requirements by substituting a "C" grade for any incomplete courses, may also apply to the program. They will be admitted under the condition that they subsequently complete the missing courses with a "C" grade or better.
2. Probationary admissions: Students whose prerequisite course grades do not meet the acceptance threshold may be accepted with strict performance requirements for the first semester of the program and meet the following conditions:
   - Students must achieve a composite GPA of 3.4 or better in their technical courses taken in the first spring and summer semesters of their admission to the program.
   - Students must complete all the unfulfilled prerequisite courses with a "C" grade or better.
   - Students must complete the Organic Chemistry I + Lab in the first spring or summer semesters of their admission with a "C" grade or better. These grades will also be part of the composite GPA used for admission evaluation.

Admission timing: The minimum duration of the BME major program is 5 semesters, starting in the spring semester of the entry year into the major. Thus, students are strongly encouraged to seek admission to the major in time for the **Spring semester of their sophomore year** in order to best meet the prerequisite requirements and complete the program on time. A delay in admission application after this deadline may present significant disadvantages to the student leading to prolonging the program beyond 5 semesters and causing delays in graduation.

Catalog Year The Catalog Year is critical for students as it determines the courses that are required for graduation. The setting of catalog year is based on the academic year in which students enter the major and take BME 3301 (Computational Methods), usually their first upper division course (3000 level or above, **excluding BME 3091**) in the program. Note that students admitted in the freshman year should use the same criteria for determining their catalog year.

Students may opt to change their catalog year to a later date in order to adjust to advantageous changes in the requirements of the program. Such a change in catalog year MUST occur under advisement of a Undergraduate Advisor and must be documented in the student's file. The last time to adjust catalog year occurs as part of the application for graduation.

3.3 Transfer Credit and Exceptions to Policy

Students wishing to apply credit from another school for any technical class which is not included in the College of Engineering Articulation Agreement (available on the University of Utah web site) must submit a Petition for Transfer Credit or Variance (the "tan sheet") along with thorough supporting documentation. Only after the petition has been approved by the Department will transfer of technical credit be allowed toward completion of the BS degree in BME. This requirement applies even to classes that have been accepted by the University for general transfer credit; the classes must still be submitted for Departmental acceptance for transfer credit toward the degree by petition (unless they appear on the Articulation Agreement, in which case approval is automatic). Note that any exception to the Department's academic policies must be requested by submission of this same form, and that such an exception is allowed only after the petition has been approved by the Department.

3.4 Scholarships

The Department, in cooperation with the College of Engineering, provides a limited number of scholarships to highly qualified applicants. Applications for scholarships are usually due on February 1 of each year. Contact the Department Office or see the Department web site for details.

4 Requirements for the B.S. Degree in BME

The undergraduate degree (B.S.) in Biomedical Engineering is granted upon successful completion of a minimum of 127 semester hours of the following requirements:

1. University's General Education requirements,
2. Mathematics and Science courses,
3. BME core courses, and
4. BME Electives.

These program requirements are described in detail below. Note that some of the requirements have changed from previous years and may continue to change.

Some of the General Education, mathematics, and science courses may be waived for students who have AP credit from high school in those subjects and who have achieved certain scores on the AP test. Details are at the website https://admissions.utah.edu/advanced-placement-credit/ under the department offering the specific course.

4.1 General education requirements

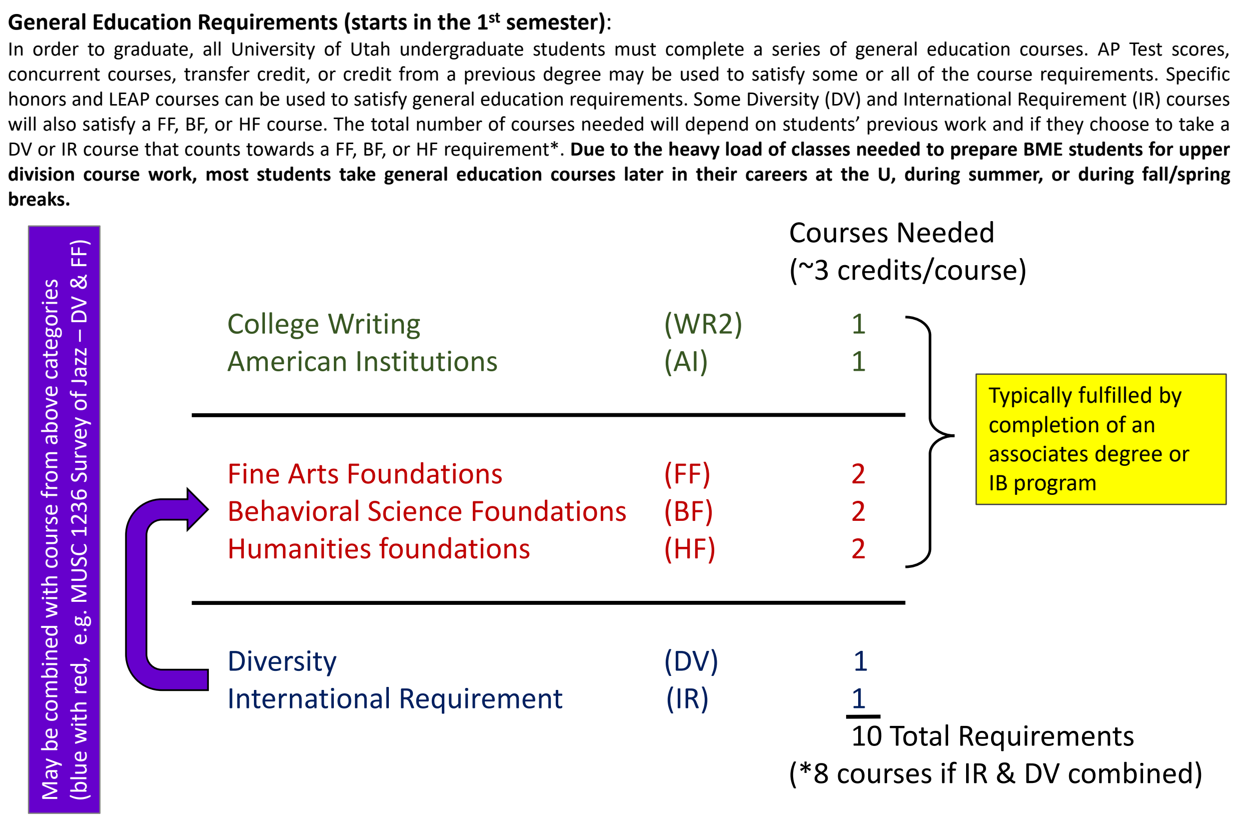


Figure 1: Gen Ed Requirements. Flowchart of the general education requirements to complete the University of Utah's BS degree.

See the website https://ugs.utah.edu/general-education/requirements for a description of the University's General Education requirements and see the website https://ugs.utah.edu/general-education/intersection-courses.

php for more details on Gen Courses and guidelines. General Education includes Intellectual Explorations courses (including a Diversity requirement), and the Writing, American Institutions, and Quantitative Reasoning course requirements.

Lower division writing Writing 2010 or the equivalent is required.

Upper division communications/writing The University's upper-division communication/writing requirement will automatically be met by successful completion of BME 4992 (Thesis Writing and Communication II) in the senior year.

American institutions See this website for courses that meet the American Institutions requirement. The American Institutions requirement may also be cleared by AP credit or by examination at the Testing Center in the Student Services Building during regular testing room hours.

Quantitative reasoning The Quantitative Reasoning and Quantitative Intensive course requirements (QA, QB, and QI) are met by the Biomedical Engineering curriculum through the calculus requirements and through BME 4001 and BME 4250 (Biotransport/Biomolecular and Biomechanics).

International Course Requirement Each student entering the University on or after Fall, 2007, must fulfill an upper division International Course Requirement. This requirement will give students a broad base of knowledge about global issues and about global perspectives in a comparative context. It will introduce students to international frames of reference so that they may think critically about long-standing and newly emerging issues. It will help students accept and appreciate the interdependence of nations and the viewpoints of other nations, and give them the ability to communicate with people across international borders.

At present, the College of Engineering does not offer an accredited class for this requirement. Please see this web site for more information and an up to date list of accepted courses.

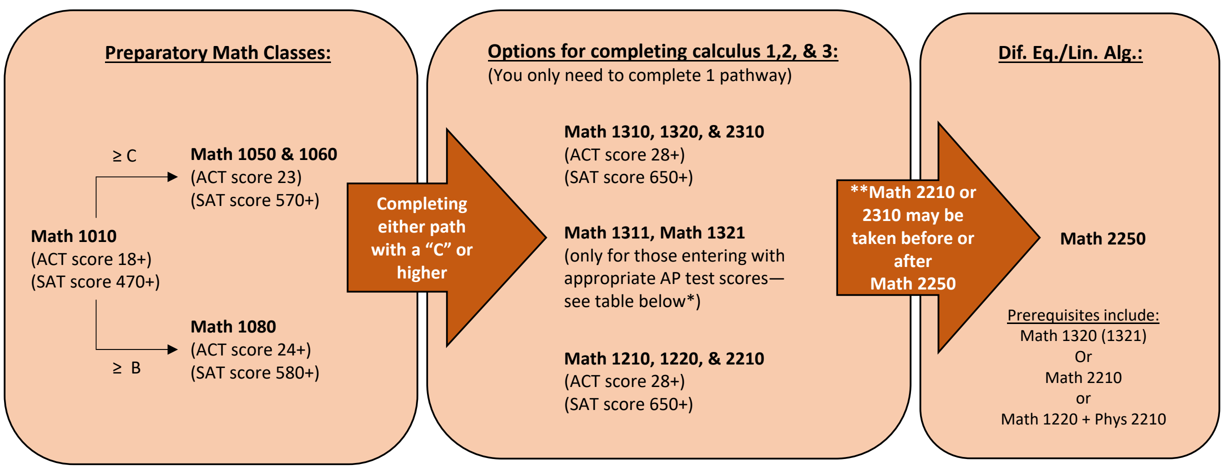
4.2 Mathematics Courses

The following courses (or their equivalent) are required from the areas of mathematics:

MATH 1310	Eng Calc I
MATH 1320	Eng Calc II
MATH 2310	Calc III
or (recommended)	
MATH 1311	Honor's Accelerated Eng Calc I
MATH 1321	Honor's Accelerated Eng Calc II
MATH 2250	Diff Eq/Lin Alg

Math (starts in the 1st semester):

All BME students must master the concepts in at least calculus 1, 2, & 3 as well as differential equations/linear algebra. There are 3 options for completing the calculus series. Selecting the correct path will depend on your previous college courses and/or test scores. Furthermore, depending on your previous courses/test scores, additional classes may be required in order to be prepared for entry into one of the University of Utah's calculus series.



Note: If any student does not believe their ACT/SAT test scores accurately represent their math skills, students may take the Accuplacer Exam for placement purposes. Accuplacer exams are administered by appointment in the Testing Center (SSB 498) at the Student Services Building (and most other colleges/universities). Weeklong preparatory boot camps are held to prepare students for the Accuplacer exam each summer.

AP Calc Exam & Score	Courses you may start in
BC of 4 or 5	Math 1321 or 2210
BC of 3	Math 1311, 1320, or 1220
AB of 4 or 5	Math 1311
AB of 3	Math 1310 or 1210

**Math 2210 or 2310 may be taken before or after taking Math 2250 (most student do)

Figure 2: Math class requirements. Flowchart of the math course requirements for admission to the BME program.

4.3 Science Courses

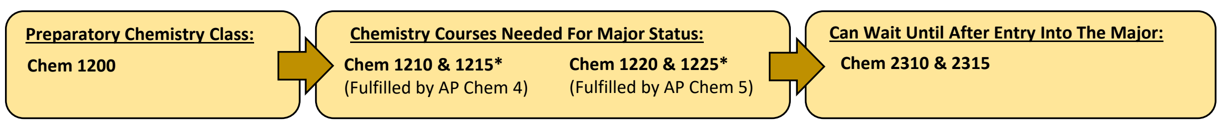
The following courses (or their equivalent) are required from the areas of science:

PHYS 2210/3210	Physics for Scientists and Engineers I
PHYS 2220/3220	Physics for Scientists and Engineers II
CHEM 1210 or CHEM 1211	General Chemistry I
CHEM 1215	General Chemistry Lab I
CHEM 1220 (or CHEM 1221)	General Chemistry II (or honors)
CHEM 1225 (or CHEM 1241)	General Chemistry Lab II (or honors)
CHEM 2310	Organic Chemistry I
CHEM 2315	Organic Chem Lab I
BIOL 2020/2021	Cell Biology

The flowchart in Figure 3 shows the Chemistry and BME courses required for admission to the program and Figure 4 shows the Physics and Biology course requirements.

Chemistry (starts in the 1st semester):

All BME students must master the concepts in at least General Chemistry 1 & 2 as well as Organic Chemistry 1 (with the accompanying labs for each course). If a student does not have previous Chemistry experience, we recommend taking a preparatory Chemistry course (1200) prior to taking General Chemistry 1 (Chem 1210). AP testing can be used to count for one or both of the General Chemistry courses. However, students who plan on going to Medical School may still need to take both General Chemistry courses as most Medical Schools require at least 4 semesters of College Chemistry with labs and typically do not recognize AP Scores in this subject (the U of U med school will waive the first semester with a score of 4 or 5). If AP students also completed a laboratory component at their high school, they may petition the Chemistry department to waive one or both of the General Chemistry lab requirements by submitting their lab notebooks to the Chemistry Department. Honors versions of these classes are also available but are offered less frequently.

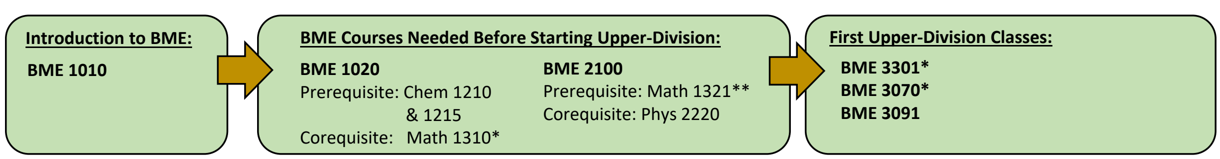


*Chemistry labs may be fulfilled by review of AP lab notebook

Prior Work	Courses you may start in
No High School Chemistry or Math ACT <25 and Math AB <2 and Accuplacer AAF < 263	Chem 1200
Math ACT 25+ or Math AB 2+ or Accuplacer AAF 263+ or Math 1050 (1080)+	Chem 1210
AP Chem 4 or (5 and premed)	Chem 1220
AP Chem 5 & not premed	Chem 2310

Biomedical Engineering Classes (starts in the 1st semester):

All BME students will take the BME core (49 credits) plus will choose a set of BME electives (15 credits). The first class a student typically takes is BME 1010: Careers in Biomedical Engineering. The class serves as an introduction to the variety of career paths possible with a degree in BME, how best to prepare to enter a career, and the type of activities (including core skill development and class selection) that will be useful in career development. Topics will also cover how best to organize a plan of study and to get involved in research. After the first semester, students will start progressing through the major classes starting in the spring semester with a Fundamentals of BME class (BME 1020) focused on an introducing to materials, chemistry, and biology fundamentals.



*or Math 1310 (Math 1220) **or Math 1320 (Math 1220)
Note: These classes can be taken in either order.
*Entry by Permission: fourth semester of program

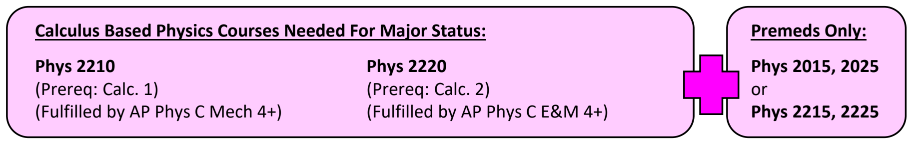
Figure 3: Chemistry and BME requirements. Flowchart of the chemistry and BME course requirements for admission to the BME program.

All mathematics, science, and biomedical engineering core and technical elective courses should be taken for letter grade whenever this option is available.

Classes Started in Subsequent Semesters

Physics (start in the 2nd semester):

All BME students must complete Physics for Scientists and Engineers 1 & 2 (Calculus-based physics). Success in physics classes in part is achieved through adequate development of mathematic and problem-solving skills (developed in BME and chemistry classes). For students planning to go to Medical School, please note that you should also take two physics labs to fulfill the entry requirements of most medical schools. Either the algebra or calculus-based physics labs will count. Wherever available, honors versions of the courses may be substituted to satisfy the requirements.



Biology (second year):

All BME students must complete Cell Biology in the second year. In order to take Cell Biology, the biology department requires either an AP Biology Score of 4+, our Fundamentals of Biomedical Engineering I (BME 1020), or General Biology (Biol 1610). Note: General Biology is not required for a BME degree and will not count as a BME elective course. However, for students planning to go to Medical School, please note that those medical schools typically require two biology courses. Also if you are planning on Medical School, you should also take the Cell Biology lab (or an alternate biology lab) to fulfill the entry requirements of most medical schools. Wherever available, honors versions of the courses may be substituted to satisfy the requirements.

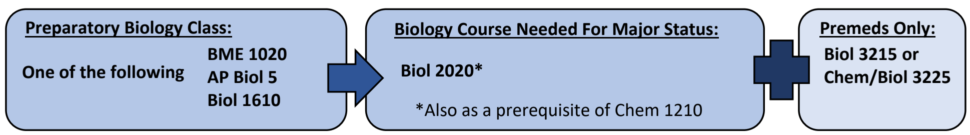


Figure 4: Physics and Biology class requirements. Flowchart of the Physics and Biology course requirements for admission to the BME program.

4.4 Biomedical Engineering Core

The following 16 courses are required from the BME Core:

Pre-major	
BME 1010	Careers in Biomedical Engineering
BME 1020	Fundamentals of Biomedical Engineering I
BME 2100	Fundamentals of Biomedical Engineering II
Major	
BME 3070	Biomedical Engineering Statistics*
BME 3091	Current Research in Biomedical Engineering
BME 3101	Biosignal Analysis
BME 3202	Physiology for Engineers
BME 3301	Computational Methods for Biomedical Engineers
BME 3801	Biomedical Engineering Design I
BME 4801	Biomedical Engineering Design II
BME 4990	Biomedical Research
BME 4991	Thesis Writing and Communication I
BME 4992	Thesis Writing and Communication II
BME 4001	Biotransport and Biomolecular Engineering
BME 4101	Biosystems Analysis and Modeling
BME 4250	Biomechanics I
BME 4301	Intro to Modern Biomaterials
BME 5900	Digital Design and Fabrication**

* It is possible to substitute another statistics class from the College of engineering *e.g.,* ECE 3530,

or CS 3130 (but **not** MET E 3070) for this requirement. We will not accept the Math 3070 course as a substitute. ** The class number for this course will change from a special topics class to a permanent 3000 number by spring 2024.

4.5 BME Electives

BME electives are courses that students use to help achieve the main goal of the program—to determine (or confirm) the future direction of their post graduate career and to ensure they are optimally prepared for that career. For some students, BME elective classes offer the opportunity to deepen and focus their knowledge in order to prepare for a career in a specific area of biomedical engineering. Others take electives to help make the decision among the wide range of directions open to students in biomedical engineering, in anticipation of subsequent education and training in the selected area(s).

The BME program is loosely organized into the following foci or areas of emphasis. Note that students make take classes from any focus area so that the **selection of a focus direction is not restrictive:**, rather, the set of BME electives can include topics from more than one of the focus areas described below.

Bioelectrical Engineering: based on course material from electrical engineering typically with a focus on instrumentation, device development, or electrically based diagnostics and therapy.

Biomaterials Engineering: based on course material from materials science, material engineering, and mechanical engineering focused on the role of materials in biomedical applications. Also includes topics like biocompatibility, tissue engineering, biomimetic materials, and synthetic biology.

Biomechanical Engineering: based on course material from physics or mechanical engineering focused on mechanical aspects of the body, mechanical characteristics of biomedical materials, fluids, use of heat and heat-inducing therapies, and prosthetics.

Biomedical Imaging: based on courses in mathematics, radiology, and biomedical engineering that cover the underlying physics and mathematics of medical imaging as well as the use of image processing to extract information from those images.

Computational Biomedical Engineering: based on courses in computer science, physics, and mathematics and focused on the application of numerical and computational approaches to the analysis, interpretation, visualization, and simulation of living systems.

Premedical Preparation: includes the required courses for entry to most medical and dental programs with an emphasis on clinical perspectives of engineering.

A student must propose a set of BME elective classes based on his/her career goals and often after a discussion with an Undergraduate Advisor in order to meet one or more of the following needs:

- Deeper knowledge of a particular technical field because of a pre-existing interest or focused career goals.
- Broader knowledge of a technical field in order to be prepared for a diverse career based on post graduate training.
- Exploration of a wide variety of technical directions and courses in order to identify the most compelling and fulfilling future career directions.

Section 7 contains specific requirements and lists of approved BME electives. Note that approval of the BME electives **must occur with the approval of Dr. Rob MacLeod**.

4.6 COOP/Internship Opportunities

Students interested in including industrial experience in their university education should consider participating in the Department's COOP/Internship Program. Internships can also lead to credit through the required BME 4990 Research Class, or the BME 4995 Class for additional elective credit. Note: all students must take BME 4990 as part of the core requirements. The BME 4995 is a course for Coop or internship students wishing to receive additional elective credit.

4.7 Continuing Performance

A student admitted to major status must maintain a cumulative University of Utah GPA, as reported on his or her transcript, at or above 3.00. **Students must also have a minimum of a 3.0 cumulative GPA to graduate.**

Each course taken to satisfy departmental requirements in mathematics, chemistry, physics, biology, biomedical engineering core, and the BME electives must be taken for credit and passed with a grade of C or better. **Generally, and in accordance with College of Engineering policy, a student may repeat these technical courses only once, and the second grade received will be counted for the requirement.** It is possible to apply for a variance from these requirements by meeting with Dr. Rob MacLeod.

4.8 Leave of Absence

Students are expected to complete all degree requirements within four years of acceptance to major status (6 years for students admitted as freshmen). Students accepted into major status who are planning to be absent from the program for more than one year should request a leave of absence by submitting a letter to an Undergraduate Advisor. (A copy should also be sent to the University Admissions Office to avoid the necessity of reapplying for admission and repaying the admission fee upon return.)

Students who move to a part time status and do not take the normal course load should apply to an Undergraduate Advisor, fill out a variance (tan colored form), and work out an acceptable plan for continuing progress in the program.

Otherwise, students accepted into major status who are not making satisfactory progress may be dropped from the program and declared inactive. To be reinstated to active status, students must submit a written petition to an Undergraduate Advisor. Reinstated students matriculate under the graduation requirements in place at the time they are reinstated.

4.9 Probation

A student admitted to major status whose cumulative GPA falls below 3.00 is placed on departmental academic probation and given written instructions for a return to good standing. Normally, these conditions must be met during the ensuing semester. Students who fail to meet probationary conditions are dropped from the program. Reinstatement requires a written petition to Dr. Rob MacLeod. Reinstated students matriculate under the graduation requirements in place at the time they are reinstated.

4.10 Repeat and Withdrawal Policies

The BME program adheres to the College of Engineering policies for a course that is repeated and for withdrawals. In particular, a technical course required for the degree may be repeated only once, and the second grade received will be counted toward application for admission to major status and to the continuing performance requirement. Grades of W, I or V on the student's record count as having taken the class. This policy does not apply to courses taken to satisfy Intellectual Exploration and lower division Writing requirements.

4.11 Academic Misconduct

The Biomedical Engineering program has a zero tolerance policy with any form of academic misconduct. We encourage group interactions and exchange but ultimately, each student must submit individual homework assignments, projects, and exams (with the exception of Design Class projects or those assignments explicitly declared otherwise). We follow the University policy on academic misconduct, as follows:

Definitions

"Academic misconduct" includes, but is not limited to, cheating, misrepresenting one's work, inappropriately collaborating, plagiarism, and fabrication or falsification of information, as defined further below. It also includes facilitating academic misconduct by intentionally helping or attempting to help another to commit an act of academic misconduct.

1. *"Cheating" involves the unauthorized possession or use of information, materials, notes, study aids, or other devices in any academic exercise, or the unauthorized communication with another person during such an exercise. Common examples of cheating include, but are not limited to, copying from another student's examination, submitting work for an in-class exam that has been prepared in advance, violating rules governing the administration of exams, having another person take an exam, altering one's work after the work has been returned and before resubmitting it, or violating any rules relating to academic conduct of a course or program.*
2. *Misrepresenting one's work includes, but is not limited to, representing material prepared by another as one's own work, or submitting the same work in more than one course without prior permission of both faculty members.*
3. *"Plagiarism" means the intentional unacknowledged use or incorporation of any other person's work in, or as a basis for, one's own work offered for academic consideration or credit or for public presentation. Plagiarism includes, but is not limited to, representing as one's own, without attribution, any other individual's words, phrasing, ideas, sequence of ideas, information or any other mode or content of expression.*
4. *"Fabrication" or "falsification" includes reporting experiments or measurements or statistical analyses never performed; manipulating or altering data or other manifestations of research to achieve a desired result; falsifying or misrepresenting background information, credentials or other academically relevant information; or selective reporting, including the deliberate suppression of conflicting or unwanted data. It does not include honest error or honest differences in interpretations or judgments of data and/or results.*

Sanctions:

A student who engages in academic misconduct as defined above may be subject to academic sanctions including but not limited to a grade reduction, failing grade, probation, suspension or dismissal from the program or the University, or revocation of the student's degree or certificate. Sanctions may also include community service, a written reprimand, and/or a written statement of misconduct that can be put into an appropriate record maintained for purposes of the profession or discipline for which the student is preparing.

1. *Any person who observes or discovers academic misconduct by a student should file a written complaint with the faculty member responsible for the pertinent academic activity within thirty (30) business days of the date of discovery of the alleged violation.*
2. *A faculty member who discovers or receives a complaint of misconduct relating to an academic activity for which the faculty member is responsible shall take action under this code and impose an appropriate sanction for the misconduct.*

3. *Upon receipt of a complaint or discovery of academic misconduct, the faculty member shall make reasonable efforts to discuss the alleged academic misconduct with the accused student no later than twenty (20) business days after receipt of the complaint, and give the student an opportunity to respond. Within ten (10) business days thereafter, the faculty member shall give the student written notice of the academic sanction, if any, to be taken and the student's right to appeal the academic sanction to the Academic Appeals Committee for the college offering the course. Such sanctions may include requiring the student to rewrite a paper(s) or retake an exam(s), a grade reduction, a failing grade for the exercise, or a failing grade for the course. In no event shall the academic sanction imposed by the faculty member be more severe than a failing grade for the course.*
4. *If the faculty member imposes the sanction of a failing grade for the course, the faculty member shall, within ten (10) business days of imposing the sanction, notify in writing, the chair of the student's home department and the senior vice president for academic affairs or senior vice president for health sciences, as appropriate, of the academic misconduct and the circumstances which the faculty member believes support the imposition of a failing grade. If the sanction imposed by the faculty member is less than a failing grade for the course, the faculty member should report the misconduct to the dean or chair of the student's home department or college. Each college shall develop a policy specifying the dean and/or the chair as the appropriate person to receive notice of sanctions less than a failing grade for the course.*
5. *A student who believes that the academic sanction given by the faculty member is arbitrary or capricious should discuss the academic sanction with the faculty member and attempt to resolve the disagreement. If the student and faculty member are unable to resolve the disagreement, the student may appeal the academic sanction to the Academic Appeals Committee for the college offering the course within fifteen (15) business days of receiving written notice of the academic sanction.*
6. *If the faculty member, chair or vice president believes that the student's academic misconduct warrants an academic sanction of probation, suspension or dismissal from a program, suspension or dismissal from the University, or revocation of a student's degree or certificate, they may, within thirty (30) business days of receiving notice of the misconduct, prepare a complaint with recommendations, refer the matter to the chair or dean's designee of the student's home department or college, and notify the student of the complaint and recommendation. The chair and/or dean's designee of the home department/college may undertake an investigation of the allegations and recommendations set forth in the complaint. Within ten (10) business days of receipt of the complaint, the chair and/or dean's designee shall forward the complaint and recommendation to the Academic Appeals Committee of the home college for proceedings in accordance with Section C, below, and so notify the student in writing. The chair and/or dean may accompany the complaint with his/her own recommendation supporting or opposing the sanction sought in the complaint. The person initiating the original complaint continues as the complainant in the case unless that person and the chair/dean's designee both agree that the latter shall become the complainant. If the student has appealed the academic sanction imposed by the faculty member, the time periods set forth in this paragraph may be extended until ten (10) business days after the resolution of the student's appeal.*
7. *If a department chair, the dean, the senior vice president for academic affairs and/or the senior vice president for health sciences, become aware of multiple acts of academic misconduct by a student, they or their designees may, within thirty (30) business days after receiving notice of the last act of misconduct, prepare a complaint with recommendations*

for probation, suspension or dismissal from a program, suspension or dismissal from the University, or revocation of a degree or certificate, and refer the matter to the Academic Appeals Committee of the student's home college for proceedings in accordance with Section C, below, and so notify the student in writing.

4.12 Preparation for Graduation and Exit Interviews

In order to be cleared to graduate, a student **must meet with Dr. Rob MacLeod** to review the DARS audit report and to verify that all graduation requirements will be completed by the time of graduation. This meeting must occur **one semester prior to graduation**. See Applying for Undergraduate Degree for the details. Each student should seek guidance from the instructor of the Senior Thesis Writing and Presentation class (BME 4991/2), currently Heather Palmer, for the steps required for this approval.

Immediately prior to graduation, the student must attend an exit interview with a faculty member during a time announced in the senior classes. This exit interview **is required** and provides important feedback to the Department to help improve the BME program.

4.13 Undergraduate Advising

To receive specific advising, please visit the Department of Biomedical Engineering undergraduate office, SMBB Suite 3100, Office 3221, or contact any of the Undergraduate Advisors listed in Section 1.

5 BME Minor Program

The minor program is available to students interested in learning how to apply the knowledge gained in another engineering major to biomedical applications. It includes a set of required credits from BME, many of which can also count as electives in the home department.

5.1 Admission to the Minor program

To apply for admission to the program use see the Minor Application Form at the end of this document (Section 10). GPA requirements for the minor are consistent with those of the BME major (see Section 3.2). After completing the form, meet with the Department's Minor Program Advisor to finalize your application.

5.2 BME Minor classes

The course requirements for the BME Minor include two prerequisite courses:

BIOL 2020 (or BIOL 2021)	Cell Biology (or equivalent)
MATH 2250	Diff Eq/Lin Alg

and then 6 cr. hrs. of *Life Science Emphasis* courses from the following list:

BME 3202	Physiology for Engineers (4) Fall
BME 4001	Biotransport/Biomolecular (3) Spr
BME 4301	Introduction to Biomaterials (3) (Meets with MSC 5040) Spr
BME 5005	Computational Neuroscience (3) Spr odd years
BME 5160	Engineering Aspects of Clinical Medicine (2) Spr
BME 5306	Genetic Eng./Synthetic Biology (3) Spr
BME 6000*	Systems Physiology I (4) Spr
BME 6002*	Molecular Biophysics (3) Fall
BME 6230*	Functional Anatomy for Engineers (3) (Meets with ME EN 7120) Spr
BME 6302*	Biomaterials II (3) Spr
BME 6303*	Cell and Tissue Engineering (3) Fall
BME 6304*	Intro to Biopolymers (3) Fall
BME 6305*	Cell and Tissue Engineering Organ Systems (3) Fall
BME 6308*	Biomolecular Engineering (3) Spr
BME 6405*	Nanomedicine (3) every other Fall
BME 6430*	Systems Neuroscience (4) (Meets with NEUSC 6050) Spr
BME 6440*	Neural Engineering (3) Fall
BME 6770*	Genomic Signal Processing (3) Spr

and 7 cr. hrs. of *Engineering Emphasis* courses from the following list:

BME 1020**	Fundamentals of BME I (3) Spr
BME 2100**	Fundamentals of BME II (4) Fall
BME 3070	Biomedical Engineering Statistics (3) Spr
BME 3101	Biosignals Analysis (3) Spr
BME 3301	Computational Methods for BME (3) Spr
BME 4101	Biosystems Analysis & Modeling (4) Fall
BME 4250	Biomechanics I (4) Fall
BME 5110	Intro to Regulatory Affairs (3) Fall
BME 5401	Medical Imaging Systems (3) Fall
BME 5480	Ultrasound (3) (Meets with ECE 5480) Fall even years
BME 5701	Microfluidic Chip Design (3) (Meets with ME EN 5730) Spr
BME 5220	Biofluid Mechanics (3) Spr even years
BME 6421*	Fundamentals of Micromachining (3) (Meets with ECE 5221, ME EN 5050, MSE 6421) Spr
BME 6433*	Biomedical Stat. Sig. Proc. (3) Spr even years
BME 6640*	Introduction to Image Processing (3) (Meets with CS 6640 & ECE 6532) Fall
BME 7210*	Computational Biomechanics (3) Fall even years

* Note: These 6000-level classes may be taken by qualified undergraduates with permission of the instructor. Students must have appropriate prerequisites to take these classes.

** Only one of 1020 or 2100 can be included, the former for students interested in chemistry-based approaches and the latter for physics-based approaches to BME.

6 Sample BME Plan of Study

Here is a sample plan of study, a plan few students follow exactly but a useful starting point for planning. The best order of classes will depend on the needs of the student and the Undergraduate Advising can assist in selection of courses. **Note:** many students use the summer semesters for courses in the Sciences and Math and for the Gen Ed requirements. Descriptions of Biomedical Engineering Department courses can be found at https://bme.utah.edu/course-list

Fall Semester			**Spring Semester**		
Course #	**Title**	**Hrs**	**Course #**	**Title**	**Hrs**
Freshman Year					
BME 1010	Careers in Biomed Eng	1	BME 1020	Funds of BME I	3
CHEM 1210	General Chemistry I	4	CHEM 1220	General Chemistry II	4
CHEM 1215	General Chemistry Lab I	1	CHEM 1225	General Chemistry Lab II	1
MATH 1311	Hon Accel Eng Calc I(1)	4	MATH 1321	Hon Accel Eng Calc II(1)	4
WRTG 2010	College Writing	3	PHYS 2210	Physics for Scientists I	4
	Gen Ed Elective 1	3	or 3210		
Total		16			16
Sophomore Year (Spring Entry in Program)					
BME 2100	Funds of BME II	4	BME 3301	Computational Methods	3
BIOL 2020(2)	Cell Biology	3	BME 3091	Current Research in BME	1
MATH 2250	Diff Eq/Lin Alg	4	BME 3070	Statistics for Eng(3)	3
PHYS 2220	Physics for Sci. & Eng II	4	BME 5900	Digital Design and Fabrication	2
or 3220			CHEM 2310	Org. Chem I	4
			CHEM 2315	Org. Chem I Lab	2
Total		15			15
Junior Year					
BME 3202	Physiology for Engineers	4	BME 3101	Biosignals Analysis	3
BME 4250	Biomechanics I	4	BME 3801	bioDesign I	3
	BME Elective 1	3	BME 4301	Biomaterials	3
	Gen Ed Elective 2	3	BME 4990(4)	Biomedical Eng. Res.	1
	Amer. Inst. Elective	3		BME Elective 2	3
				Gen Ed Elective 3	3
Total		17			16
Senior Year					
BME 4801	bioDesign II	3	BME 4001	Biotransport/Biomolecular	3
BME 4991	Sen. Thes. Commun. I	2	BME 4992	Sen. Thes. Commun. II	2
BME 4101	Biosystems Anal./Model.	4		BME Elective 4	3
	Gen Ed Elective 4	3		BME Elective 5	3
	BME Elective 3	3		Gen Ed Elective 5	3
				Gen Ed Elective 6	3
Total		15			17
Grand total					127

6.1 Additional Notes

(1) As an alternative to this math sequence, students may take MATH 1310, 1320 and 2310.

(2) Students will take BME 1020, a required BME core class, which meets one of the prerequisites for BIOL 2020. Students may also take BIOL 1610 to meet the BIOL 2020 prerequisite, but it is neither required nor recommended for BME majors.

(3) ECE 3530, or CS 3130 may also stand as replacement courses for BME 3070. The MET E 3070 and Math 3070 will **not be considered** a substitute.

(4) All students must take BME 4990 before they begin the Writing & Communication series (BME 4991/2). In addition, students may also take BME 4995 once and apply that credit to the required BME electives. Students who perform a research internship outside of the University of Utah or with a faculty mentor who is not a member of the Department of Biomedical Engineering must seek prior approval for BME 4995 and, upon completion, a grade from the BME 4995 Course Director (Heather Palmer)

6.2 Prerequisites

While there are many variations on the plan laid out above, there are some courses which must be taken in certain orders. Such sequences are aimed at ensuring suitable preparation for all students and more productive and fulfilling experiences in the intermediate and advanced classes.

The current set of prerequisites and class sequences among the BME core classes are as follows:

1. PHYCS 2220 (or 3220), Physics for Scientists II, is a prerequisite for BME 3202, 4101, and 4001.
2. BME 3301 Computational Methods: should be one of the first classes students take in the program and is a prerequisite or co-requisite for almost all other BME classes at the sophomore, junior, or senior levels, *i.e.,* BME 3070, 3101, 3202, 4101, 4301, 4250, and 4001.
3. BME 3070 Statistics for Engineers should be taken in the first spring semester of the major, *i.e.,* directly after regular admission. It is a prerequisite or co-requisite for almost all other BME classes at the junior or senior levels. For transfer students or other, exceptional situations, it is possible to take BME 4301 together with BME 3070.
4. BME 1020 Fundamentals I: requires Math 1310 or 1311, and Chem 1210 and 1215. Chem 1220 and 1225 must also be taken before or concurrently.
5. BME 2100 Fundamentals II: requires Math 1320 or 1321 and Physics 2220 (or 3220) is a corequisite.
6. BME 4101 requires BME 3101 as prerequisite and BME 3202 as a pre- or co-requisite.
7. BME 3202 Physiology requires 3301 as a prerequisite.
8. BME 3802 bioDesign I is a prerequisite for BME 4801 bioDesign II.
9. BME 4991 Writing & Communication I requires BME 4990, BME Research, as a prerequisite.
10. BME 4992 Thesis Writing & Communication II requires BME 4991 Thesis Writing & Communication I as a prerequisite.

7 BME Electives

To successfully complete the BME elective component of the program requires a selection of courses that meets the following goals:

1. a minimum of **15** credit hours of course work, of which

2. at least **5** hours must be from courses taught in the College of Engineering and/or the College of Mines & Earth Sciences* (ensures meeting ABET course requirements), and

3. at least 9 of the hours must be at the upper division level (3000 or above).

4. and of which up to **3** hours may come from upper division courses outside the colleges of Science and Engineering, or be non-technical classes taught within the College of Engineering, provided they are approved by Dr. Rob MacLeod **before they are taken.** The goal of such classes is to provide exposure to materials from other disciplines, *e.g.,* Business, Law, Ethics, that directly support the individual goals of each student. All such courses must have a significant and direct link to engineering and must deepen the skill set and exposure of students in a field related to Biomedical Engineering. Note again that if a students would like to take a course from this category, the course **must be approved by Dr. Rob MacLeod BEFORE it is taken.**

The following are useful guidelines when selecting BME Electives:

- **Note:** Transfer credits are generally only accepted as a BME elective if they are lower division (1000 and 2000 level) and must first be approved for transfer by means of a Petition for Transfer Credit or Variance (the "tan sheet"). Additionally, if transferred upper-division BME electives are accepted, they will count as lower-division credit. See Section 3.3 for more details on transfer classes.

- Students should use past schedules as guidelines in scheduling BME elective classes to ensure that they do not conflict with required classes.

- For admission to graduate level classes (6000, 7000), all students must simply meet standard prerequisites and obtain written (email) permission from an instructor in order to apply for admission. Students should then forward the permission directly to an Undergraduate Advisor, who will then hand-enroll the student in the course. Note that admission to 7000 classes is generally restricted to PhD students so only available to undergraduates with explicit permission.

- A list of Biomedical Engineering Department courses suitable for inclusion as a BME elective appears at the end of this section.

- Students must pay attention to prerequisites to be sure the courses are taken in the correct order.

- Note that entry into upper division courses in other departments is often possible without the standard prerequisites for those departments as long as the associated BME core course is completed. For example, to enter upper division classes in Mechanical Engineering, ensure that the BME 4250, Biomechanics I course, is completed first (or concurrently). When in doubt, contact Dr. Rob MacLeod for clarification or assistance.

- Organic Chemistry II, both the lecture and lab courses, (CHEM 2320 and CHEM 2325), typically required for entry to medical school, are acceptable as BME elective.

- If students perform a second semester of research in a lab or internship with a company, they may take the class BME 4995 for a maximum of 1 hour of BME elective credit.

- Directed reading, independent study, literature surveys, and special project classes do **not** generally qualify as BME electives. Exceptions are possible but Dr. Rob MacLeod must approve these **beforehand**.
- Some research seminar classes (*e.g.,* BME 5280 and BME 6280, Biomechanics Research) may be acceptable for 1 hour of BME elective credit, but usually when they are used only to ensure adequate **college** credit hours, *i.e.,* they are not counted as part of the minimum 15 hours. Again, students must consult with Dr. Rob MacLeod beforehand to receive permission.

7.1 Approval of BME Electives

A student's BME elective plan must be approved by Dr. Rob MacLeod by submitting a BME elective Coursework Plan via the BME Undergraduate web site Seeking approval for a BME elective plan should occur in the first or second semester after admission to major status and before starting the BME elective sequence. Students may (and almost always do) update their plans through the course of their studies and should review the plan each semester. A final version of the plan must be approved in order to complete graduation requirements. **Students who have not applied for BME elective approval by the middle of the fall semester immediately following their admission may not be allowed to register for the following semester BME courses**.

Below are some samples of courses organized by focus or emphasis area. Note that in many cases, BME students can progress directly to the upper division classes offered by other departments **without completing the usual requirements** for those classes. When in doubt, Dr. Rob MacLeod or the instructor of the course can provide guidance.

7.2 Waiting Lists

Some of the BME electives that are offered only during specific semesters or are very popular are regulated via wait lists. All BME undergraduate advisors have access to these wait lists and can assist students in being added to the courses of interest. These courses include the following:

- BME 5160, Engineering Aspects of Clinical Medicine;
- BME 6110, Biomedical Technology in Anesthesia;
- and BME 6230, Functional Anatomy

7.3 Bioelectrical Engineering Focus

Students with a bioelectric focus are likely to take several ECE courses as part of their BME elective requirements. To satisfy those courses' prerequisites, these students should take some ECE-relevant BME-core courses earlier than other students. In particular, BME 2100, 3301, 3101, 4101 all satisfy some ECE prerequisties. Students may take BME 2100 and BME 3301 at the normal time, but BME 3101 and BME 4101 should be taken sooner than is typical. One simple way to take those courses early is to swap BME 3101 and a General Education Elective between sophomore and junior spring semesters, and to swap BME 4101 and BME 4250 between the junior and senior fall semesters.

The ECE undergraduate coordinators typically approve the following prerequisite substitutions:

1. BME 2100 can replace ECE 1250
2. BME 3301 can replace CS 1410/1420
3. BME 3101 + BME 4101 can replace ECE 2240 + ECE 3500

We designate three subspecialties in this focus area: 1) Biomedical instrumentation, 2) Cardiac Bioelectricity, and 3) Neural Bioelectricity. Each of these has the following associated recommended set of electives that will develop the specific skills needed to pursue each area. Note that some General Education electives may need to be moved around to accommodate the following BME elective plans.

7.3.1 Biomedical Instrumentation

Fall Semester			Spring Semester		
Course #	**Title**	**Hrs**	**Course #**	**Title**	**Hrs**
Sophomore Year (Assuming otherwise standard classes)					
BME 2100	Fundamentals II	4	MATH 3150	PDE's for Engineers.	2
			BME 3101	Biosignals	3
Junior Year					
ECE 2280	Fund of Eng Electronics	4	BME 5433	Biomed Stat Sig Processing	3
BME 4101	BioSystems	4	MATH 3150	PDE's for Engineers	2
Senior Year					
ECE 5960	Medical Instrumentation	3	ECE 3110	Engineering Electronics II	4

7.3.2 Cardiac Bioelectricity

Fall Semester			Spring Semester		
Course #	**Title**	**Hrs**	**Course #**	**Title**	**Hrs**
Sophomore Year (Assuming otherwise standard classes)					
BME 2100	Fundamentals II	4	MATH 3150	PDE's for Engineers.	2
			BME 3101	Biosignals	3
Junior Year					
BME 4101	BioSystems	4	BME 6000	Systems Physiology I	4
ECE 5960	Medical Instrumentation	3	PHYS 3730	Intro To Computing In Physics	4
Or					
ECE 5960	Bioelectricity Measurement	3			
Senior Year					
BME 6003	Cell. Electrophys.	3	BME 5433	Biol. Stat Sign Process.	3
Or					
BME 6460	Bioelectricity	3	CS 3200	Intro to Scientific Computing	3

7.3.3 Neuro Bioelectricity

Fall Semester			Spring Semester		
Course #	**Title**	**Hrs**	**Course #**	**Title**	**Hrs**
Sophomore Year (Assuming otherwise standard classes)					
BME 2100	Fundamentals II	4	MATH 3150	PDE's for Engineers.	2
			BME 3101	Biosignals	3
Junior Year					
BME 4101	BioSystems	4	BME 5433	Biomed Stat Sig Processing	3
ECE 2280	Fund of Eng Electronics	4			
Senior Year					
BME 6440	Neural Engineering	3	BME 5005	Computat. Neurosci.	3
BME 6003	Cellular Electrophysiology	3			

7.3.4 Summary of Bioelectric elective courses

BME 5460	Engineering Aspects of Clinical Medicine
BME 5480	Ultrasound
BME 5005	Computational Neuroscience
BME 5433	Biological Signal Processing
BME 6002	Cellular Electrophysiology
BME 6421	Fundamentals of Micromachining Processes
BME 6440	Neural Engineering
BME 6460	Bioelectricity
BME 6110	Biomedical Technology in Anesthesia and Critical Care
ECE 2280	Fundamentals of Engineering Electronics
ECE 3110	Engineering Electronics II
ECE 3300	Fundamentals of Electromagnetics and Transmission Lines
ECE 3510	Introduction to Feedback Systems
ECE 5231/32	Microsensors Lecture/Lab
ECE 5325	Wireless Communication Systems
ECE 5340	Numerical Techniques in Electromagnetics
ECE 5410	Lasers and Their Applications
ECE 5510	Random Porcesses
ECE 5530	Digital Signal Processing
ECE 5780	Embedded System Design
ECE 5960	Bioelectrical Measurement
ECE 5960	Medical Instrumentation
MATH 4600	Mathematics in Physiology and Medicine
PHYS 3610	Electronics for Scientific Instrumentation
PHYS 3620	Data Acquisition for Scientific Instrumentation
PHYS 4310	Physics in Biology
ENG 5020/6020	Emerging Technologies and Entrepreneurship

7.4 Biomedical Imaging Focus

BME 5480	Ultrasound
BME 5601	Scanning Electron Microscopy
BME 6330	Principles of Magnetic Resonance Imaging
BME 6401	Medical Imaging Systems
BME 6500	Mathematics of Imaging
BME 6640	Introduction to Image Processing
BME 7310	Advanced Topics in Magnetic Resonance Imaging
BME 7320	3-D Reconstruction Techniques in Medical Imaging
CS 5320	Computer Vision
CS 7640	Advanced Image Processing
MATH 3150	PDEs for Engineers
PHYS 3730	Intro To Computing In Physics
PHYS 4310	Physics in Biology

7.5 Biomaterials Engineering Focus

BME 5308	Biomolecular Engineering
BME 5601	Scanning Electron Microscopy
BME 6002	Molecular Biophysics
BME 6302	Biomaterials II
BME 6303	Cell and Tissue Engineering: Stem Cells in Tissue Engineering
BME 6305	Cell and Tissue Engineering: Organ Systems Design
BME 6304	Polymers and Biopolymers
BME 6405	Nanomedicine
BME 6422	Biomedical Applications of Micromachining
BME 6900	Biomimetic Materials Engineering
BIOL 3210	Microbiology
CH EN 6853	Thermodynamics
CH EN 3453	Heat Transfer
CH EN 5103	Biochemical Eng.
CH EN 5810	Nanoscience
MSE 2160	Elements of Materials Science & Engineering
MSE 3010	Materials Processing
MSE 3310	Introduction to Ceramics
MSE 3011	Materials Characterization
MSE 3210	Electronic Properties of Solids
MSE 3410	Introduction to Polymers
MSE 5072	Thin Film Techniques
MSE 5073	Nanostructured Materials: Science & Technology
MSE 5074	Photovoltaic Materials & Solar Cells
MSE 5353	Physical Ceramics
MSE 5354	Processing of Ceramics
MSE 5475	Introduction to Composites
ME EN 2010	Statics
ME EN 2030	Dynamics
ME EN 5060	Sustainable Products and Processes
MET E 1620	Introduction to Physical Metallurgy
MET E 3530	Experimental Techniques in Metallurgy
MET E 5260	Physical Metallurgy I
MET E 5450	Mechanical Metallurgy
MET E 5600	Corrosion Engineering

Note: for a complete list of elective course in Materials Science Engineering, please see the MSE Technical Electives web page.

7.6 Biomechanical Engineering Focus

BME 5220/6220	Biofluid Mechanics
BME 5250/6250	Biomechanics II (treat as a required class)
BME 5601	Scanning Electron Microscopy
BME 6230	Functional Anatomy for Engineers
BME 6421	Fundamentals of Micromachining
BME 5280	Biomechanics Research (treat as required class, maximum enrollment of 1 semester)
BME 6280	Biomechanics Research (treat as optional, second semester of research seminars)
BME 7210	Computational Biomechanics
CH EN 6853	Thermodynamics
CH EN 3453	Heat Transfer
CS 3200	Introduction to Scientific Computing
CS 5962	Programming for Engineers
CS 5963	Introduction to Data Science
MATH 3150	PDEs for Engineers
ME EN 5250	Programming for Engineers
ME EN 5510	Introduction to Finite Elements
ME EN 2650	Manufacturing for Engineering Systems
ME EN 2010	Statics
ME EN 2030	Dynamics
ME EN 3300	Strength of Materials
ME EN 3610	Thermodynamics
ME EN 3650	Heat Transfer
ME EN 3710	Fluid Mechanics
ME EN 4610	Heat Transfer
ME EN 4650	Thermal luid and Energy Systems (TFES) Lab
ME EN 5010	Principles of Manufacturing Processes
ME EN 5035	Design of Experiments
ME EN 5060	Sustainable Products and Processes
ME EN 5160	Fundamentals of Systems Engineering
ME EN 5170	Systems Engineering and Integration
ME EN 5300	Advanced Strength of Materials
ME EN 5500	Engineering Elasticity
ME EN 5520	Composites
ME EN 5720	Comp. Fluid Mechanics
ME EN 5960	Product Safety
ME EN 6200	Classical Control Systems
ME EN 6205	System Dynamics
ME EN 6220	Robotics
PHYS 3730	Intro To Computing In Physics
PHYS 4310	Physics in Biology
ENG 5020/6020	Emerging Technologies and Entrepreneurship

7.7 Computational and Informatics Focus

BME 6005	Computational Neuroscience
BME 6640	Introduction to Image Processing
BME 6670	Genomic Signal Processing
BME 6760	Modeling and Analysis of Biological Networks
CH EN 5353	Computational Fluid Dynamics
CH EN 6703	Applied Numerical Methods
CS 1410	Object-Oriented Prog
CS 1420	Accelerated Intro to Object-Oriented Prog
CS 2100	Discrete Structures
CS 2420	Introduction to Algorithms & Data Structures
CS 3100	Models of Computation
CS 3190	Foundations of Data Science
CS 3200	Introduction to Scientific Computing (recommended)
CS 3500	Software Practice I
CS 3505	Software Practice II
CS 3810	Computer Organization
CS 4150	Algorithms
CS 4300	Artificial Intelligence
CS 4960	Intro. Computational Geometry
CS 4964	Math for Data
CS 5150	Advanced Algorithms
CS 5300	Artificial Intelligence
CS 5310	Robotics
CS 5320	Computer Vision
CS 5340	Natural Language Processing
CS 5350	Machine Learning
CS 5530	Database Systems
CS 5540	Human/Computer Interaction
CS 5600	Introduction to Computer Graphics
CS 5610	Interactive Computer Graphics
CS 5630	Scientific Visualization
CS 5650	Visual Perception from a Computer Graphics and Visualization Perspective
CS 5962	Programming for Engineers
CS 5360/Math 4100	Introduction to Data Science
CS 5968	Algorithms & Approximation
CS 6210	Advanced Scientific Computing I
CS 6320	3D Computer Vision
CS 6330	Intro to Robot Control
CS 6630	Visualization

7.7 Computational and Informatics Focus (con't)

ECE 5340	Numerical Techniques in Electromagnetics
MATH 3150	PDEs for Engineers
MATH 3600	Mathematics in Medicine
MATH 4600	Mathematics in Physiology and Medicine
MATH 5110	Mathematical Biology I
MATH 5120	Mathematical Biology II
MATH 5600	Survey Numerical Analysis
MATH 5610	Intr. Numerical Analysis I
MATH 5740	Mathematical Modeling
ME EN 5510	Introduction to Finite Elements
PHYS 3730	Intro To Computing In Physics (recommended)

7.8 Design, Regulatory, & Entrepreneurship Focus

This focus requires a subset of the following classes:

BME 5110	Regulatory Affairs I
BME 5120	Regulatory Affairs II
BME 5160	Engineering Aspects of Clinical Medicine
BME 6110	Biomedical Technology in Anesthesia
ENGIN 5020(1)(2)	Engineering Entrepreneurship
ENGIN 5790(1)(2)	The Business of Entrepreneurship
ENGIN 5791(1)(2)	Launching Technology Ventures
MDCRC 6000	Intro to Biostatistics
MDCRC 6050	Biostatistics for Basic Science
MDCRC 6040	Design and Implementation of Clinical Trials
MDCRC 6430(2)	Bioethical Issues of Clinical research
MDCRC 6470	Implementation of Clinical Trials
ME EN 5000(1)(2)	Engineering Law & Contracts (or "IP and business Law")
ME EN 5035	Design of Experiments
ME EN 5050	Fundamentals of Micromachining Processes
ME EN 5051	Microsensors
ME EN 5055	Microsystems Design and Characterization
ME EN 5100	Ergonomics
ME EN 5130	Design Implications for Human-Machine Systems
ME EN 5160	Fundamentals of Systems Engineering
ME EN 5170	Systems Engineering and Integration
PHIL 3520(2)	Bioethics

(1) Taking BME 5110, ENGIN 5020, 5790, & 5791 will complete the Engineering Entrepreneurship Certificate (see the College of Engineering Entrepreneurship web site for details). Note: While ME EN 5000 is listed as a College of Engineering requirement for the Entrepreneurship Certificate, due to the heavily regulated nature of the medical device industry, biomedical engineering students must complete BME 5110 instead of ME EN 5000 to complete the certificate.

(2) Only one of these classes may be counted for BME elective credit. The class will fill the maximum 3 credits that may come from upper division non-technical courses.

7.9 Premedical Focus

Students planning on applying to medical school may wish to design a set of BME electives that supports this goal. The BME electives selected should meet, to the extent possible, three criteria:

1. Students complete course requirements set by the medical schools for admission;
2. The selected courses are from a subject area in which the student performs well;
3. The courses provide the student a sound foundation for an alternative career choice should the medical schools not respond favorably.

The BS program in BME generally meets all the course requirements for medical school with the exception of Organic Chemistry II (lecture and laboratory) and laboratories in introductory courses in Biology. However, the BME core courses taken in the junior and senior years supply laboratory course hours which may be accepted in lieu of these explicit laboratory courses. Some medical schools also require an upper division writing course, *i.e.,* they may not accept the Thesis Writing and Communications series BME 4991/4992 as equivalent.

Because there is considerable variability in what is both recommended and required among different medical schools, students should review the entrance requirements of the medical schools to which they are considering applying and determine which of the following courses (or equivalent) to include in their BME electives. They should also schedule advisory visits with TBD, the special advisory for pre-medical students.

BME 5480	Ultrasound
BME 6000	Systems Physiology I: Cardiovascular System
BME 6303	Cell and Tissue Engineering: Stem Cells in Tissue Engineering
BME 6305	Cell and Tissue Engineering: Organ Systems Design
BME 6401	Medical Imaging Systems
BME 6230	Functional Anatomy for Engineers
BME 6405	Nanomedicine
BME 6430	Systems Neuroscience
BME 6440	Neural Engineering
BME 6110	Biomedical Technology in Anesthesia and Critical Care
BIOL 2030	Genetics
BIOL 3210	Microbiology
BIOL 3215	Cell Biology Lab
BIOL 3230	Developmental Biology
BIOL 3510	Biological Chemistry I (highly recommended)
BIOL 3515	Biological Chemistry Lab
BIOL 3520	Biological Chemistry II
CHEM 2320	Organic Chemistry II (a required class for medical school)
CHEM 2325	Organic Chemistry II Lab (a required class for medical school)
PATH 5030	Basic Immunology
MATH 3600	Mathematics in Medicine
ME EN 5035	Design of Experiments
PHYS 2215	Physics Lab I for S & E
PHYS 2225	Physics Lab II for S & E
PHYS 4310	Physics in Biology

7.10 Courses approved for inclusion as BME electives

All regular courses offered by Biomedical Engineering outside the required core classes in the BME program are recommended and approved for inclusion in the BME electives plan. This course list is changing constantly and course offerings change in other departments, so please consult with Dr. Rob MacLeod whenever making a decision on the BME electives. **It is up to the individual student to ensure that the BME elective courses exist and are offered at the time the student wishes to take them. Note that some courses are taught only every second year or may be postponed for a host of reasons.** For the most updated list of course offered by the Biomedical Engineering department, visit the "Course List" page on the department web site

7.11 Courses NOT acceptable for inclusion as a BME elective

The following courses are **not** acceptable as a BME elective. The reasons for excluding courses include:

- course does not include adequate engineering or biomedical content;
- course overlaps too much with a course already in the core curriculum of the BME program;
- course level, requirements, or evaluation are not equivalent to the rest of the BME program;
- course does not require active participation of the student

BME 4999	Honors Thesis/Project
BME 5950/6910	Independent Study
BME 6090/1	Department Seminar
BME 6464	Cardiac Electrophysiology and Biophysics Seminar*
BME 6810	Medical Imaging Seminar*
BME 6900	Special Topics**
BME 6930	Special Project
PHYS 3110	Physics of the Human Body I
PHYS 3111	Physics of the Human Body II
PHYS 2015 and 2025	Physics I/II Labs (take the Engineering and Sciences versions PHYS 2215/2225 instead).
	Language training courses

* Generally, students may take these courses for BME electives credit only if they otherwise have adequate numbers of hours but need to achieve the required number of college hours.

** Special topics class may count as BME electives, depending on the type and structure of the course. Please see Dr. Rob MacLeod **before** taking a special topics class to determine its status.

BioInnovate classes: The following courses are part of the graduate BioInnovate program and are open only to MS/PhD students in that program. They **do not** qualify as BME electives.

BME 6081	bioInnovate I
BME 6082	bioInnovate II
BME 6181	Clinical Problem Solving Through Strategic Analysis I
BME 6182	Clinical Problem Solving Through Strategic Analysis II

8 Thesis Writing and Communications Project

The goals of the senior thesis project are to develop specific experience and skills in scientific research and/or engineering design and development and to learn to present the results of such a study in all forms: written, oral, and visual. For most students, the senior project should be the culminating activity of their program in which they use skills acquired from numerous courses and laboratory experiences and develop a whole new set of abilities in the science (and art) of organizing and presenting ideas.

The senior thesis project involves two components:

1. A substantial involvement (approximately 200 hours) in one of three research activities, each of which requires participation in the BME 4990 class:
   - A scientific research project supervised by a faculty member either in or affiliated with the Biomedical Engineering Department.
   - A design project that extends above and beyond the scope of the BME Design Course, mentored by a BME faculty member.
   - A substantial design or research project undertaken as part of an industrial or academic internship.
2. Completing the Thesis Writing and Communications course series (BME 4991/2).

Success in the senior project requires students to take the following steps. Students must:

1. At the very latest in the last week of the winter break of the Junior year, obtain a position in a research lab, internship, or receive permission to use the design class project as your Thesis project. For help in finding lab placement there is a department directory that is organized by research topics at this link. After reading about their research, students should contact individual faculty whose research sounds interesting and ask for a meeting to discuss opportunities. Students must be prepared to volunteer in the lab (although paid positions often become available once they have established some skills).
2. Obtain the research contract and associated information and templates from the BME 4990 course web page or in Section 10 of this document.
3. Discuss with a mentor/manager the specific needs of the senior project and develop a plan to carry out and complete, **by August 1 of the summer before taking BME 4991**, a project of adequate scope to generate the results for the senior project. Students must obtain their signature on the Memorandum of Understanding (MOU) and the contract and submit this and an abstract to an Undergraduate Advisor to obtain the necessary permission code.
4. Request a permission code at the Undergrad Program Resources web page and sign up for BME 4990 before the fall semester in which you wish to take BME 4991.

The sections below contain more details about each of these steps.

8.1 Biomedical Engineering Research class

BME 4990 (BME Research) is course that meets weekly to provide coaching and best practices for research laboratory or the internship experience. This course runs in the spring semester and is a prerequisite for Senior Thesis Writing and Communications classes (BME 4991/2). To be allowed to take BME 4990, student must be actively working on a thesis project, either in a laboratory setting or in an internship. Additionally, enrollment will require a permission code that students receive when they demonstrate that they are actively participating in research, no fewer than 14 days before the beginning of the semester in which students wish take the course. Demonstration of participation in research is by means of a research/project contract to be read and signed by both the student and his/her Principle Investigator/Manager, and when applicable, the graduate student supervising the student's research.

More information about the course is available on the Department Course List web page and the contract template in Section 10 of this manual.

8.2 Biomedical Engineering Thesis Writing and Communication classes

This course sequence uses each student's required senior project as source information that the student will repeatedly present to the class in both a written and oral format. Due the communication emphasis of the class, the combination of BME 4991/2 covers the University's upper-division communication/writing requirement. During the course of the class, each student provides several drafts of their research thesis and several oral presentations that generate instructional criticism from the class students and the instructor(s). Each student also prepares a draft of their final project poster at the conclusion of the semester that are critiqued and returned at the start of BME 4992 for revision and resubmission.

8.3 Research opportunities

The program encourages all students to take advantage of opportunities to pursue a project in a research lab on the campus. Such projects are typically the basis for the data needed for the Thesis Writing and Communications course series but can also become a source of employment or the starting point of a research career.

A typical dialog with a student about pursuing research opportunities might go as follows:

Student: "I have a few questions concerning the senior project that I am hoping you can help me with: "Does my project need to be related to the bioelectric engineering focus I chose? "

Advisor: "Heavens, no! Often the point of the project is to delve into some biological system or applications area that is new to you. Or to simply see how a lab operates."

Student: "Does the project need to be solely my own work or can I build my project off of previous research?"

Advisor: "We always assume that senior projects are pieces of a larger project; most research we engage in is like this actually. The main thing is to be sure you understand the larger project and how your piece fits. You can make this context clear in your writing and your presentations."

Student: "Would you recommend using the design project as the senior project? What are the advantages and disadvantages of choosing this option?"

Advisor: "This is a path less traveled and so we are still gaining experience on how to make this work. We have perhaps 1 student per year who has decided on this option. I think all students benefit from a true lab experience, especially those considering medical or graduate school. The design experience also has value but all things about the specific project have to be just right for it to work out well as a senior project."

Student: "Are you aware of any lab openings within the biomedical engineering department that could help me get started on a project? If so, how is the best way to contact them?"

Advisor: "We don't keep lists of openings but rather respond to students approaching us by creating projects such students could work on. Some faculty place limits on the number of UG students they have in the lab at any given time, while others are more flexible. So the best approach is to identify those faculty who pursue research that you find motivating and interesting. The department web site is a good place to start such a search, in the Directory by Research Area web page

"Once you have narrowed the search, contact some professors by email and ask them for an appointment to discuss possible senior projects they might have. It is helpful to come to the interview informed from reading some of the professor's papers, enough to at least have an idea of the research and some questions prepared. Then see what options emerge."

Student: "I am concerned that since it is the spring of my Junior year, I am behind in getting started on this, so I would appreciate any help you could give me in getting started."

Advisor: "If you start aggressively now with the plan of working over the summer on the project, then you should be fine. But do start NOW and feel free to contact me again with more questions or to get suggestions."

If there are questions or uncertainty at any step in the process, the Major Advisor is available to help.

8.4 Planning for Graduate School

Here are some tips to help prepare for further training in graduate school, especially a PhD or research MS degree. These describe a personal perspective of Dr. Rob MacLeod, Director of the Undergraduate Studies.

> "Finding a good mentor or mentors at each step is key. These are people who not only write nice letters for you but are there on a regular basis to answer the little questions that come up along the way, to bounce ideas off when you are considering various options. They should be people you respect, have relevant experience, and who you feel you can trust to put your interests ahead of other considerations. It helps if you feel like you can talk openly and honestly with them. Natural candidates are the PIs from the lab(s) you spend time in, perhaps also a mature post doc or even a grad student, perhaps even a mix of these different roles. Finding someone who already does what you might one day want to do can be very helpful too, be this an academic person or someone from industry.
>
> "If you have a passion, *e.g.,* sports, music or arts, you can also seek out mentors who understand your situation. We usually have several PhD students who are former varsity or even national team level athletes and they could help you understand and also overcome the special challenges of balancing sports and school in a way that most cannot. I (Dr. MacLeod) was not a student athlete but rather a manager of our varsity hockey team as a student. I had arguably a worse schedule than the athletes with practice and travel and all the support and organizational work behind the scenes; it was tough to keep up course work (even tougher to give up ski seasons). Very few of my team were taking challenging academic courses and it was pretty isolating at times when I was awake late at night in some hotel room finishing my physics homework. Someone who working full time as a student has a different experience, as does someone starting a family, or someone with full financial support and few other obligations. If you can find people who have been through your experience, they will always be more empathetic and supportive, hopefully also helpful.
>
> "A book to consider owning (and reading!) is called 'A PhD is not Enough', which is useful even before the PhD and clearly once you are doing it. It summarizes are lot of information about the process. There are other books with similar goals so feel free to browse them too and see if they speak to you.
>
> "Consider attending a meeting like BMES, which is really directed towards students, both grad and undergrad. They have a wide range of science sessions, which are mediocre but still a nice venue to present your own research. More important are the opportunities to meet other students and to check out different programs; most good programs have a booth to get information and meet people and there is also a social event evening when programs put on a party. So each of a set of hotel rooms at the conference host parties from different programs where you are meant to mingle and meet people. The deadline for submitting something to this meeting is usually March or April (the meeting is always in the fall) so make sure you plan ahead, talk to your research mentor about what it would take to go to this meeting with a poster

or even a presentation, start to seek out financial support (the department will often help, for example, as will the ASUU).

"Similarly, make sure you are getting UROP funding and take advantage of the special sessions they have. They accept applications a couple times per year so find out those deadlines and then work with your research mentor to prepare a solid application.

"Find a like minded group of undergrads, students who share your goals and with whom you can discuss openly. They do not need to be BME students, just students who aspire to a PhD program. It is like any other team setting, when you can share the stresses and the joys of trying to reach your goals. They can be sources of information and motivation and as a group, can often help leverage or even initiate events. The University and certainly our program are very responsive to students and if a groups proposes something useful like a panel discussion or a meeting with some successful people in the profession, then there are often ways to organize such things.

"Attend the Senior Symposium even before you have to present at it. It is usually around the third week in April in the evening and it is an excellent chance to see the sort of research and the level of presentations that you should be aiming for. You can meet students this way, talk to seniors who are also planning on graduate school or who have perhaps worked in labs you might be targeting. They can, for example, tell you about how a specific lab works in practice, how to improve your chances of getting into that lab or generally being successful in undergraduate research."

9 B.S./M.S. Program

The Department offers for students interested in rapidly advancing to the Master's level a combined B.S./M.S. program. The program is described in a separate document on the BS/MS web page and students interested in the program should read this description carefully to ensure that their course of study complies with the requirements.

For students interested in pursuing the BS/MS, please first meet with any of the Undergraduate Advisors. They are well-situated to provide foundational information about the program. Once students have completed their first official semester in the major (typically spring of sophomore year), they should plan to meet with the Graduate Advisor to discuss the best way to navigate both the admission and completion process for the BS/MS degree.

Note that international students on visas are not eligible to participate in the combined BS/MS programs, per SEVIS regulations according to the U.S. Immigration and Customs Enforcement (http://www.ice.gov/sevis).

10 Forms

The forms on the following pages are also available in paper form from an Undergraduate Advisor and in electronic form on the department UG Program website.

Note: To submit proposed BME electives, please use the electronic entry system available at the BME Undergraduate Resources web site .

Department of Biomedical Engineering
Application for Admission to Major Status in BME (2022/23)

Instructions: To earn a Bachelor of Science in BME, you must be admitted to major status before registering for upper-division Biomedical Engineering courses. To be considered for major status, each of the courses listed below must be passed with a grade of C or better, the GPA among the courses listed below must be at least a 3.4, and the cumulative U of U GPA must be at least a 3.0. If any of these criteria are not met, your application may not be considered.

Applications are due by the last day of fall classes of every year; **late applications will not be considered.**

For classes in progress at the time the application is submitted, DO NOT include a grade. However, DO indicate the semester and year a course is being taken. Indicate if you intend to apply for an Honors designation on your Bachelor Degree.

Write legibly, and ensure that all grades included on the application are correct. Grades will be verified, and any inaccuracy may disqualify the application.

Application for Major Status Submission Process: set up a meeting with a BME academic advisor. Come prepared to complete the application for major status and bring with you a specific plan for your graduation timeline. In the meeting, you will discuss your graduation plan and submit permission code requests for the upper-division BME courses that you intend to take in the spring, as you begin the major. The application process is incomplete without exactly following this procedure.

Name: ____________________ Student No. __________

Address: ____________________ Phone: __________

____________________ Email: __________

Intention to apply for Honors designation Y / N? _____

Course		Letter Grade	Grade Value*	x	Credit Hours	=	Points	Semester/Year Taken
Example:		*A-*	*3.70*	*x*	*3*	=	*11.10*	*Fall 18)*
BME 1010	Careers in Biomedical Engineering	_____	**N/A**		**N/A**		**N/A**	_____
BME 1020	Fund. of Biomedical Engineering I	_____	_____	x	3	=	_____	_____
BME 2100	Fund. of Biomedical Engineering II	_____	_____	x	4	=	_____	_____
BIOL 2020	Cell Biology	_____	_____	x	3	=	_____	_____
CHEM 1220	General Chemistry II	_____	_____	x	4	=	_____	_____
CHEM 1225	General Chemistry II Lab	_____	_____	x	1	=	_____	_____
MATH 1311, 1320 or 1220	Accel. Eng. Calc I, Calculus II	_____	_____	x	4	=	_____	_____
MATH 1321,	Accel. Eng. Calc II	_____	_____	x	4	=	_____	_____
2210, or 2310	Calculus III/Vector Calc	_____	_____	x	3	=	_____	_____
MATH 2250	Diff. Equations & Linear Algebra	_____	_____	x	4	=	_____	_____
PHYCS 2210	Physics for Scientist & Engineers I	_____	_____	x	4	=	_____	_____
PHYCS 2220	Physics for Scientist & Engineers II	_____	_____	x	4	=	_____	_____
	Total				**34 or 35**			

* Grade Values: A = 4.00, A- = 3.70, B+ = 3.30, B = 3.00, B- = 2.70, C+ 2.30, C=2.00

A GPA from courses above (Total Points / Total Credit Hours): __________

B U of U Cumulative GPA reported on transcript: __________

Student Signature: ____________________ Date: __________

Office use

Confirmed: ____________________

Action date(s): _________ *Admit* _________ *Wait list* _________ *Decline*

Department of Bioengineering

APPLICATION FOR ADMISSION TO THE MINOR PROGRAM IN BIOMEDICAL ENGINEERING

(Return in person to the Dept. Minor Program Advisor)

Name ________________________ Student ID#____________________

Address ____

Email ________________________ Phone #____________________

Major Department____________________ University GPA (as on DARS) __________

Expected date of graduation ________________________________

—Proposed Program of Study –

Courses	**Semester Taken or to be Taken**
A. Math 2250 – ODEs and Linear Algebra	____________
Biology 2020 – Principles of Cell Biology	____________

B. Category I – Life Science Emphasis (see approved courses on website)– 6 cr. hrs. reqd.

____________________	____________
____________________	____________
____________________	____________

C. Category II – Engineering Emphasis (see approved courses on website) – 7 cr. hrs. reqd.

____________________	____________
____________________	____________
____________________	____________

NOTES

1. Minimum Grades – All courses listed above must be passed with a letter grade of C or better.
2. Cross-Listing – Courses that are cross-listed between the Bioengineering Department and another department may be taken from either department to count toward the minor.
3. Registration – If admitted to the minor program, you may obtain permission codes to allow you to register for upper-division Bioengineering courses by contacting the Undergraduate Secretary in the Bioengineering Department office.
4. Graduation Clearance – The semester before your plan to graduate, please bring the Graduation Clearance form (the same one signed by your major advisor) to the Minor Program Advisor in the Bioengineering Department to be signed.

- -

For Office Use Only: Univ. GPA checked ____________

Admission Decision: Admit __________ Don't Admit __________

Signed ____________________ Date ____________

Graduation cleared ______________ GPA at graduation ________

Semester____________________________ Year_________________

Student – Faculty/Manager Mentor Contract: BME 4990 (BME Research/Internship)

Student

Duties

- Minimum of 200 actively engaged project hours
  - Hours don't include training time and are often spread over multiple semesters
  - 80 hours minimum for 1 credit of BME 4990 (may be repeated under BME 4995)
  - Approximately 6 hours/week (minimum)
- Be integrated into a research/design group
  - Make weekly contact with faculty advisor/manager (or representative)
  - Participate in lab/company culture including attending group meetings
  - Become trained to perform experiments, simulations, device testing, or related tasks
- Conduct literature review for project
  - Read key papers related to research project under guidance of research advisor/manager
- **Be actively engaged in the research or design activity for the thesis project**
  - Actively participate in experimental/engineering design
  - Conduct experiments, simulations, tests and/or designs
  - Apply statistics to experimentation
- Generate results for papers, posters, and presentations to be used in BME 4991/4992
  - Papers, posters, and presentations will be single author documents in BME 4991/4992
  - Students must not plagiarize, including other lab documents
  - Material submitted for a grade in BME 4991/4992 must be the student's work product and should accurately reflect the student's ability (i.e. mentor/manager will not write or edit the thesis)
- Create a project that is approved by PI/Manager
  - **Submit a 3-5 page research report to the Thesis course Primary Instructor (Heather Palmer) prior to enrolling in BME 4991 (Thesis I). See assignment sheet for report requirements.**

Expectations/Deliverables

- Collect data for and complete thesis project prior to taking BME 4991
  - Minimum of 200 total research/project hours
  - Typically done over several semesters but can be done in one
- Successful completion of BME 4990 (C grade or better) allows enrollment in BME 4991
- Volunteer position unless UROP or other funding is obtained
- **Submit a 3-5 page research report to the Thesis course Instructor/Coordinator prior to enrolling in BME 4991**

Faculty Advisor/Manager

Duties

- Act as a mentor for the student
  - **Direct in development of a clearly defined thesis project**
  - Meet regularly with student
  - Provide direct, regular feedback to student on his/her performance
  - Facilitate lab participation (e.g., be considerate of student's class schedule)
- Provide instruction on bibliography generation
  - Provide three papers to start literature research
  - Instruct student on literature search methodologies
- Provide instruction on lab methodologies
  - Involve student in experimental or engineering design of project
  - Instruct on lab safety and appropriate methodologies for project
  - Introduce appropriate statistical treatment of data and post-hoc analysis
- Provide limited review of project-relevant papers, posters, and presentations
- Papers, posters, and presentations will be single author documents in BME 4991/4992
  - Remind students not to plagiarize lab documents
  - Material submitted to BME 4991/4992 must be the student's work product and accurately reflect the student's ability (i.e. mentor/manager will not write or edit the thesis)
- Identify intellectual property concerns and develop an appropriate disclosure strategy
  - Student will publically present work in April of the year taking BME 4992
  - The senior symposium in April is considered a public disclosure by USPTO standards

Expectations

- Student will contribute at least 80 hours for BME 4990
- Student will contribute at least 200 hours toward completing thesis project
- Student will enhance lab/company community
- Student has no expectation to be paid for research hours (except in an internship setting in industry) but advisor is not restricted from paying the student

I, the undersigned, hereby acknowledge that I have read and understand the advisor/manager expectations as well as the student expectations and will comply with them to the best of my ability. **I also understand and verify that the project is the student's thesis project and that it will be used for and presented in BME 4991/4992.**

Advisor/Manager's Name (Please Print):____

Advisor/Manager's Signature:____________________________________ Date:___________________________

Advisor/Manager's Email:____

Graduate Student's Name (if applicable):____________________________ Date:___________________________

Graduate Student's Email:____

Student (print):______________________________________ Date:____________________________________

Student Email:____ Student ID #:___________________________

Semester___________________________ Year________________

BME 4990 Research/Design Report Assignment

Purpose: Eligibility for BME 4991 (Thesis Writing and Communication I) is based on the content of this report. As you are aware, you need to meet two minimum requirements: 1-at least 200 hours of research on one project (this can be done as part of an internship) and 2-a completed research/internship project. The research/internship project may be done in conjunction with a graduate student or coworker, but you will EXCULSIVELY focus on your personal contribution to the research/project. This paper is SINGLE AUTHOR (i.e. you).

Your eligibility will be determined by the results you include in this report. Please provide relevant tables, charts, and figures to demonstrate your findings.

Your audience for this report is a general, academic biomedical engineering reader. Your audience dictates much about the writerly choices you make.

This report is **due by the last day of classes in the semester (the specific date will be communicated to you)**. Please use Microsoft Word, not pdf.

Please cover these 7 aspects as thoroughly as possible in 3-5 pages (1.5 or double spaced). Include headers to designate specific sections (e.g. Introduction, Methods, Results, Timeline). Note that the page limit does not include figures, charts, and tables (these can take as many pages as necessary beyond the 3-5):

1. **Title and author**: Use a title that balances the general area of the research with your specific contribution. A reader will decide whether or not to continue with a scientific article based on the title, so choice of words and phrasing is part of the effectiveness of the paper—be careful to make the title accessible and not unwieldy. Finally, this is a single-author paper, so only your name will appear in this area.

2. **Introduction**: Appropriately cover the global context as well as the project's context. Be sure to include your hypothesis, design aim, or method aim. Any work that is not your own that is included here should be cited.

3. **Methods**: Include the materials used, describe the experimental method and the rationale behind why this method was used, and describe any data processing used (including statistical analysis). You may organize the methods according to subheadings. Provide sufficient detail to demonstrate that you followed a robust methodological approach.

4. **Results**: Include the relevant results derived from your methods. You need sufficient detail to allow your reader to fully understand your findings, but DO NOT interpret. You may organize the results section according to the relevant subheadings found in methods, but it isn't required. You need sufficient detail to allow your reader to fully understand your findings. Also, include appropriate tables with useful titles and figures with useful captions, and relevant statistics.

5. **In-text References**: Cite any information pulled from primary literature according to *IEEE Transactions on Biomedical Engineering*.

6. **Reference Section**: Include 5-7 references. Cite in the text where applicable (this is most likely to come up in the background). Format according to *IEEE Transactions on Biomedical Engineering*.

The report format is submission style (i.e. single-column, 1.5 or double spaced, 10 or 12 pt., any professional font). However, provide your charts, tables and figures as near as possible to the text where you describe them. Also include a title and page numbers.

7. **Timeline:** If you are finished with your project, please simply indicate that you are done. If the results are preliminary, provide a detailed timeline (dates) of when you will have your results. The results must be collected, analyzed, and ready to report by August 1. The timeline will greatly determine whether or not you will be allowed to take BME 4991.

Please refer to the grading rubric for more details on content areas.

Semester___________________________ Year_________________

BME 4990 Report Rubric	Comments
Background:Global Context, Project Context, Research/Design/Method Statement, Strategy and Accomplishments	
Methods:Description of Materials, Experimental methods with rationale, and data processing, including statistics	
Results: Detailed description of findings or prospective findings from methodological approaches (qualitatively and quantitatively) Include data analysis and statistics (if available)	
Timeline: If results are preliminary, provide a timeline of major milestones	
Structure and Organization: Logically ordered ideas, Flow, Transitions, Appropriate sign-posting and over-viewing (between sections), Clearly identifiable topic sentences, Balance	
Supporting Material/References: 5-7 relevant references; Consistent citation format	
Overall written presentation quality: Effectively communication to the intended audience (discourse community) Balance between concision and detail Definition of terms/abbreviations/symbols	

Semester___________________________ Year________________

BME 4991/4992 (Thesis Writing and Communication I and II)

Faculty/Manager Memorandum of Understanding

Thesis Writing and Communication I and II (BME4991/4992) are the research writing and communication capstone experience for the undergraduates in the Biomedical Engineering BS degree in the Department of Biomedical Engineering at the University of Utah. Prior to taking this course sequence, students have participated in health-related, data-driven research, and have completed a research project. The scope of the project can be broad or narrow, simple or robust, but the purpose of the project is to be mentored and learn research practice, data analysis, and making claims substantiated by results. Furthermore, the project can be performed as a component of a larger project, but the student may only make claims based on his or her own contribution to that work.

The deliverables of this course are as follows:

1. A single-author (the student), publishable-quality thesis paper,
2. A conference-quality research poster geared toward a generally educated biomedical engineering audience and shown at the annual Biomedical Engineering Senior Research Symposium*,
3. A 15-minute, conference-quality scientific presentation given to an audience of peers, and
4. A 5-minute research presentation geared to a public, non-scientific audience that will be presented at the annual Biomedical Engineering Senior Research Symposium in April.**

I understand that _______________________________ (student) will be using research done under my guidance for his/her Thesis Project. He/she has my permission to use this research in the ways outlined above.

Name:____ Date:__________________________________

Signature: _____________________________________

*The student will meet with his/her advisor to receive an additional permission on the research poster prior to it being presented at the Symposium.

**If you have concerns about a public disclosure (for reasons of IP), it is possible for the student to meet the course requirements with a private, closed presentation to the course instructors.

Note: If you feel that presenting the research publically is acceptable but feel uncomfortable with the way your name or lab may be represented, there is no obligation to have yourself included on the poster as the research advisor or in the presentation. Please simply request that the student remove your name.