Department of Bioengineering
Undergraduate Handbook
2009 - 2010
University of Utah Department of Bioengineering

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Salt Lake City, Utah 84112
585-3651 (WEB) and 581-8559 (BPRB)

The Department of Bioengineering offers a Bachelor of Science degree in Biomedical Engineering, as well as two programs for earning a combined BS/MS degree in Bioengineering. The Department also offers MS, and PhD degrees (described elsewhere).

This handbook is intended to give information about policies and procedures for the undergraduate program in Biomedical Engineering. Please come to the Department office at 2646 Warnock Engineering Building, or email an advisor, if you have questions not answered here. The information in this handbook as well as various downloadable forms are also available online at *www.bioen.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. Such markings may not be visible in the HTML version of the handbook—please see the pdf edition for clarification.

Contact Information and Links

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Department Web Site:	www.bioen.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		
Web Sites:	www.embs.org		

Contents

1 Program description

1.1 Mission

The mission of the Department of Bioengineering is to advance human understanding, health, and the quality of life through:

- internationally recognized research, discovery, and invention in the area of biomedical engineering;
- education of world-class Ph.D. scientists and engineers for accomplishment in research, academics, medicine, and industry;
- education of 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 of scientific discoveries and biomedical technology to the private sector nationwide;
- delivery of high-quality M.E. continuing education to enhance the economy by supporting biomedical industries;
- training of students throughout the College of Engineering in bio-based solutions to traditional engineering problems and in the application of their specialty to biological and biomedical science.

1.2 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;
- motivated to pursue life-long learning, including understanding contemporary questions at the interface of biomedical science, technology, and society.

1.3 Program outcomes

The Undergraduate Engineering Program Outcomes are:

- an ability to apply knowledge of mathematics, science, and engineering;
- an ability to design and conduct experiments, as well as to analyze and interpret data;
- an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
- an ability to function on multidisciplinary teams;
- an ability to identify, formulate, and solve engineering problems;
- an understanding of professional and ethical responsibility;

- an ability to communicate effectively in an oral format;
- an ability to communicate effectively in a written format;
- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
- a recognition of the need for, and an ability to engage in life-long learning;
- a knowledge of contemporary issues;
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The BME Specific Program Outcomes include:

- an understanding of biology;
- an understanding of physiology;
- an ability to make measurements and interpret data from living systems an ability to address problems associated with the interaction between living and nonliving materials and systems;
- a capability to solve the problems at the interface of engineering and biology by applying ADVANCED MATH including differential equations;
- a capability to solve the problems at the interface of engineering and biology by applying STATISTICS;
- a capability to solve the problems at the interface of engineering and biology by applying SCIENCE (hypothesis driven research);
- a capability to solve the problems at the interface of engineering and biology by applying ENGINEERING (design and analysis).

2 Status and admissions

2.1 Pre-Major status

Students beginning the undergraduate program, including transfer students, should choose the Pre-Biomedical Engineering category as their major for registration purposes. Pre-major students are eligible to register for all 1000 and 2000 classes listed in the freshman and sophomore years of the **Suggested Biomedical Engineering Plan of Study** in Section 4. 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 department. Pre-majors are strongly encouraged to meet early with the Pre-Major Advisor in the Department to outline a course of study that will prepare them to apply for major status in a timely manner.

2.2 Admission to major status

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 **specific grade point average made up of selected courses**. See Application Form at the end of this document and check with the 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).

To be considered for admission to major status, a student must have completed the following courses:

BIOEN 1101	Fundamentals of Bioengineering I
BIOEN 1102	Fundamentals of Bioengineering II
BIOEN 2000	Careers in Biomedical Engineering
BIOL 2020	Cell Biology (or equivalent)
CHEM 2310	Organic Chemistry I
CHEM 2315	Organic Chem Lab I
MATH 2250	Diff Eq/Lin Alg
PHYCS 2210	Physics for Scientists I

with an overall grade point average (GPA) in these classes of 3.0 or better. Combining this score with the overall University GPA (including transfer credit) leads to a composite GPA (as calculated on the application form) which must be 3.25 or higher for automatic admission. Students with a composite GPA below 3.25 but above 3.0 will join an admission waiting list.

2.3 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 and in the Department of Bioengineering Office) 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 technical credit by allowed toward completion of the BS degree in Biomedical Engineering. This 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.

2.4 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 March 1. Contact the Department Office or see the Department web site for details.

3 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 126 semester hours of the following requirements:

1. University's General Education requirements,
2. Mathematics and Science courses,
3. Biomedical Engineering core courses, and
4. Track 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 grades on the AP test. Details are in the www.ugs.utah.edu/catalog/ under the department offering the specific course.

3.1 General education requirements

See the website www.ugs.utah.edu/student/gened/index.htm for a description of the University's General Education requirements. General Education includes Intellectual Explorations courses (including a Diversity requirement), and the Writing, American Institutions, and Quantitative Reasoning course requirements.

Intellectual explorations Students must take two courses in each of the areas of Fine Arts, Humanities, and Social and Behavioral Science. The requirement in the Physical and Life Science area is automatically met by the Biomedical Engineering curriculum. One of the Intellectual Explorations courses selected should also meet the Diversity requirement. See the website www.ugs.utah.edu/student/gened/dv.htm for a description and list of Diversity courses. Note that not all of the classes that meet the Diversity criterion are also courses in the Intellectual Explorations lists. Students should try to take a Diversity course that will clear two requirements (Diversity and Intellectual Explorations) simultaneously.

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 BIOEN 4202 (Bioengineering Project II) in the senior year.

American institutions See the website http://www.ugs.utah.edu/student/gened/ai.htm 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 BIOEN 5001 and BIOEN 5201 (Biophysics and Biomechanics).

International Course Requirement Each student entering the University on or after Fall, 2007, must fulfill an upper division Internal 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 the Undergraduate Studies Web site for more information and an up to date list of accepted courses.

3.2 Mathematics and Science

The following courses are required from the areas of mathematics and science:

MATH 1250	Calculus AP Students I
MATH 1260	Calculus AP Students II (or equivalent)
MATH 2250	Diff Eq/Lin Alg
PHYS 2210	Physics for Scientists I
PHYS 2220	Physics for Scientists II
CHEM 1210	General Chemistry I
CHEM 1215	General Chemistry Lab I
CHEM 1220	General Chemistry II
CHEM 1225	General Chemistry Lab II
CHEM 2310	Organic Chemistry I
CHEM 2315	Organic Chem Lab I
BIOL 2020	Cell Biology

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

3.3 Biomedical Engineering Core

The following 16 courses are required from the BME Core:

Premajor	
BIOEN 1101	Fundamentals of Bioengineering I
BIOEN 1102	Fundamentals of Bioengineering II
BIOEN 2000	Careers in Biomedical Engineering
Major	
BIOEN 3070	Statistics for Bioengineering*
BIOEN 3091	Current Research in Bioengineering
BIOEN 3202	Physiology for Engineers
BIOEN 3301	Computation Methods for Bioengineers
BIOEN 3801	Biomedical Engineering Design I
BIOEN 4801	Biomedical Engineering Design II
BIOEN 4200	Biomedical Research or BIOEN 4990 Internship
BIOEN 4201	Biomedical Engineering Project I
BIOEN 4202	Biomedical Engineering Project II
BIOEN 5001	Biophysics
BIOEN 5101	Bioinstrumentation
BIOEN 5201	Biomechanics
BIOEN 5301	Biomaterials
BIOEN 5501	Bimolecular Engineering

* It is possible to substitute another statistics class *e.g.,* Math 3070, for this requirement. **However,** taking the Math edition increases the track class requirement for courses from the College of Engineering from 5 of 15 hours to 8 of 15 hours.

3.4 Tracks

Track classes are electives 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, track classes offer the opportunity to deepen and focus their knowledge in order to prepare for a career in a specific area of biomedical engineering. For others, the goal is to add even more breadth in preparation for post graduate education or professional training. Others take track classes 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 Biomedical Engineering program is loosely organized into the following areas of emphasis:

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.

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 and Bioengineering that cover the underlying physics and mathematics of all forms of medical imaging as well as the use of image processing to extract information from those images.

Biomolecular Engineering: based on course material from chemistry and chemical engineering and focused on the chemical characteristics of materials, biochemistry of living systems, and chemical based diagnostics and therapeutic drugs and materials

Computational Bioengineering: based on courses in computer science and mathematics and focused on the application of numerical and computational approaches to all aspects of 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.

Special: for students with unique goals in their engineering degree; draws on courses from many engineering disciplines and the basic or medical sciences.

A student chooses an area based on his or her career goals and a discussion with the undergraduate advising in order to meet one or more of the following needs:

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

The student then selects a set of courses that must be approved by the Program Directory.

Section 5 contains specific requirements and lists of approved track classes. Note that discussion and approval of the track electives **must occur in discussion with the Major Advisory**.

3.5 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 BIOEN 4990, which can also be used as a track course (for 1 hour of credit). Contact Dr. Brenda Mann for more details (see website for contact information).

Note: BIOEN 4990 carried up to 3 hours of credit towards the degree but only **1 hour** of track course credit!!!

3.6 Continuing Performance

A student admitted to major status must maintain a cumulative University of Utah GPA, as reported on his or her transcript, above 3.00. Each course taken to satisfy departmental requirements in mathematics, chemistry, physics, biology, biomedical engineering core, and the track electives must be taken for credit and passed with a grade of C or better. **A student may repeat these technical courses only once, and the second grade received will be counted for the requirement.**

3.7 Leave of Absence

Students are expected to complete all degree requirements within four years of acceptance to major status. 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 the 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 the Major Advisor and a variance (tan colored form) and to 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 the Director of Undergraduate Studies. Reinstated students matriculate under the latest graduation requirements.

3.8 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 the Director of Undergraduate Studies. Reinstated students matriculate under the latest graduation requirements.

3.9 Repeat and Withdrawal Policies

The Biomedical Engineering 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.

3.10 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 individuals 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 students 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 students 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 students 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 students degree or certificate, he/she may, within thirty (30) business days of receiving notice of the misconduct, prepare a complaint with recommendations, refer the matter to the chair or deans designee of the students home department or college, and notify the student of the complaint and recommendation. The chair and/or deans 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 deans 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 students 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.

3.11 Exit Interviews and Graduation

In order to be cleared to graduate, a student must meet with the Major Advisor to review the DARS audit report and to verify that all graduation requirements will be completed by the time of graduation. This must be done one semester prior to graduation. Immediately prior to graduation, the student attends an exit interview with a faculty member during a time announced in the senior classes. This exit interview provides important feedback to the Department to help improve the Biomedical Engineering program.

3.12 Undergraduate Advising

Please visit the Department of Bioengineering undergraduate office, 2750 Warnock Engineering Building, or call (801) 585-3651 for academic advice and information about the undergraduate program .

4 Sample Biomedical Engineering Plan of Study

Here is a sample plan of study, followed exactly as outlined. 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 Bioengineering Department courses can be found at www.bioen.utah.edu/

Fall Semester			Spring Semester		
Course #	**Title**	**Hrs**	**Course #**	**Title**	**Hrs**
Freshman Year					
BIOEN 1101	Funds of Bioeng I	3	BIOEN 1102	Funds of Bioeng II	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 1250	Calculus AP Students I*	4	MATH 1260	Calculus AP Students II*	4
WRTG 2010	College Writing	3		Gen Ed Elective 1	3
Total		15			15
Sophomore Year					
BIOEN 2000	Careers in Biomed Eng	1	BIOEN 3301	Computational Methods	3
BIOL 2020	Cell Biology**	3	PHYCS 2220	Physics for Scientists II	4
CHEM 2310	Organic Chemistry I	4	BIOEN 3091	Current Research in BME	1
CHEM 2315	Org. Chem I Lab	1		Gen Ed Elective 2	3
MATH 2250	Diff Eq/Lin Alg	4		Gen Ed Elective 3	3
PHYCS 2210	Physics for Scientists I	4			
Total		17			14
Junior Year					
BIOEN 3202	Physiology for Engineers	4	BIOEN 3801	BME Design I	3
BIOEN 5101	Bioinstrumentation	4	BIOEN 5301	Biomaterials	4
BIOEN 3070	Statistics for Eng***	3	BIOEN 5501	Biomolecular Engineering	4
	Engineering Track 1	3		Engineering Track 2	3
	Gen Ed Elective 4	3		Amer. Institut. Elective	3
			BIOEN 4200	Bioengineering Research	1
Total		17			18
Senior Year					
BIOEN 4801	BME Design II	3	BIOEN 4202	BME Project II	2
BIOEN 4201	BME Project I	2	BIOEN 5001	Biophysics	4
BIOEN 5201	Biomechanics	4		Gen Ed Elective 5	3
	Engineering Track 3	3		Engineering Track 4	3
	Engineering Track 5	3		Gen Ed Elective 6	3
Total		15			15
Grand total					126

4.1 Additional Notes

1. As an alternative to this math sequence, students may take MATH 1270 and 1280 or the three-semester calculus series MATH 1210, 1220, and 2210.

2. Students who have not had AP Biology in high school (with a score of 4 or 5) should take BIOL 1210

as a prerequisite to BIOL 2020.

3. Math 3070 is an acceptable replacement for BIOEN 3070. **However,** taking the Math edition increases the track class requirement for College of Engineering courses from 5 of 15 hours to 8 of 15 hours.

4. All students must take BIOEN 4200 or BIOEN 4990 at least once before they begin the senior project (BIOEN 4201). Students may also repeat BIOEN 4200 or BIOEN 4990 up to once and apply that credit to the track requirements.

5. 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 Bioengineering must seek prior approval for BIOEN 4200 and, upon completion, a grade from the Major Advisor.

6. BIOEN 4200 will be offered for the first time in Summer Semester, 2009. Students anticipating taking Senior Project in fall, 2009 are encouraged to take BIOEN 4200 at this time. Any student who has already completed a research project should still sign up for the course and will receive a grade from the Major Advisor. Alternatively, students who have already completed their research may also take BIOEN 4200 concomitantly with Senior Project class I (BIOEN 4201).

5 Track Courses

Note: There have been changes in the track classes for the 2009 catalog year that are required for all students entering the program after September 1, 2008. Other students may opt to follow the new requirements after discussion with the Major Advisor.

To successfully complete the track course 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** may come from upper division courses outside the colleges of Science and Engineering, provided they are approved by the Major Advisor **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.

*** Note:** When Math 3070 is substituted for BIOEN 3070, the requirement for College of Engineering classes increase from 5 of 15 hrs to 8 of 15 hrs.

A student's track plan must be approved by the Department's Major Advisor by submitting a Track Coursework Plan (the "green sheet") available from the BE office, the back pack of this handbook, or on the program web site. Seeking approval for the track plan should occur in the first semester after admission to major status and before starting the track sequence. **Students who have not submitted a track sheet by the middle of the semester immediately following their admission will not be allowed to register for the following semester Bioengineering courses**.

5.1 Tips for planning track classes

- A list of Bioengineering Department courses suitable for inclusion in a track appears at the end of this section.
- 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 BIOEN 5201, Biomechanics, is completed first (or concurrently). When in doubt, contact the Program Director for clarification or assistance.
- Organic Chemistry II and the Physics lab course required for entry to medical school are acceptable track classes.
- BIOEN 4990, Internship, must be taken once by all students who use data from an internship for their senior project (BIOEN 4201/4202). If students perform a second semester of internship with a company, they may take the class a second time for a maximum of 1 hour of track credit, even when the course contributes additional hours to the program of study.
- Directed reading, independent study, literature surveys, and special project classes do not generally qualify as track classes. Exceptions are possible but the Program Director must approve these **beforehand**.

- Some seminar classes (*e.g.,* BIOEN 6480, BIOEN 6464) may be acceptable for 1 hour of track credit, but only when they are used only to ensure adequate college credit hours, *i.e.,* they are not counted as part of the minimum 15 hours.

Below are some samples of course selections organized by track. Note that in many cases, Bioengineering students can progress directly to the upper division classes offered by other departments **without completing the usual requirements** for those classes. When in doubt, the Major Advisor or the instructor of the course can provide guidance.

5.2 Bioelectrical Engineering Track

BIOEN 5401	Medical Imaging Systems
BIOEN 5460	Engineering Aspects of Clinical Medicine
BIOEN 5480	Ultrasound
BIOEN 6330	Principles of Magnetic Resonance Imaging
BIOEN 6410	Bioinstrumentation: Biosignals and Biosensors
BIOEN 6421	Fundamentals of Micromachining Processes
BIOEN 6500	Mathematics of Imaging
BIOEN 6640	Introduction to Image Processing
ECE 2260	Fundamentals of Electric Circuits
ECE 2280	Fundamentals of Engineering Electronics
ECE 3110	Engineering Electronics II
ECE 3300	Fundamentals of Electromagnetics and Transmission Lines
ECE 3500	Fundamentals of Signals and Systems
ECE 3510	Introduction to Feedback Systems
ECE 5325	Wireless Communication Systems
ECE 5340	Numerical Techniques in Electromagnetics
ECE 5410	Lasers and Their Applications
ECE 5530	Digital Signal Processing

5.3 Biomaterials Engineering Track

MSE 2010	Introduction to Materials Science & Engineering
MSE 3010	Materials Processing Laboratory
MSE 3310	Introduction to Ceramics
MSE 3011	Structural Analysis of Materials
MSE 3210	Electronic Properties of Solids
MSE 3310	Introduction to Ceramics
MSE 3410	Introduction to Polymers
MSE 3510	Introduction to Metallic Materials
MSE 5010	X-ray Diffraction Techniques
MSE 5035	Electron Microscopy Techniques
MSE 5061	Transport Phenomena in Materials Science and Engineering
MSE 5201	Semiconductor Device Physics I
MSE 5202	Semiconductor Device Physics II
MSE 5211	Semiconductor Device Fabrication Laboratory I
MSE 5212	Semiconductor Device Fabrication Laboratory II
MSE 5240	Principles and Practice of Transmission Electron Microscopy
MSE 5353	Physical Ceramics
MSE 5354	Processing of Advanced Ceramics
MSE 5471	Polymer Processing
MSE 5473	Polymer Synthesis and Characterization
MSE 5475	Introduction to Composites
ME EN 1300	Statics and Strength of Materials
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

5.4 Biomedical Imaging Track

BIOEN 5401	Medical Imaging Systems
BIOEN 5460	Engineering Aspects of Clinical Medicine
BIOEN 5480	Ultrasound
BIOEN 6330	Principles of Magnetic Resonance Imaging
BIOEN 6500	Mathematics of Imaging
BIOEN 6640	Introduction to Image Processing
BIOEN 7320	3-D Reconstruction Techniques in Medical Imaging

5.5 Biomechanical Engineering Track

BIOEN 6230	Functional Anatomy for Engineers
BIOEN 6421	Fundamentals of Micromachining
BIOEN 7210	Biosolid Mechanics
BIOEN 7220	Biofluid Mechanics
ME EN 1300	Statics and Strength
ME EN 2080	Dynamics
ME EN 2300	Thermodynamics I
ME EN 2450	Numerical Techniques in Engineering
ME EN 3300	Strength of Materials
ME EN 3650	Heat Transfer
ME EN 3700	Fluid Mechanics
ME EN 5300	Advanced Strength of Materials
ME EN 5500	Engineering Elasticity
ME EN 5510	Introduction to Finite Elements
ME EN 5520	Composites
ME EN 5720	Comp. Fluid Mechanics

5.6 Biomolecular Engineering Track

BIOEN 5090	Biophysical Chemistry
BIOEN 6002	Molecular Biophysics
BIOEN 6140	Fundamentals of Tissue Engineering
BIOEN 6421	Fundamentals of Micromachining Processes
BIOEN 6505	Biotransport Phenomena
BIOEN 7111	Physicochemical Approach to Proteins and Nucleic Acids
BIOEN 7120	Biocompatibility
BIOEN 7140	Advanced Topics in Tissue Engineering
BIOL 2030	Genetics
BIOL 3215	Cell Biology Laboratory
BIOL 3230	Developmental Biology
CH EN 5103	Biochemical Engineering
CH EN 5104	Biochemical Engineering Laboratory
CHEM 3510	Biological Chemistry I
CHEM 3515	Biological Chemistry Laboratory
CHEM 3520	Biological Chemistry II
CHEM 3525	Molecular Biology of DNA Lab
CHEM 5810	Nanoscience: Where Biology, Chemistry and Physics Intersect
MSE 2010	Introduction to Materials Science & Engineering
MSE 3410	Introduction to Polymers
MSE 5010	X-ray Diffraction Techniques
MSE 5035	Electron Microscopy Techniques
MSE 5061	Transport Phenomena in Materials Science and Engineering
PATH 5030	Basic Immunology

5.7 Computational Bioengineering Track

BIOEN 6500	Mathematics of Imaging
BIOEN 6640	Introduction to Image Processing
BIOEN 6760	Modeling and Analysis of Biological Network
BIOEN 7320	3-D Reconstruction Techniques in Medical Imaging
CS 1010	Introduction to Unix
CS 2000	Introduction to Programming in C
CS 2010	Discrete Structures
CS 3200	Scientific Computation
CS 3500	Software Practice I
CS 3505	Software Practice II
CS 3700	Fundamentals of Digital System Design
CS 4100	Advanced Algorithms and Data Structures
CS 5300	Artificial Intelligence
CS 5310	Robotics
CS 5320	Computer Vision
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 6210	Advanced Scientific Computing I
CS 6220	Advanced Scientific Computing II
ECE 3700	Fundamentals of Digital System Design
ECE 5340	Numerical Techniques in Electromagnetics
CH EN 5353	Computational Fluid Dynamics
CH EN 6703	Applied Numerical Methods
ME EN 5510	Introduction to Finite Elements
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

5.8 Premedical Track

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

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

The BS program in Biomedical Engineering generally meets all the course requirements for medical school with the possible exception of Organic Chemistry II (lecture and laboratory) and laboratories in introductory courses in Biology and Physics. However, the Biomedical Engineering 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 do not accept the Senior Project classes BIOEN 4201/4202 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 tracks.

BIOEN 5090	Biophysical Chemistry
BIOEN 5401	Medical Imaging Systems
BIOEN 5460	Engineering Aspects of Clinical Medicine
BIOEN 5480	Ultrasound
BIOEN 6000	Systems Physiology I: Cardiovascular System
BIOEN 6010	Systems Physiology II: Nervous/Endocrine Systems
BIOEN 6140	Fundamentals of Tissue Engineering
BIOEN 6230	Functional Anatomy for Engineers
BIOL 2030	Genetics
BIOL 3215	Cell Biology Lab
BIOL 3230	Developmental Biology
BIOL 3510	Biological Chemistry I
BIOL 3515	Biological Chemistry Lab
BIOL 3520	Biological Chemistry II
PATH 5030	Basic Immunology

5.9 Department of Bioengineering courses approved for inclusion in BME tracks

The following courses are all recommended and approved for inclusion in the track plan for Biomedical Engineering. This course list is changing constantly and course offerings change in other departments so please consult with the Major Advisor whenever making a decision on the track plan. **It is up to the individual student to ensure that the courses in the track exist and are offered at the time the student wishes to take them. Note that many courses are taught only every second year.**

BIOEN 4200	Biomedical Research (max 1 Credit Hour)
BIOEN 4990	Internships and Cooperative Education (max 1 Credit Hour)
BIOEN 5090	Biophysical Chemistry
BIOEN 5401	Medical Imaging Systems
BIOEN 5460	Engineering Aspects of Clinical Medicine
BIOEN 5480	Ultrasound
BIOEN 6000	Systems Physiology I: Cardiovascular System
BIOEN 6010	Systems Physiology II: Nervous/Endocrine Systems
BIOEN 6002	Molecular Biophysics
BIOEN 6003	Cellular Electrophysiology and Biophysics
BIOEN 6050	Cellular Physiology for Engineers
BIOEN 6080	Ideas Into Dollars: Writing Grant Proposals
BIOEN 6140	Fundamentals of Tissue Engineering
BIOEN 6230	Functional Anatomy for Engineers
BIOEN 6310	Physics of MEG, X-Ray and Ultrasound
BIOEN 6320	Physics of Nuclear Medicine and MRI
BIOEN 6330	Principles of Magnetic Resonance Imaging
BIOEN 6421	Fundamentals of Micromachining Processes
BIOEN 6422	Biomedical Applications of Micromachining
BIOEN 6430	Systems Neuroscience
BIOEN 6433	Biological Statistical Signal Processing
BIOEN 6440	Neural Engineering
BIOEN 6450	Bioengineering Control Systems
BIOEN 6460	Electrophysiology and Bioelectricity
BIOEN 7111	Physicochemical Approach to Proteins and Nucleic Acids
BIOEN 7120	Biocompatibility
BIOEN 7130	Pharmaceutical Applications of Colloid and Interfacial Science
BIOEN 7140	Advanced Topics in Tissue Engineering
BIOEN 7150	Introduction to Biomimetic Engineering
BIOEN 7155	Neural Interfaces Laboratory
BIOEN 7160	Physical Nature of Surfaces
BIOEN 7168	Proteins at Interfaces and in Membranes
BIOEN 7210	Biosolid Mechanics
BIOEN 7220	Biofluid Mechanics
BIOEN 7310	Advanced Topics in Magnetic Resonance Imaging
BIOEN 7320	3D Reconstruction Techniques in Medical Imaging

5.10 Courses NOT acceptable for inclusion as a track elective

The following courses are not acceptable as a track elective for the Biomedical Engineering program. 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

BE 4999	Honors Thesis/Project
BE 5020	Interactive Science Exhibits
BE 5950/6910	Independent Study
BE 6090/1	Department Seminar
BE 6062	Biomedical Engineering Literature Survey
BE 6480	Biomechanics Seminar*
BE 6464	Cardiac Electrophysiology and Biophysics Seminar*
BE 6900	Special Topics**
BE 6930	Special Project
MSE 2160	Elements of Materials Science and Engineering Take MSE 2010 instead (Introduction to Materials Science & Engineering)
MSE 2170	Elements of Materials Science and Engineering Take MSE 2010 instead (Introduction to Materials Science & Engineering)
PHYS 3110	Physics of the Human Body I
PHYS 3111	Physics of the Human Body II

* students may take these courses for track 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 for track electives depending on the type and structure of the course. Please see the Major Advisor **before** taking a special topics class to determine its status.

6 Senior Project

A major component of the undergraduate program is the senior project, which involves two components:

1. A substantial involvement (approximately 200 hours) in one of three activities:
   - A scientific research project supervised by a faculty member either in or affiliated with the Bioengineering Department. Students should register for BIOEN 4200 while they are engaged in this research project; the advisor for the project will set the grade.
   - A design project that extends above and beyond the scope of the Bioengineering Design Course, mentored by a Bioengineering faculty member. Students should register for BIOEN 4200 while they are engaged in this design project; the advisor for the project will set the grade.
   - A substantial design or research project undertaken as part of an industrial or academic internship. Students participating in an industrial internship should take BIOEN 4990 and students performing research at a remote location should register for BIOEN 4200; in the latter case, the Major Advisor will set the grade.
2. Completing the Senior Project class (BE 4201 and BE 4202).

The goals of the senior 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 previous laboratories and develop a whole new set of abilities in the science (and art) of organizing and presenting ideas.

Success in the senior project requires taking the following steps:

1. As the very latest in the spring of the Junior year, obtain a placement in a research lab, with a biomedical engineering form, or in a lab related to the design class project.
2. Discuss with a mentor the specific needs of the senior project and develop a plan to carry out a project of adequate scope to generate the results for the senior project.
3. Make sure that by the **beginning of the fall semester** in the Senior year, there are enough results/data to write and talk about in the Senior Project class BE 4201.

6.1 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 Senior Project 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 molecular engineering track 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 bioengineering 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 section:

www.bioen.utah.edu/research/faculty_by_technical_area.php

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 will be available to help.

7 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 Department website and students interested in the program should read this description carefully to ensure that their course of study complies with the requirements.

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 (URL: www.ice.gov/sevis).

Department of Bioengineering
Application for Admission to Major Status in Biomedical Engineering

Instructions: In order to earn a Bachelor of Science degree in Biomedical Engineering, you must be admitted to major status before registering for any upper level Biomedical Engineering classes. To be considered for admission to major status requires, as a minimum, completion of the courses listed below with a grade point average of 3.00 or better. You may repeat technical courses only once, and the second grade received will be counted for the requirement. Actual admission is based on the composite GPA as calculated on this form. Students with composite GPAs of 3.25 or higher will be automatically admitted to major status; students with composite GPAs below 3.25 but above 3.0 will be placed on a wait list and admitted as space permits at the end of the next summer session.

To apply for admission to major status, submit this application form, an ***official*** copy of your University of Utah transcript and a summary of transfer credits (if applicable) to the Undergraduate Secretary any time during the academic year but no later than one day after the posting of grades for the previous summer session. Applications for admission will be considered as they are received. Students admitted to major status before the beginning of spring semester may start taking major classes that semester.

Name: _____ Student No. _____

Address: _____ Phone: _____

_____ Email: _____

Course *(Example*		**Letter Grade** *A-*	**Grade Value** *3.70*	**x** *x*	**Credit Hours** *3*	**=** =	**Points** *11.10*	**Semester/Year Taken** *Fall 02)*
BIOEN 2000	Careers in Biomedical Engineering	_____	**N/A**		**N/A**		**N/A**	_____
BIOEN 1101	Fund. of Bioengineering I	_____	_____	x	3	=	_____	_____
BIOEN 1102	Fund. of Bioengineering II	_____	_____	x	3	=	_____	_____
BIOL 2020	Cell Biology	_____	_____	x	3	=	_____	_____
CHEM 2310	Organic Chemistry I	_____	_____	x	4	=	_____	_____
CHEM 2315	Organic Chemistry Lab I	_____	_____	x	1	=	_____	_____
MATH 2250	Diff. Equations & Linear Algebra	_____	_____	x	3	=	_____	_____
PHYCS 2210	Physics for Scientist & Engineers I	_____	_____	x	4	=	_____	_____
	Total				**21**		_____	

* 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 (adjusted to include transfer grades weighted by hrs.): _____

C Composite GPA: (0.50 x **A** + 0.50 x **B**): _____

Student Signature: _____ Date: _____

Office use
Confirmed: _____

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

2008

Department of Bioengineering

Track Coursework Plan (Catalog Year 2009)

Name: _____ Student No: _____

Address: _____

Phone number: _____ Email address: _____

Indicate one of these areas that best describes your track:

- ❑ Bioelectrical Engineering
- ❑ Biomechanical Engineering
- ❑ Computational Bioengineering
- ❑ Biomedical Imaging
- ❑ Biomaterials Engineering
- ❑ Biomolecular Engineering
- ❑ Premed
- ❑ Special

List below a set of courses that is consistent with meeting your career goals. The plan must be well-thought out and coherent in terms of these goals. Examples of possible track courses are given in the Undergraduate Handbook.

Each of the courses listed below must be in the area of science or engineering. They must total 15 or more credit hours. At least 9 of the hours must be at the 3000 level or above. At least 5 of the hours must be from the College of Engineering and/or the College of Mines & Earth Sciences. Students who select Math 3070 for the statistics course requirement, must ensure that at least 8 (rather than 5) of their track hours are from the College of Engineering and/or the College of Mines & Earth Sciences.

Consult with the Bioengineering Department's Major Advisor in planning your track. Submit this completed form to the Department's Major Advisor for approval before taking courses toward the track requirements. Any subsequent changes to your plan must also be approved using this form.

Course Number	Course Title	Credit Hrs	Semester/Yr

Student Signature: _____

Department Approval: _____ Date: _____